Indian Institute of Technology Kanpur
Dean of Academic Affairs Office

OARS Course Master Database (as on 08-SEP-2016)
Dept.-wise list of courses with course contents

Course No.	L-T-P-D-C	Pre-requisite	Course Contents/References	Course Title
***** Department of AE *****				
AE100	1-0-2-0-0		**Course Contents:** History of aviation, spaceflight. Aerodynamic shape, generation of forces.Aerodynamics of airfoils. Atmosphere. Performance, stability & control. Structurallayout. Power plants. Instruments & navigational aids. Materials. Aircraftsystems. Missiles, spaceships, helicopters, airships & hovercrafts. Trips to windtunnel facilities, flight, structural, propulsion and high speed aerodynamiclaboratories together with demonstrative experiments. **References/Text Books:**	INTRODUCTION TO PROFESSION
AE201A	3-0-0-0-5		**Course Contents:** Fixed wing vehicles: History of Aviation, introduction to fixed wing vehicles,configuration and layout, propulsion, lift generation mechanism, balance offorces and moments, control mechanisms (10 hr)Rotary wing vehicles: History of rotary wing vehicles, configuration and layout,propulsion, lift generation mechanism, balance of forces and moments,control mechanisms (6 hr)Space Vehicles: History, configuration and layout, propulsion, lift generationmechanism, balance of forces and moments, navigation. (4 hr) Demo. Flights in motorized gliders **References/Text Books:** Introduction to Flight: J.D. Anderson, Jr., McGrawHill International Editions.	INTRODUCTION TO AEROSPACE ENGINEERING
AE211	3-0-0-1-4		**Course Contents:** Introduction to aerodynamics Atmosphere (ISA) and its stabilityContinuum hypothesis, dynamic similarity,Aero foil nomenclature, forces and momentsIncompressible irrotational flow, Complex potential, Singularities andsuperposition, Blasius theorem, Method of imagesCirculation, Robins Magnus effect and Kutta .Joukowski theoremConformal Mapping and Joukowski airfoil. Kelvin's circulation theoremThin Airfoil theoryHelmholtz theorems, Finite wing theoryComputational methods; Panel and vortex lattice methodsLow aspect ratio wings and slender body theoryViscous flows: Introduction to NS equationsPrandtl boundary layer equations, Similarity solutions. Integral approachIntroduction to transition 8< turbulence. Turbulent boundary layer **References/Text Books:** 1) Aerodynamics for Engineering Students by E.L. Houghton, P.W. Carpenter2) Physical Fluid Dynamics by D.J. Tritton, Oxford Science Publication.3) An Introduction to Fluid Dynamics by G.K. Batchelor, CambridgeUniversity Press.4) An Introduction to Theoretical and Computational Aerodynamics by JackMoran, Dover.	AERODYNAMICS I
AE211A	3-1-0-0-11	ESO204A/ME231A	**Course Contents:** Introduction to aerodynamics 1Atmosphere (ISA) and its stability 2Continuum hypothesis, dynamic similarity, 2Aerofoil nomenclature, forces and moments 1Incompressible irrotational flow, Complex potential, Singularities andsuperposition, Blasius theorem, Method of images5Circulation, Robins Magnus	INCOMPRESSIBLE AERODYNAMICS

			effect and Kutta Joukowski theorem (2 HRS)Conformal Mapping and Joukowski airfoil, Kelvins circulation theorem (3 HRS)Thin Airfoil theory (3 HRS)Helmholtz theorems, Finite wing theory (5 HRS)Computational methods; Panel and vortex lattice methods (3 HRS)Low aspect ratio wings and slender body theory (3 HRS)Viscous flows: Introduction to NS equations (2 HRS)Prandtl boundary layer equations, Similarity solutions. Integral approach (4 HRS)Introduction to transition & turbulence. Turbulent boundary layer (4 HRS) **References/Text Books:** *Aerodynamics for Engineering Students by E.L. Houghton, P.W. Carpenter* Physical Fluid Dynamics by D.J. Tritton, Oxford Science Publication.* An Introduction to Fluid Dynamics by G.K. Batchelor, CambridgeUniversity Press.* An Introduction to Theoretical and Computational Aerodynamics by JackMoran, Dover.	
AE231	2-0-0-0-2		**Course Contents:** Introduction: Particle dynamics 4Rigid body dynamics: Planar and threedimensional 12Theory of vibrations: Singledegreeoffreedom, multidegreeoffreedomsystems; free and forced vibrations; modal analysis; eigensystem analysis; 18response for general excitation; types of damping, proportional dampingPrinciple of virtual work 2Hamilton's Principle; Lagrange's equation 4 **References/Text Books:** 1. Engineering Mechanics: Dynamics (Fifth Edition): J.L. Meriam and L.G. Kraige,John Wiley and Sons.2. Elements of vibration analysis: L. Meirovitch, McGrawHill International Editions3. Theory of vibration with applications: W.T. Thomson and M.D. Dalleh, Prentice Hall4. Mechanical Vibrations: SS Rao, Pearson Education.	ELEMENTS OF VIBRATION
AE232	3-0-0-1-4		**Course Contents:** Static equilibrium, determinate and indeterminate structures, static stabilityconcepts, planar and space trusses. Beamsbending & extension, stress resultants,modulus weighted section properties, bending shear stressessolid and opensection. Idealization of stiffened shells. Shear center, shear flow in thin walledmulticell box beams, effect of taper. Tasian of then walled Section Work andenergy principles, strain energy and complementary strain energy, potential andcomplementary potential theorems, unit load method, reciprocal theorem.Application of energy principles for analysis of determinate and indeterminatestructures. **References/Text Books:**	AIRCRAFT STRUCTURES - I
AE251A	2-0-2-0-8		**Course Contents:** ContentPrinciples of measurement Introduction Description of MeasuringInstruments Performance Characteristics ofInstruments, Calibration, Accuracy,Precision, Bias, Dynamic responseVirtual Instrumentation and Dataacquisition Introduction to VI Graphical programming usingLABView: Vis and sub Vis, loops,arrays, clusters, file I/O Data acquisition: ADC, DAC, DIO,serial and GPIB communication Motion control systemSensors Strain Gage Motion Force, Torque, Power Pressure and Sound Temperature and Heat Flux FlowError analysis and data reduction Uncertainties in measurements Probability distributions Propagation of errors Estimates of Mean and Errors Curve fitsAdvanced Optical Measurements (PIV,LDV,etc.) **References/Text Books:** *. Measurement Systems Application and Design, E. O. Doebelin*. Data Reduction and Error Analysis for Physical Sciences, P. R. Bevington and D. K.Robinson.*. Experimental Stress Analysis, James W. Dally, William F. Riley*. Mechanical Behavior of Materials, Norman E. Dowling	EXPERIMENTS IN AEROSPACE ENGINEERING-I
AE311	3-1-0--4	ESO212	**Course Contents:** Review of thermodynamics Governing equations of compressible flowIsentropic flow. Area Mach number relation .Speed of sound, Mach cone, Flow regimes in terms of MachnumberStationary and moving normal	AERODYNAMICS - II

			shock, Rankine Hugoniot relations. Oblique shock, PrandtlMeyer expansionReflection, intersection of shocks and expansion wavesConvergingdiverging nozzle, supersonic wind tunnel1D unsteady flow: Riemann problemMethod of characteristicsSmall perturbations applied to, subsonic & supersonic airfoils,slender bodies.Similarity rules and area ruleCurved shock and Crocco's TheoremShockBoundary layer interactionTransonic small perturbation (TSP) equationsTransonic full potential equationsRayleigh & Fanno flowExperimenta I techniquesIntroduction to hypersonics **References/Text Books:** I) Elements of gasdynamics: Leipmann and Roshko, John Wiley and Sons.2) The dynamics and thermodynamics of compressible flows: A. H Shapiro, John Wileyand Sons.	
AE311A	3-0-0-0-9	ESO201A ESO204A	**Course Contents:** Review of thermodynamics (2HRS) Governing equations of compressible flow (2HRS) Isentropic flow, Area Mach number relation (3 HRS) Speed of sound, Mach cone, Flow regimes in terms of Machnumber (1 HRS) Stationary and moving normal shock, Rankine Hugoniot relations (2 HRS) Oblique shock, PrandtlMeyer expansion (3 HRS) Reflection, intersection of shocks and expansion waves (2 HRS) Convergingdiverging nozzle, supersonic wind tunnel (2 HRS) 1D unsteady flow: Riemann problem (2 HRS) Method of characteristics (2 HRS) Small perturbations applied to, subsonic & supersonic airfoils,slender bodies. (3 HRS) Similarity rules and area rule (2 HRS) Curved shock and Croccos Theorem (1 HRS) ShockBoundary layer interaction (1 HRS) Transonic small perturbation (TSP) equations (2 HRS) Transonic full potential equations (2 HRS) Rayleigh & Fanno flow (2 HRS) Experimental techniques (2 HRS) Introduction to hypersonics (2 HRS) **References/Text Books:** *Elements of gasdynamics: Leipmann and Roshko, John Wiley and Sons.*The dynamics and thermodynamics of compressible flows: A. H Shapiro, John Wileyand Sons.	COMPRESSIBLE AERODYNAMICS
AE312	3-0-0-1-4		**Course Contents:** Dynamics & thermodynamics of 1D flow, isentropic flow,1D wave: normal shock,central expansion. Supersonics, oblique shock, 2D steady flows: reflection,intersection; PrandtlMeyer flow. Method of characteristics. Small perturbationsapplied to, subsonic & supersonic airfoils, slender body. Similarity rules.Transonic area rule. Hypersonics; similitude, high temp and rarefaction. **References/Text Books:**	AERODYNAMICS-II
AE321	3-0-0-1-4		**Course Contents:** Standard atmosphere Definition of altitude, relation betweengeopotential and geometric altitudes, pressure, temperature, density altitudes 1Airfoil nomenclature, Airfoil data, infinite vs finite wings,critical mach number, drag divergence mach number, wavedrag, swept wings. Aerodynamic properties of wings andcomponents '3Airplane drag estimation for subsonic and supersonic flightregime for fuselage, wings, tail and other components of aircraft 3Flaps mechanism of high lift, estimation ofCL, CD, CLICD, for different flaps at various configurations.2Aircraft power plants 4Introduction to drag polar, equations of motion, thrust requiredfor level and unaccelerated flight, thrust available andmaximum velocity, power required for level and unacceleratedflight, power available and maximum velocity (reciprocatingenginepropeller combination, jet engine), altitude effepts onpower required and available. Rate of climb, gliding flight, absolute and service ceiling, time to climb, range andendurancepropeller driven airplane, range and endurance jetairplane, take off and landing performance, turning flight andthe Vn diagram, accelerated rate of climb (energy method),special consideration for supersonic airplane20Optimal performance of airplanes 5Introduction to performance estimation of fixed wing Unmanned aerial Vehicles2 **References/Text Books:** I. Introduction to Flight: J.D. Anderson, McGraw Hill International Editions.2. Miele, A., "Flight MechanicsTheory of Flight Paths, Vol.l",AddisonWesley, Reading, MA.3. Tewari, A., "Atmospheric and	FLIGHT MECHANICS - I

			Space Flight Dynamics", Birkhauser,Boston, 20064. Mechanics of Flight: Warren F. Phillips. John Wiley and Sons, Inc	
AE321A	3-0-0-0-9		**Course Contents:** Standard atmosphere Definition of altitude, relation betweengeopotential and geometric altitudes, pressure, temperature, densityaltitudesAirfoil nomenclature, Airfoil data, infinite vs finite wings, criticalmach number, drag divergence mach number, wave drag, sweptwings. Aerodynamic properties of wings and components Airplane drag estimation for subsonic and supersonic flight regimefor fuselage, wings, tail and other components of aircraft Flaps mechanism of high lift, estimation of CL, CD, CL/CD, fordifferent flaps at various configurations. Aircraft power plants Introduction to drag polar, equations of motion, thrust required forlevel and unaccelerated flight, thrust available and maximumvelocity, power required for level and unaccelerated flight, poweravailable and maximum velocity (reciprocating enginepropellercombination, jet engine), altitude effects on power required andavailable. Rate of climb, gliding flight, absolute and service ceiling,time to climb, range and enduranceproller driven airplane, rangeand endurance jet airplane, take off and landing performance, turningflight and the Vn diagram, accelerated rate of climb (energy method), special consideration for supersonic airplaneOptimal performance of airplanes Introduction to performance estimation of fixed wing Unmannedaerial Vehicles **References/Text Books:** * Introduction to Flight: J.D. Anderson, McGraw Hill International Editions.* Miele, A., "Flight MechanicsTheory of Flight Paths, Vol.I",AddisonWesley, Reading, MA.* Tewari, A., "Atmospheric and Space Flight Dynamics", Birkhauser,Boston, 2006* Mechanics of Flight: Warren F. Phillips. John Wiley and Sons, Inc	FLIGHT MECHANICS I
AE322	1-0-3-0-3		**Course Contents:** Definition of stability and control static stability and dynamic /stability. Moments on an airplane. Definition of pitch angle, flightpath angle and angle of attack. Criteria for longitudinal and staticstability.2Aerodynamic model (lollgitudinal mode), Longitudinal staticstability and control, contribution of the wing, tai fuselage tototal moment about CG of aircraft. Equations oflongitudinal staticstability. Calculation of elevator angle to trim in stick fixed vs stick free longitudinal static stability, estimation of neutral point(both stick fixed and stick free), estimation of static margin,estimation of maneuvering point (both stick fixed and stick free).12Directional static stability, lateral static stability, estimation of static margin, estimation of trim condition 6Equations of airplane motion 3Concept of stability and control derivatives 5Longitudinal and lateral directional dynamic modes 5Airplane response to controls 4Introduction to flying qualities and stability augmentation systems3 **References/Text Books:** 1. Flight Stability and Automatic Control: R. Nelson, McGraw Hill Education2. Introduction to Flight: J.D. Anderson, McGraw Hill International Editions3. Elkin, B., "Dynamics of Flight: Stability and Control", 3rd ed., Wiley, New York, 19954. Mechanics of Flight: Warren F. Phillips. John Wiley and Sons, Inc	FLIGHT MECHANICS-II
AE322A	3-0-0-0-9	AE321A	**Course Contents:** Definition of stability and control static stability and dynamicstability. Moments on an airplane. Definition of pitch angle, flightpath angle and angle of attack. Criteria for longitudinal and staticstability .Aerodynamic model (longitudinal mode), Longitudinal staticstability and control, contribution of the wing, tail, fuselage tototal moment about CG of aircraft. Equations of longitudinal staticstability. Calculation of elevator angle to trim in stick fixed vsstick free longitudinal static stability, estimation of neutral point(both stick fixed and stick free), estimation of static margin,estimation of maneuvering point (both stick fixed and stick free). Directional static stability, lateral static stability, estimation ofstatic margin, estimation of trim condition Equations of airplane motion Concept of stability and control derivatives Longitudinal and lateral directional dynamic modes Airplane response to controls Introduction to flying qualities and stability augmentation system	FLIGHT MECHANICS- II

			References/Text Books: *. Flight Stability and Automatic Control: R. Nelson, McGraw Hill Education*. Introduction to Flight: J.D. Anderson, McGraw Hill International Editions*. Etkin, B., "Dynamics of Flight: Stability and Control", 3rd ed., Wiley, New York, 1995*. Mechanics of Flight: Warren F. Phillips. John Wiley and Sons, Inc	
AE331	1-0-3-0-3		**Course Contents:** Loads on an aircraft .2Elements of Linear Theory of Elasticity4Idealization of Aerospace Structure '1Stress Resultant2Extensionbending of nonhomogenous EulerBernoulli4Bending shear stress (openclosedsolid)2St. Venant torsion of arbitrary crosssection3Shear flow2Thin Walled beams: Single celled and multi celled box beams.5Shear center for open and closed section4Tapered beams2BeamColumn Euler Buckling5Principle of virtual work4 **References/Text Books:** 1, Theory and analysis of flight structures: R.M. Rivello.No. oflectures2, Aircraft Structures for Engineering Students (Fourth edition): T.H.G. Megson,Elsevier Aerospace Engineering Series.3. Analysis of Aircraft Structures (second edition): B.K. Donaldson, CambridgeAerospace Series.	EXPERIMENTS IN STRUCTURES
AE331A	3-0-0-0-9	ESO202A	**Course Contents:** Loads on an aircraft (2 HR)Elements of Linear Theory of Elasticity (4 HR)Idealization of Aerospace Structure (1 HR)Stress Resultant (2 HR)Extensionbending of nonhomogenous EulerBernoulli (4 HR) Bending shear stress (openclosedsolid) (2 HR) St. Venant torsion of arbitrary crosssection (3 HR) Shear flow (2 HR) Thin Walled beams: Single celled and multi celled box beams. (5HR) Shear center for open and closed section (4 HR) Tapered beams (2 HRS) BeamColumn Euler Buckling (5 HRS)Principle of virtual work (4 HRS) **References/Text Books:** * Theory and analysis of flight structures: R.M. Rivello.* Aircraft Structures for Engineering Students (Fourth edition): T.H.G. Megson,Elsevier Aerospace Engineering Series.* Analysis of Aircraft Structures (second edition): B.K. Donaldson, CambridgeAerospace Series.	INTRODUCTION TO AEROSPACE STRUCTURES
AE332	0-0-2-0-2		**Course Contents:** Buckling of columns. Differential equation approach, energy approach, approximatetechniques. Beam columns. Buckling strength of flat sheets in compression,combined stress. Local buckling of composite shapes. Buckling of sheet stiffenercombination. **References/Text Books:**	AEROSPACE STRUCTURES-II
AE332A	0-0-2-0-2		**Course Contents:** Buckling of columns. Differential equation approach, energy approach, approximate techniques. Beam columns. Buckling strength of flat sheets in compression, combined stress. Local buckling of composite shapes. Buckling of sheet stiffener combination. **References/Text Books:**	AEROSPACE STRUCTURES-II
AE341	3-0-0-1-4		**Course Contents:** Introduction 2 Principle of Propulsion Air breathing and Rocket Propulsion*Reading assignment and Home work on Basic Fluid Mechanics,Thermodynamics and Compressible Flows should be zivenAeroThermodynamics of Gas Turbine Engines 5 Introduction Type of Airbreathing jet engines Performance of Gas Turbine Engines (fhrust, efficiency, range)Cycle Analysis of Airbreathing Jet Engines (Ideal and Aetna! Cycles) 12 Ramjet Turbojet Turbofan Turboprop Turbo shaftAir Intakes 3Rocket Propulsion 6 Introduction Single and multiStage RocketsPerformance of Chemical Rockets . 10 Principle of Combustion Estimation of Adiabatic Flame Temperature Thrust Coefficient Characteristic Velocity Types	PROPULSION - I

			ofNozzles and EfficienciesGas Turbine Combustors and Afterburners 2 **References/Text Books:** 1. Mechanics and Thermodynamics of Propulsion, P. Hill and C. Peterson,2. Gas Turbine Theory, H. Cohen, G. F. C. Rogers, H. I. H. Saravanamuttoo3. Jet Propulsion, N. Cumpsty4. Rocket Propulsion Elements, G. P. Sutton and D. M. Ross5. Modern Compressible Flow, J. D. Anderson, McGraw Hill6. Fundamentals of Combustion, D.P. Mishra, Prentice Hall oflndia, New Delhi, revisededition, 2010.7. Gas Turbine Propulsion, D.P. Mishra, Annamaya Publisher, New Delhi 20 II	
AE341A	3-0-0-2-11	AE311A	**Course Contents:** Introduction Principle of Propulsion Air breathing and Rocket Propulsion*Reading assignment and Home work on Basic Fluid Mechanics,Thermodynamics and Compressible Flows should be given//AeroThermodynamics of Gas Turbine Engines Introduction Type of Airbreathing jet engines Performance of Gas Turbine Engines (Thrust, efficiency, range)//Cycle Analysis of Airbreathing Jet Engines (Ideal and Actual Cycles) Ramjet Turbojet Turbofan Turboprop Turboshaft//Air Intakes //Rocket Propulsion Introduction Single and multiStage Rockets//Performance of Chemical Rockets Principle of Combustion Estimation of Adiabatic Flame Temperature Thrust Coefficient Characteristic Velocity Types of Nozzles and Efficiencies//Gas Turbine Combustors and Afterburners // **References/Text Books:** *. Mechanics and Thermodynamics of Propulsion, P. Hill and C. Peterson,*. Gas Turbine Theory, H. Cohen, G. F. C. Rogers, H. I. H. Saravanamuttoo*. Jet Propulsion, N. Cumpsty*. Rocket Propulsion Elements, G. P. Sutton and D. M. Ross*. Modern Compressible Flow, J. D. Anderson, McGraw Hill*. Fundamentals of Combustion, D.P. Mishra, Prentice Hall of India, New Delhi, revisededition, 2010.*. Gas Turbine Propulsion, D.P. Mishra, Annamaya Publisher, New Delhi 2011	AEROSPACE PROPULSION
AE342	3-0-3-1-5		**Course Contents:** Elements of combustion: adiabatic flame temperature, flammability and stabilitylimits. Gas turbine combustors & afterburners. Nozzles types & nonideal flows,Chemical rockets: Rocket vehicle mechanics, multistaging, propellants, heattransfer and cooling. Rocket ramjet. Measurements of volumetric flow rate,speed, torque, power and temperature. Experiments on axial compressor unit,gas turbine unit, and continuous combustion unit, cascades and curved diffuser. **References/Text Books:**	PROPULSION-II
AE345A	3-0-0-0-9		**Course Contents:** Attitude dynamics and stability ofthreeaxis stabilized, singlespin, dualspin, and multibodyspacecraft with a1ticulated antennas, sensors, and solar arrays.Design of control ofthreeaxis stabilized spacecraft in orbit using reaction wheels, thrusters,magnets, single and doublegimbaled control moment gyrosLargeangle threeaxis attitude maneuver controllers using reaction wheels and thrustersControl of spinning spacecraft in transfer orbit during delta_ v firing and in operational orbitsaround the Earth, and design of active nutation controlAttitude stabilization of bias momentum spacecraft using magnets and thrustersDynamics and control of dualspin spacecraftPrecision pointing and tracking controllers for tracking landmarks, moving objects, and othersatellites for crosslink communicationSolar array controllers for tracking the Sun; determining the array's orientation with sun sensorsModeling of dynamics of flexible solar arrays, its interaction with spacecraft dynamics andcontrol systemsAttitude determination with gyros, star trackers, sun sensors, and horizon sensors usingalgorithms such as TRIAD and QUEST (quaternion estimator); sensors error characteristics; andKalman filteringGuidance and navigation for spacecraft rendezvousThe above control techniques will be related with the control of Indian communication, remotesensing, and other special purpose satellites (Ca1tosat, Edusat, telemedicine). **References/Text Books:** Course Reference : * Hughes, P.C., Spacecraft Attitude Dynamics, John Wiley, 1986.* Sidi, M.J., Spacecraft	SPACECRAFT GUIDANCE NAVIGATION AND CONTROL

			Dynamics and Control, Cambridge University Press, 1997* Noton, M., Spacecraft Navigation and Guidance, Springer 1998* Kaplan, M.H., Modern Spacecraft Dynamics and Control, John Wiley, 1976* Agrawal, B., Design of Geosynchronous Spacecraft, Prentice Hall, 1986* Bryson, A.E., Control of Spacecraft and Aircraft, Princeton University Press, 1994* Pocha, J.J., An Introduction to Mission Design for Geostationary Satellites, D. Reidel,1987* Mara[, G., and Bousquet, M., Satellite Communications Systems, Fourth Edition, JohnWiley, 2006.* Wie, B., Space Vehicle Dynamics and Control, AIAA Education Series, 1998	
AE351A	0-0-4-1-5	AE251A	**Course Contents:** Course content: Dimensional analysis, Wind tunnels, Basic Experiments with different sensors,Material characterization, Flow Visualization. About 12 experiments will be conducted in thecourse. The breakup of the experiments will be as follows: Aerospace Structures: 4 Low Speed Aerodynamics: 4 Aerospace Propulsion: 2 High speed Aerodynamics: 2List of Experiments:Aerospace Structures:1. Bending of beams2. Shear centre estimation3. Estimation of Principal Axes4. Torsion5. UTM (static tests)Low Speed Aerodynamics:1. Laser light flow visualization2. Smoke flow visualization3. Hot wire anemometry (calibration + test)4. Force balance calibration5. Calibration of lowspeed tunnel6. Flow past airfoil/circular cylinder Cp distribution.Aerospace Propulsion:1. Calibration and use of pressure sensors2. Calibration and use of thermocouplesHigh Speed Aerodynamics:1. Schlieren + shadowgraphy2. Estimation of Mach number from static pressure measurement in supersonic tunnel **References/Text Books:** *. Measurement Systems Application and Design, E. O. Doebelin*. Data Reduction and Error Analysis for Physical Sciences, P. R. Bevington and D. K.Robinson.*. Experimental Stress Analysis, James W. Dally, William F. Riley*. Mechanical Behavior of Materials, Norman E. Dowling	EXPERIMENTS IN AEROSPACE ENGINEERING -II
AE361	0-0-3-0-2		**Course Contents:** Design and fabrication of aero models/components; Balsa, Styrofoam, wood,parchment, composites based model making; model upgradation; design, fabrication and testing of components; use of flight simulator, RC devices.40 **References/Text Books:**	AEROMODELLING DESIGN & FABRICATION
AE361A	0-0-3-0-3		**Course Contents:** Design and fabrication of aero models/components; Balsa, Styrofoam, wood,parchment, composites based model making; model upgradation; design,fabrication and testing of components; use of flight simulator, RC devices.(40 hr) **References/Text Books:** *Introduction to Flight: J.D. Anderson, Jr., McGrawHill International Editions.*Handouts.*Internet resources.	AEROMODEL DESIGN & FABRICATION
AE391A	0-0-0-0-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UG PROJECT (UGP-I)
AE401A	0-0-2-2-2		**Course Contents:** Selection of topic of research or review; development of presentationmaterial; preparation of technical report; technical presentations **References/Text Books:**	TECHNICAL COMMUNICATION
AE411	2-0-3-0-4		**Course Contents:** Experiments and model testing. Similiude, flow visualization, low and high speedtunnels: features & performance. Balances, Measurements; flow velocity:hotwire, laser doppler, pressure, temperature.Lab work:	EXPERIMENTS IN AERODYNAMICS

			Set of experiments **References/Text Books:**	
AE421A	1-0-2-0-3		**Course Contents:** Introduction to fliaht testing and instrumentation 1Techniques and data reduction methods, Error analysis 2Calibration of flight and special flight test instruments 1Evaluation of cruise and climb performance of a small airolane 1Determination of static and maneuver stability and control characteristics 1Observations of airplane dvnamic modes and stall characteristics1Introduction to flight testing and instrumentation 3Techniaues and data reduction methods, Error analysis 6Calibration of flight and special flight test instruments 3Evaluation of cruise and climb performance of a small airplane 3Determination of static and maneuver stability and control characteristics 3Observations of airplane dynamic modes and stall characteristics 3 **References/Text Books:**	EXPERIMENTS IN FLIGHT MECHANICS
AE422	1-0-2-0-2		**Course Contents:** Introduction to flight testing, instrumentation, techniques and data reductionmethods, calibration of flight and special flight test instruments. Evaluationof glider drag polar. Evaluation of cruise and climb performance of a smallairplane. Determination of static and maneuvre stability and control characteristics.Observations of airplane dynamic modes and stall characteristics. Introductionto GPS based navigation. Introduction to autopilot. **References/Text Books:**	EXPERIMENTS IN FLIGHT MECHANICS
AE441A	3-0-0-0-5	AE311A	**Course Contents:** Introduction to Turbomachinery Types of Turbomachinery Conservation of Angular MomentumCentrifugal Compressors Principle of operation Stage dynamics and Cascade Efficiency and Losses Compressor Characteristics Rotating Stall and SurgeAxial Compressors Principle of operation Stage dynamics Multistaging Radial Equilibrium Efficiency and CharacteristicsAxial Turbines Elementary Theory Stage dynamics Efficiency and losses Blade cooling Compressor Turbine matching **References/Text Books:** 1) Mechanics and Thermodynamics of Propulsion, P. Hill and C. Peterson2) Gas Turbine Theory, H. Cohen, G. F. C. Rogers, H. I. H. Saravanamuttoo3) Fluid Mechanics and Thermodynamics of Turbomachinery, S. L. Dixon4) Modern Compressible Flow, J. D. Anderson, McGraw Hill5) Gas Turbine Propulsion, D.P. Mishra, Annamaya Publisher, New Delhi 2011	TURBO-MACHINERY
AE451	0-0-2-0-2		**Course Contents:** List of Experiments:Low Speed Aerodynamics Lab:1. Turbulence measurement'2.0 Boundary Layer. measurement3. Aerodynamic characterization of a model aircraftHigh Speed Aerodynamics Lab:1. Characterization of supersonic jets2. Forces and moments on a projectile at supersonic speedsStructures Lab:I. Experiments in photoelasticity2. Experiments in vibration3. Dynamic characterization of elastomeric materials4. Inertia measurementPropulsion Lab:I. Characterization of intake2. Experiments in compressor/turbine cascades3. Performance analysis of2stage axial fan4. Performance of gas turbine engine5. Experiments in continuous combustion unit **References/Text Books:** * Measurement Systems Application and Design, E. 0. Doebelin*Data Reduction and Error Analysis for Physical Sciences, P. R. Bevington and D. K.Robinson.* Experimental Stress Analysis, James W. Dally, William F. Riley* Mechanical Behavior of Materials, Norman E. Dowling	EXPERIMENTS IN AEROSPACE ENGINEERING
AE451A	0-0-3-2-5	AE351A	**Course Contents:**	EXPERIMENTS IN

			List of Experiments:Low Speed Aerodynamics Lab:1. Turbulence measurement'2.0 Boundary Layer. measurement3. Aerodynamic characterization of a model aircraftHigh Speed Aerodynamics Lab:1. Characterization of supersonic jets2. Forces and moments on a projectile at supersonic speedsStructures Lab:I. Experiments in photoelasticity2. Experiments in vibration3. Dynamic characterization of elastomeric materials4. Inertia measurementPropulsion Lab:I. Characterization of intake2. Experiments in compressor/turbine cascades3. Performance analysis of2stage axial fan4. Performance of gas turbine engine5. Experiments in continuous combustion unit **References/Text Books:** * Measurement Systems Application and Design, E. 0. Doebelin*Data Reduction and Error Analysis for Physical Sciences, P. R. Bevington and D. K.Robinson.* Experimental Stress Analysis, James W. Dally, William F. Riley* Mechanical Behavior of Materials, Norman E. Dowling	AEROSPACE ENGINEERING III
AE461	2-0-4-0-5		**Course Contents:** Conceptual design based on preliminary mission requirementsSurvey of existing vehicular configurations (in similar category); lofting(preliminary layout sketches); preliminary weight estimationSelection of wing loading; thrust loading; wing section and planformFuselage layout and weight balance.Estimation of aerodynamic characteristics and performance evaluationDesign of tail areas and control surfacesEstimation of spanwise load distributions on wing and tailTOTAL LABORATORY OF THE COURSEConceptual design based on preliminary mission requirements; survey ofexisting vehicular configurations (in similar category); lofting (preliminarylayout sketches); preliminary weight estimation; selection of wingloading; thrust loading; wing section and planform; fuselage layout andweight balance; estimation of aerodynamic characteristics and performanceevaluation; design of tail areas and control surfaces; estimation of spanwiseload distributions on wing and tail. **References/Text Books:** Aircraft Design: A Conceptual Approach, D. Raymer (4th Ed.), AIAA Press, 2006.	AIRCRAFT DESIGN-I
AE461A	1-0-2-2-7		**Course Contents:** Conceptual design based on preliminary mission requirementsSurvey of existing vehicular configurations (in similar category); lofting(preliminary layout sketches); preliminary weight estimationSelection of wing loading; thrust loading; wing section and planformFuselage layout and weight balance.Estimation of aerodynamic characteristics and performance evaluationDesign of tail areas and control surfacesEstimation of spanwise load distributions on wing and tailTOTAL LABORATORY OF THE COURSEConceptual design based on preliminary mission requirements; survey ofexisting vehicular configurations (in similar category); lofting (preliminarylayout sketches); preliminary weight estimation; selection of wingloading; thrust loading; wing section and planform; fuselage layout andweight balance; estimation of aerodynamic characteristics and performanceevaluation; design of tail areas and control surfaces; estimation of spanwiseload distributions on wing and tail. **References/Text Books:** Aircraft Design: A Conceptual Approach, D. Raymer (4th Ed.), AIAA Press, 2006.	AIRCRAFT DESIGN-I
AE462	2-0-4-0-5		**Course Contents:** Concepts of structural design; Vn diagram; airworthiness requirementsStress resultants for swept and unswept wings; application of modifiedbeam theoryMethods for wing stress analysis; yielding based designBuckling (of columns, panels and stiffened panels) based design of thinstructuresRibspacing; sizing and preliminary layout of wing; margin of safety;advanced analysis (using FEM based commercial/opensource software)for full wing.TotalLaboratory component of the course:TopicConcepts of structural design; Vn diagram; airworthiness requirements;stress resultants for swept and unswept wings; application of modifiedbeam theory; methods for wing stress analysis; yielding based design;buckling (of columns, panels and stiffened panels) based design of thinstructures; ribspacing; sizing and preliminary layout of wing; margin ofsafety; advanced analysis (using FEM based commercial/opensourcesoftware) for	AIRCRAFT DESIGN-II

			full wing. **References/Text Books:** *. Analysis and design of Flight Vehicle Structures: E.F. Bruhn*. Airframe Structural Design: M. Niu*. Aircraft Design: A Conceptual Approach, D. Raymer (4th Edition), AIAA Press,2006.	
AE462A	1-0-1-0-4		**Course Contents:** Concepts of structural design; Vn diagram; airworthiness requirementsStress resultants for swept and unswept wings; application of modifiedbeam theoryMethods for wing stress analysis; yielding based designBuckling (of columns, panels and stiffened panels) based design of thinstructuresRibspacing; sizing and preliminary layout of wing; margin of safety;advanced analysis (using FEM based commercial/opensource software)for full wing.TotalLaboratory component of the course:TopicConcepts of structural design; Vn diagram; airworthiness requirements;stress resultants for swept and unswept wings; application of modifiedbeam theory; methods for wing stress analysis; yielding based design;buckling (of columns, panels and stiffened panels) based design of thinstructures; ribspacing; sizing and preliminary layout of wing; margin ofsafety; advanced analysis (using FEM based commercial/opensourcesoftware) for full wing. **References/Text Books:** *. Analysis and design of Flight Vehicle Structures: E.F. Bruhn*. Airframe Structural Design: M. Niu*. Aircraft Design: A Conceptual Approach, D. Raymer (4th Edition), AIAA Press,2006.	AIRCRAFT DESIGN-II
AE471	0-0-0-0-2		**Course Contents:** Registration for project with the selection of topic & getting started on thedesign, fabrication work, algorithm etc. **References/Text Books:**	PROJECT-I
AE471A	0-0-0-0-9		**Course Contents:** Registration for project with the selection of topic & getting started on thedesign, fabrication work, algorithm etc. **References/Text Books:**	B TECH PROJECT
AE472	0-0-0-0-4		**Course Contents:** Continuation of the project work initiated as a part of projectI and completion. **References/Text Books:**	PROJECT-II
AE481	3-0-0--4	ESO212	**Course Contents:** Conclusions from small BL thickness, BL eqns, exact & similar solns: Blasius,Howarth & Merk. Methods: continuation & integral conditions, Polhausen, Walz,Weighardt. Axisymm BL. Mangler transformation, elementary 3D BL., Transition,turb BL. Walz integral method. BL control. **References/Text Books:**	BOUNDARY LAYER THEORY
AE481A	3-0-0-0-9	ESO204A	**Course Contents:** Conclusions from small BL thickness, BL eqns, exact & similar solns: Blasius,Howarth & Merk. Methods: continuation & integral conditions, Polhausen, Walz,Weighardt. Axisymm BL. Mangler transformation, elementary 3D BL., Transition,turb BL. Walz integral method. BL control. **References/Text Books:**	BOUNDARY LAYER THEORY

AE601	3-0-0-0-4		**Course Contents:** History of aviation. History of spaceflight. Earths atmosphere and gravitationalfield. Anatomy of Flight vehicles. Bluff bodies v/s streamlined body, airfoil. Liftgeneration, significance of L/D ratio. Aerodynamic forces. Propulsion. Spacecrafts.Aircraft performance. Aerospace materials. Structural layout. Flight envelopeand Vn diagrams. Instruments and navigational aids. Exposure to flight testing. **References/Text Books:**	INTRO TO AEROSPACE ENGG.
AE601A	3-0-0-0-9		**Course Contents:** History of aviation. History of spaceflight. Earths atmosphere and gravitationalfield. Anatomy of Flight vehicles. Bluff bodies v/s streamlined body, airfoil. Liftgeneration, significance of L/D ratio. Aerodynamic forces. Propulsion. Spacecrafts.Aircraft performance. Aerospace materials. Structural layout. Flight envelopeand Vn diagrams. Instruments and navigational aids. Exposure to flight testing. **References/Text Books:**	INTRO TO AEROSPACE ENGG.
AE602	3-0-0-0-4		**Course Contents:** Matrices, determinants, vector spaces, linear transformation, eigensystems,linear equations, introduction to ordinary differential equations, homogeneouslinear equations of second order, nonhomogeneous linear equations of secondorder, free and forced oscillation problems, problems with variable coefficients,systems of equations, Fourier series, Fourier transform, Laplace transform,introduction to differencing methods; basic concepts of partial differentialequations, classification of second order equations, wave propagation in onedimension,parabolic equations, higher dimensional problems, Laplace equation,series solutions, transform methods, elements of complex variables. **References/Text Books:**	MATHEMATICS FOR AEROSPACE ENGG.
AE602A	3-0-0-0-9		**Course Contents:** differential equations, homogeneouslinear equations of second order, nonhomogeneous linear equations of secondorder, free and forced oscillation problems, problems with variable coefficients,systems of equations, Fourier series, Fourier transform, Laplace transform,introduction to differencing methods; basic concepts of partial differentialequations, classification of second order equations, wave propagation in onedimension,parabolic equations, higher dimensional problems, Laplace equation,series solutions, transform methods, elements of complex variables. **References/Text Books:**	MATHEMATICS FOR AEROSPACE ENGG.
AE603	2-0-1-0-4		**Course Contents:** Basics of Computing & Discretization, Errors: Different types of error, Interpolation and extrapolation, Root finding: Polynomials; NewtonRaphson Method, Secant Method,ODE and their computations, Stiff ODEs & parasitic error, Solution of IVP (ODE), Linear Algebra & BVP(ODE), Solution of Linear System, Finding eigenvalue/eigenvector **References/Text Books:** 1. Computational Fluid Dynamics : Charles Hirsch, Wiley, Chichester, U.K. (1990)2. Computational Fluid Dynamics and heat transfer: J.C. Tannehill, D.A. Anderson and R.H. Fletcher, Taylor and Francis (1997)3. Numerical Recipes in Fortran 77, W.H. Press, S. Teukolsky, W, Vetterling and B. Flannery, Cambridge Univ. Press (1992)4. Foundation of CFD : Tapan K. Sengupta, University Press Hyderabad, India (2009).	INTRODUCTION TO SCIENTIFIC COMPUTING
AE603A	2-0-1-0-7		**Course Contents:** Basics of Computing & Discretization, Errors: Different types of error, Interpolation and extrapolation, Root finding: Polynomials; NewtonRaphson Method, Secant Method,ODE and their computations, Stiff ODEs & parasitic error, Solution of IVP (ODE), Linear Algebra & BVP(ODE), Solution of Linear System, Finding	INTRODUCTION TO SCIENTIFIC COMPUTING

			eigenvalue/eigenvector **References/Text Books:** 1. Computational Fluid Dynamics : Charles Hirsch, Wiley, Chichester, U.K. (1990)2. Computational Fluid Dynamics and heat transfer: J.C. Tannehill, D.A. Anderson and R.H. Fletcher, Taylor and Francis (1997)3. Numerical Recipes in Fortran 77, W.H. Press, S. Teukolsky, W, Vetterling and B. Flannery, Cambridge Univ. Press (1992)4. Foundation of CFD : Tapan K. Sengupta, University Press Hyderabad, India (2009).	
AE604	3-0-1-0-5		**Course Contents:** Basics of Governing Equations, Spacetime discretization for PDE, Classification of PDE, Grid Generation, Waves and disturbances in fluid flow, Spacetime scales in fluid flow, Classical methods for solving parabolic PDEs, Methods for solving elliptic PDEs, High accuracy methods, Time Discretization, Error analysis:DNS, LES, Solution of NavierStokes equations. **References/Text Books:** 1.Computational Fluid Dynamics: C. Hirsch, Wiley (1998) 2.Computational Fluid Flow and Heat Transfer, Tannehill, Anderson, Pletcher3.High Accuracy Computing Method: Fluid flow and wave phenomena: Tapan K. Sengupta, Cambridge University Press (2013)4.Foundation of CFD: Tapan K Sengupta, Universities Press, Hyderabad, India (2004)	COMPUTATIONAL FLUID MECHANICS
AE604A	3-0-0-0-9		**Course Contents:** Basics of Governing Equations, Spacetime discretization for PDE, Classification of PDE, Grid Generation, Waves and disturbances in fluid flow, Spacetime scales in fluid flow, Classical methods for solving parabolic PDEs, Methods for solving elliptic PDEs, High accuracy methods, Time Discretization, Error analysis:DNS, LES, Solution of NavierStokes equations, **References/Text Books:** 1.Computational Fluid Dynamics: C. Hirsch, Wiley (1998) 2.Computational Fluid Flow and Heat Transfer, Tannehill, Anderson, Pletcher3.High Accuracy Computing Method: Fluid flow and wave phenomena: Tapan K. Sengupta, Cambridge University Press (2013)4.Foundation of CFD: Tapan K Sengupta, Universities Press, Hyderabad, India (2004)	COMPUTATIONAL FLUID MECHANICS
AE605	3-0-1-0-5		**Course Contents:** Issues of spacetime Resolution, Computing timeaveraged unsteady problem, Defference type of high Modeling RANS, URANS, LES, DES, DNS, Generalized transformation: Orthogonal/Nonorthogonal grid, Chimera Technique, Basis of FDM, FVM, EEM, FDM and FVM: High accuracy methods **References/Text Books:** 1. Computational Fluid Dynamics : Charles Hirsch, Wiley, Chichester, U.K. (1990)2. Computational Fluid Dynamics and heat transfer: J.C. Tannehill, D.A. Anderson and R.H. Fletcher, Taylor and Francis (1997)3. Foundation of CFD : Tapan K. Sengupta, University Press Hyderabad, India (2009).	ADVANCED COMPUTATIONAL FLUID MECHANICS
AE605A	3-0-0-0-9		**Course Contents:** Issues of spacetime Resolution, Computing timeaveraged unsteady problem, Defference type of high Modeling RANS, URANS, LES, DES, DNS, Generalized transformation: Orthogonal/Nonorthogonal grid, Chimera Technique, Basis of FDM, FVM, EEM, FDM and FVM: High accuracy methods. **References/Text Books:** 1. Computational Fluid Dynamics : Charles Hirsch, Wiley, Chichester, U.K. (1990)2. Computational Fluid Dynamics and heat transfer: J.C. Tannehill, D.A. Anderson and R.H. Fletcher, Taylor and Francis (1997)3. Foundation of CFD : Tapan K. Sengupta, University Press Hyderabad, India (2009).	ADVANCED COMPUTATIONAL FLUID MECHANICS
AE610	3-0-0-0-4		**Course Contents:**	AERODYNAMICS-I

			Basic fluid mechanics Navier stokes equation, vorticity kinematics, Basicpotential flows viscous flows including boundary layer theory, turbulence(introduction) **References/Text Books:**	
AE610A	3-0-0-0-9		**Course Contents:** Basic fluid mechanics Navier stokes equation, vorticity kinematics, Basicpotential flows viscous flows including boundary layer theory, turbulence(introduction) **References/Text Books:**	AERODYNAMICS-I
AE611	3-0-0-0-4		**Course Contents:** Introduction to measurement, Wind Tunnels and Water Tunnels, Flow visualization techniques,Measurement of Pressure and volume flow rate, Force Measurements, TemperatureMeasurements, Hotwire Measurements, Data Acquisition, Processing and uncertainty analysis,Static and dynamic response of measuring systems, PIV Measurements, Integral opticalmeasurement techniques: Shadowgraph, Schlieren & Interferometers, LDV Measurements, LIFMeasurements. Measurement of Wall Shear Stress **References/Text Books:** * Fluid Mechanics Measurement, by Richard J. Goldstein SpringerVerlng. 1983* Experimental Methods for Engineers by J.P. Holman McGrawHill 2008* Measurement in Fluid Mechanics by Stavros Tavoularis. Cambridge 2005* Particle Image Velocimetry: A Practical Guide by M. Raffel, C. Willert & J.Kompenhans. Springer, 1998.* Instrumentation, Measurements, and Experiments in Fluids, byE Rathakrishnan, CRCPress, 2007* The Laser Doppler Technique, by L. E. Drain, John Wiley & Sons 1980.* Hotwire anemometry, by Perry A. E. Oxford University Press, 1982.* Particle Image Velocimetry, by Ronald J. Adrian and Jerry Westerweel CambridgeAerospace Series, 2010.	MEASUREMENTS IN FLUID MECHANICS
AE611A	3-0-0-0-9		**Course Contents:** Introduction to measurement, Wind Tunnels and Water Tunnels, Flow visualization techniques,Measurement of Pressure and volume flow rate, Force Measurements, TemperatureMeasurements, Hotwire Measurements, Data Acquisition, Processing and uncertainty analysis,Static and dynamic response of measuring systems, PIV Measurements, Integral opticalmeasurement techniques: Shadowgraph, Schlieren & Interferometers, LDV Measurements, LIFMeasurements. Measurement of Wall Shear Stress **References/Text Books:** * Fluid Mechanics Measurement, by Richard J. Goldstein SpringerVerlng. 1983* Experimental Methods for Engineers by J.P. Holman McGrawHill 2008* Measurement in Fluid Mechanics by Stavros Tavoularis. Cambridge 2005* Particle Image Velocimetry: A Practical Guide by M. Raffel, C. Willert & J.Kompenhans. Springer, 1998.* Instrumentation, Measurements, and Experiments in Fluids, byE Rathakrishnan, CRCPress, 2007* The Laser Doppler Technique, by L. E. Drain, John Wiley & Sons 1980.* Hotwire anemometry, by Perry A. E. Oxford University Press, 1982.* Particle Image Velocimetry, by Ronald J. Adrian and Jerry Westerweel CambridgeAerospace Series, 2010.	MEASUREMENTS IN FLUID MECHANICS
AE612	3-0-0--4		**Course Contents:** Thin aerofoil theory, finite wing theory, basic thermodynamics, one and twodimensionalflows, isentropic flows, waves (shock, expansion, characteristicsetc.), potential flows, perturbation equation, subsonic flows similarities Fannoand Rayleigh flows. **References/Text Books:**	AERODYNAMICS II
AE612A	3-0-0-0-9		**Course Contents:** Thin aerofoil theory, finite wing theory, basic thermodynamics, one and twodimensionalflows, isentropic flows, waves (shock, expansion, characteristicsetc.), potential flows, perturbation equation, subsonic flows	AERODYNAMICS II

			similarities Fannoand Rayleigh flows. **References/Text Books:**	
AE614	3-0-0--4		**Course Contents:** Basic concepts of BL theory; similar flows: generalized techniques of solvingBL eqns. for incompressible fluids : thermal BL. BL control. Intro. to turbulentshear flows. **References/Text Books:**	VISCOUS FLOWS
AE614A	3-0-0-0-9		**Course Contents:** Basic concepts of BL theory; similar flows: generalized techniques of solvingBL eqns. for incompressible fluids : thermal BL. BL control. Intro. to turbulentshear flows. **References/Text Books:**	VISCOUS FLOWS
AE615	3-0-0--4		**Course Contents:** Main issues of spacetime resolution: Computing timeaveraged and unsteadyproblems. Discretization with operators. Problems in physical and transformedplane: Jacobians and flux vector splitting. Generalized transformation & gridgeneration techniques: Orthogonal & Chimera gridsapplication to FIV/aeroelasticityproblems. Spectral tools of analysis for discrete schemes: FDM, FVM& FEM. High order and high accuracy schemes of FDMs and FVMs. Design ofDispersion Relation Preservation schemes. Aliasing error & its alleviation. Highaccuracy methods for DN Sand LES. SGS models for LES and their connectionto higher order upwinding. Computing equations with discontinuous solutionsand Gibbs phenomenon. Applications to incompressible viscous and compressibleflows. DNS of turbulence and acoustic problems. **References/Text Books:**	ADVANCED COMPUTATIONAL METHODS IN CFD
AE615A	3-0-0-0-9		**Course Contents:** Main issues of spacetime resolution: Computing timeaveraged and unsteadyproblems. Discretization with operators. Problems in physical and transformedplane: Jacobians and flux vector splitting. Generalized transformation & gridgeneration techniques: Orthogonal & Chimera gridsapplication to FIV/aeroelasticityproblems. Spectral tools of analysis for discrete schemes: FDM, FVM& FEM. High order and high accuracy schemes of FDMs and FVMs. Design ofDispersion Relation Preservation schemes. Aliasing error & its alleviation. Highaccuracy methods for DN Sand LES. SGS models for LES and their connectionto higher order upwinding. Computing equations with discontinuous solutionsand Gibbs phenomenon. Applications to incompressible viscous and compressibleflows. DNS of turbulence and acoustic problems. **References/Text Books:**	ADVANCED COMPUTATIONAL METHODS IN CFD
AE617	3-0-0--4	#	**Course Contents:** NavierStokes eqn. and its various forms, thin shear layer approxn. Varioustypes of flows. Instabilities in laminar flows. Relationship of instability theorywith transition to turbulence. Transition prediction. Receptivity for two & threedimensional problems. **References/Text Books:**	BOUNDARY LAYER INSTABILITY AND TRANSITION
AE617A	3-0-0-0-9		**Course Contents:** NavierStokes eqn. and its various forms, thin shear layer approxn. Varioustypes of flows. Instabilities in laminar flows. Relationship of instability theorywith transition to turbulence. Transition prediction.	BOUNDARY LAYER INSTABILITY AND TRANSITION

			Receptivity for two & threedimensional problems. **References/Text Books:**	
AE618	3-0-0--4	#	**Course Contents:** Fundamental concepts; strong form, weak form, Galerkins approximation; matrixeqns, element and global point of view; numerical integration Guassianquadrature; termporal discretization generalized trapeziodal rule; compressibleand incompressible flows; implementation of the methods; issues related tohigh performance computing. **References/Text Books:**	FINITE ELEMENT METHODS FOR FLUID DYNAMICS
AE618A	3-0-0-0-9		**Course Contents:** Fundamental concepts; strong form, weak form, Galerkins approximation; matrixeqns, element and global point of view; numerical integration Guassianquadrature; termporal discretization generalized trapeziodal rule; compressibleand incompressible flows; implementation of the methods; issues related tohigh performance computing. **References/Text Books:**	FINITE ELEMENT METHODS FOR FLUID DYNAMICS
AE621	3-0-0--4	#	**Course Contents:** Origin, examples & character of turb, Reynolds stress, energy relations, closureproblem, phenomenology, eddy viscosity. Staistics. spectra, spacetime correlations,macro & microscales, stat. theory of turb, locally isotropic turb, Kolmogorovshypothesis, correlation method, spectral method, turb. diffusion. Experimentaltechniques. **References/Text Books:**	TURBULENCE
AE621A	3-0-0-0-9		**Course Contents:** Origin, examples & character of turb, Reynolds stress, energy relations, closureproblem, phenomenology, eddy viscosity. Staistics. spectra, spacetime correlations,macro & microscales, stat. theory of turb, locally isotropic turb, Kolmogorovshypothesis, correlation method, spectral method, turb. diffusion. Experimentaltechniques. **References/Text Books:**	TURBULENCE
AE622	3-0-0--4		**Course Contents:** Eqns of fluid dynamics & its classifications. Boundary conditions. Stabilityanalysis & concept of feedback. Various explicit & implicit schemes. Gridgeneration. Solving parabolic, elliptic PDEs by explicit, implicit, acceleratedtechniques. Solving advection equation. Integral representation of NavierStokesequation;LES & DNS. **References/Text Books:**	COMPUTATIONAL FLUID DYNAMICS
AE622A	3-0-0-0-9		**Course Contents:** Eqns of fluid dynamics & its classifications. Boundary conditions. Stabilityanalysis & concept of feedback. Various explicit & implicit schemes. Gridgeneration. Solving parabolic, elliptic PDEs by explicit, implicit, acceleratedtechniques. Solving advection equation. Integral representation of NavierStokesequation;LES & DNS. **References/Text Books:**	COMPUTATIONAL FLUID DYNAMICS
AE625	3-0-0--4		**Course Contents:**	TRANSITION AND

			Elements of viscous flows and thin shear layer approximation. Different typesof TSL flows. Instabilities in flows. RayleighTaylor, KelvinHelmholtz mechanisms.Thin shear layer instabilities: for parallel and nonparallel flows. Temporal andspatial instabilities in boundary layers. convective/absolute, local/globalinstabilities of boundary layers, wakes, jets and free shear layers. Primary andsecondary instabilities and relationship of instability theories to transition.Receptivity of shear layers for 2 and 3D flows. Bypass transition in differentflows.Classified views of trubulent flows. Scales, spectra and closure of turbulent flows.Vorticity dynamics and other kinematic tools of turbulence. Role of stretchingand dispersion in small scale turbulence. Route to turbulence: Chaos via nonlinearity,instabilities and bifurcation. Coherent structures in turbulence:Universality of transitional and turbulent flows. Study of turbulence via chaosdynamics ans proper orthogonal decomposition (POD). DNS, LES and other closureschemes of turbulence **References/Text Books:** * Drazin. P.G. & Reid W.H.: Hydrodynamic Stability 1981, (CUP).* Davidson. P.A.: Turbulence (2003) (OUP)* Lmdahl. M.T. & MolloChristcnsen: Turbulence & Random Processes in Fluid Mechanics 1992 (CUP)* Holmes. P., Lumley, J .L. & Bcrkooz G.: Turbulence, Coherent structures. Dynamical systems and Symmetry. 1996 (CUP)* Sagaut. P.: Large Eddy Simulation for Incompressible Flows. 2000 (Springer)* Sengupta T.K.: Foundation of CFD, 2004 (Univ. Press)	TURBULENCE
AE625A	3-0-0-0-9		**Course Contents:** Elements of viscous flows and thin shear layer approximation. Different typesof TSL flows. Instabilities in flows. RayleighTaylor, KelvinHelmholtz mechanisms.Thin shear layer instabilities: for parallel and nonparallel flows. Temporal andspatial instabilities in boundary layers. convective/absolute, local/globalinstabilities of boundary layers, wakes, jets and free shear layers. Primary andsecondary instabilities and relationship of instability theories to transition.Receptivity of shear layers for 2 and 3D flows. Bypass transition in differentflows.Classified views of trubulent flows. Scales, spectra and closure of turbulent flows.Vorticity dynamics and other kinematic tools of turbulence. Role of stretchingand dispersion in small scale turbulence. Route to turbulence: Chaos via nonlinearity,instabilities and bifurcation. Coherent structures in turbulence:Universality of transitional and turbulent flows. Study of turbulence via chaosdynamics ans proper orthogonal decomposition (POD). DNS, LES and other closureschemes of turbulence **References/Text Books:** * Drazin. P.G. & Reid W.H.: Hydrodynamic Stability 1981, (CUP).* Davidson. P.A.: Turbulence (2003) (OUP)* Lmdahl. M.T. & MolloChristcnsen: Turbulence & Random Processes in Fluid Mechanics 1992 (CUP)* Holmes. P., Lumley, J .L. & Bcrkooz G.: Turbulence, Coherent structures. Dynamical systems and Symmetry. 1996 (CUP)* Sagaut. P.: Large Eddy Simulation for Incompressible Flows. 2000 (Springer)* Sengupta T.K.: Foundation of CFD, 2004 (Univ. Press)	TRANSITION AND TURBULENCE
AE628	3-0-0--4	#	**Course Contents:** Continuum hypersonics in entry flight. Gen features, Mach no. Small disturbtheory, similitude. Large diflecn similitude; wedge, cone, wing. Unified similitude.Lighthill & other piston analogies, NewtonBusemann theory, thin shock layers,viscousinviscid interaction. Real gas. Frozen flow. Nonequilibrium flow. **References/Text Books:**	CONTINUUM HYPERSONIC AERODYNAMICS
AE628A	3-0-0-0-9		**Course Contents:** Continuum hypersonics in entry flight. Gen features, Mach no. Small disturbtheory, similitude. Large diflecn similitude; wedge, cone, wing. Unified similitude.Lighthill & other piston analogies, NewtonBusemann theory, thin shock layers,viscousinviscid interaction. Real gas. Frozen flow. Nonequilibrium flow. **References/Text Books:**	CONTINUUM HYPERSONIC AERODYNAMICS

AE629	3-0-0--4	#	**Course Contents:** Earths atmosphere & rotation, Coriolis force, geostrophic winds. Terrain, mettheories, measuring technique. Wind power site. Atmosph BL. Aerodyn in windpower. Sails, airscrews. Vertical & horizontal axis wind turbines. Actuator disc,momentum, and vortex theories. Control of wind turbines. **References/Text Books:**	ADVANCES IN WIND ENERGY CONVERSION
AE629A	3-0-0-0-9		**Course Contents:** Earths atmosphere & rotation, Coriolis force, geostrophic winds. Terrain, mettheories, measuring technique. Wind power site. Atmosph BL. Aerodyn in windpower. Sails, airscrews. Vertical & horizontal axis wind turbines. Actuator disc,momentum, and vortex theories. Control of wind turbines. **References/Text Books:**	ADVANCES IN WIND ENERGY CONVERSION
AE640	3-0-0-0-4		**Course Contents:** Course introduction, basic definition, notion, guidance, navigation, and control loops.Review to linear algebra. Coordinated frames, kinematics and dynamics, trim conditions.Linear control and autopilot design. Introduction to probability and random processes.Accelerometer, rate gyros, pressure sensors, magnetometers, inertial measurement units (IMUs), global positioning systems (GPS). State estimation: Kalman filter (KF), Extended Kalman filter(EKF), Unscented Kalman filter (UKF), Cubature Kalman filter (CKF), Information filters, GPS aided navigation. Path planning and path following algorithms. Controllability, observability, vision guided navigation. Cooperative control **References/Text Books:** 1. D. P. Bertsekas and J. N. Tsitsiklis, Introduction to Probability, Athena Scientific, 2008.2. S. Thrun, W. Burgard, and D. Fox, Probabilistic Robotics, MIT Press, 2005.3. S. M. LaValle. Planning Algorithms. Cambridge University Press, Cambridge, U.K., 2006.	AUTONOMOUS NAVIGATION
AE640A	3-0-0-0-9		**Course Contents:** Course introduction, basic definition, notion, guidance, navigation, and control loops.Review to linear algebra. Coordinated frames, kinematics and dynamics, trim conditions.Linear control and autopilot design. Introduction to probability and random processes.Accelerometer, rate gyros, pressure sensors, magnetometers, inertial measurement units (IMUs), global positioning systems (GPS). State estimation: Kalman filter (KF), Extended Kalman filter(EKF), Unscented Kalman filter (UKF), Cubature Kalman filter (CKF), Information filters, GPS aided navigation. Path planning and path following algorithms. Controllability, observability, vision guided navigation. Cooperative control **References/Text Books:** 1. D. P. Bertsekas and J. N. Tsitsiklis, Introduction to Probability, Athena Scientific, 2008.2. S. Thrun, W. Burgard, and D. Fox, Probabilistic Robotics, MIT Press, 2005.3. S. M. LaValle. Planning Algorithms. Cambridge University Press, Cambridge, U.K., 2006.	AUTONOMOUS NAVIGATION
AE641	3-0-0-0-4		**Course Contents:** Introduction, performance of single and multistage rockets, central force motion,twobody problem, ballistic trajectories, trajectory transfer, rendezvous andinterception, Eulers eqns, satellite attitude dynamics, stabilization throughgravity gradient, spin and dual spin, effect of energy dissipation on stability. **References/Text Books:**	SPACE DYNAMICS-I
AE641A	3-0-0-0-9		**Course Contents:** Introduction, performance of single and multistage rockets, central force motion,twobody problem, ballistic trajectories, trajectory transfer, rendezvous andinterception, Eulers eqns, satellite attitude dynamics,	SPACE DYNAMICS-I

			stabilization throughgravity gradient, spin and dual spin, effect of energy dissipation on stability. **References/Text Books:**	
AE645	3-0-0--4		**Course Contents:** Attitude dynamics and stability ofthreeaxis stabilized, singlespin, dualspin, and multibodyspacecraft with a1ticulated antennas, sensors, and solar arrays.Design of control ofthreeaxis stabilized spacecraft in orbit using reaction wheels, thrusters,magnets, single and doublegimbaled control moment gyrosLargeangle threeaxis attitude maneuver controllers using reaction wheels and thrustersControl of spinning spacecraft in transfer orbit during delta_ v firing and in operational orbitsaround the Earth, and design of active nutation controlAttitude stabilization of bias momentum spacecraft using magnets and thrustersDynamics and control of dualspin spacecraftPrecision pointing and tracking controllers for tracking landmarks, moving objects, and othersatellites for crosslink communicationSolar array controllers for tracking the Sun; determining the array's orientation with sun sensorsModeling of dynamics of flexible solar arrays, its interaction with spacecraft dynamics andcontrol systemsAttitude determination with gyros, star trackers, sun sensors, and horizon sensors usingalgorithms such as TRIAD and QUEST (quaternion estimator); sensors error characteristics; andKalman filteringGuidance and navigation for spacecraft rendezvousThe above control techniques will be related with the control of Indian communication, remotesensing, and other special purpose satellites (Ca1tosat, Edusat, telemedicine). **References/Text Books:** * Hughes, P.C., Spacecraft Attitude Dynamics, John Wiley, 1986.* Sidi, M.J., Spacecraft Dynamics and Control, Cambridge University Press, 1997* Noton, M., Spacecraft Navigation and Guidance, Springer 1998* Kaplan, M.H., Modern Spacecraft Dynamics and Control, John Wiley, 1976* Agrawal, B., Design of Geosynchronous Spacecraft, Prentice Hall, 1986* Bryson, A.E., Control of Spacecraft and Aircraft, Princeton University Press, 1994* Pocha, J.J., An Introduction to Mission Design for Geostationary Satellites, D. Reidel,1987* Mara[, G., and Bousquet, M., Satellite Communications Systems, Fourth Edition, JohnWiley, 2006.* Wie, B., Space Vehicle Dynamics and Control, AIAA Education Series, 1998	SPACECRAFT GUIDANCE NAVIGATION AND CONTROL
AE645A	3-0-0-0-9		**Course Contents:** Course Details: Attitude dynamics and stability ofthreeaxis stabilized, singlespin, dualspin, and multibodyspacecraft with a1ticulated antennas, sensors, and solar arrays.Design of control ofthreeaxis stabilized spacecraft in orbit using reaction wheels, thrusters,magnets, single and doublegimbaled control moment gyrosLargeangle threeaxis attitude maneuver controllers using reaction wheels and thrustersControl of spinning spacecraft in transfer orbit during delta_ v firing and in operational orbitsaround the Earth, and design of active nutation controlAttitude stabilization of bias momentum spacecraft using magnets and thrustersDynamics and control of dualspin spacecraftPrecision pointing and tracking controllers for tracking landmarks, moving objects, and othersatellites for crosslink communicationSolar array controllers for tracking the Sun; determining the array's orientation with sun sensorsModeling of dynamics of flexible solar arrays, its interaction with spacecraft dynamics andcontrol systemsAttitude determination with gyros, star trackers, sun sensors, and horizon sensors usingalgorithms such as TRIAD and QUEST (quaternion estimator); sensors error characteristics; andKalman filteringGuidance and navigation for spacecraft rendezvousThe above control techniques will be related with the control of Indian communication, remotesensing, and other special purpose satellites (Ca1tosat, Edusat, telemedicine). **References/Text Books:** Course Reference : * Hughes, P.C., Spacecraft Attitude Dynamics, John Wiley, 1986.* Sidi, M.J., Spacecraft Dynamics and Control, Cambridge University Press, 1997* Noton, M., Spacecraft Navigation and Guidance, Springer 1998* Kaplan, M.H., Modern Spacecraft Dynamics and Control, John Wiley, 1976* Agrawal, B., Design of Geosynchronous Spacecraft, Prentice Hall, 1986* Bryson, A.E., Control of Spacecraft and Aircraft, Princeton University Press, 1994* Pocha, J.J., An Introduction to Mission Design for Geostationary Satellites, D. Reidel,1987* Mara[, G., and Bousquet, M., Satellite Communications Systems, Fourth Edition, JohnWiley, 2006.* Wie, B., Space Vehicle Dynamics and Control, AIAA Education Series, 1998	SPACECRAFT GUIDANCE NAVIGATION AND CONTROL

AE647	3-0-0-0-4		**Course Contents:** Fundamentals of vectors. Transformation of coordinates. Particle kinematics.Rigid body kinematics. Force equations in a moving frame. Moment equationsin a moving frame. Atmospheric flight Dynamics. Space flight dynamics.Gyrodynamics. **References/Text Books:**	FLIGHT DYNAMICS
AE647A	3-0-0-0-9		**Course Contents:** Fundamentals of vectors. Transformation of coordinates. Particle kinematics.Rigid body kinematics. Force equations in a moving frame. Moment equationsin a moving frame. Atmospheric flight Dynamics. Space flight dynamics.Gyrodynamics. **References/Text Books:**	FLIGHT DYNAMICS
AE648	3-0-0-0-4		**Course Contents:** Linearized equations of aircraft motion for small perturbations in stability axes.Stability analysis of linearized equations of motion. Airplane longitudinal motion.Airplane lateral motion. Airplane handling qualities. Missile and launch vehiclestability and control. Qualitative discussion of automatic flight control systems **References/Text Books:**	FLIGHT STABILITY AND CONTROL
AE648A	3-0-0-0-9		**Course Contents:** Linearized equations of aircraft motion for small perturbations in stability axes.Stability analysis of linearized equations of motion. Airplane longitudinal motion.Airplane lateral motion. Airplane handling qualities. Missile and launch vehiclestability and control. Qualitative discussion of automatic flight control systems **References/Text Books:**	FLIGHT STABILITY AND CONTROL
AE649	3-0-0--4		**Course Contents:** 1. Introduction to Automatic Control Systems.(Plant Models, Control Algorithms, Sensors, Actuators, Control SystemsClassification.)2. Introduction to Rigid Body Dynamics and Flight Models.3. Linear Systems(Analog and Digital Systems, Transfer Function and FrequencyResponse, State Space Representations, Stability, Performance, and Robustness).4. Single Variable Linear Control(Proportional, Integral, Derivative Control, Rate and RateIntegrating Gyros,Single Input Regulation by Pole Placement, Linear Observers, SISO Compensationand Tracking, Single Axis Attitude Control, Aircraft Heading Autopilot, Aircraft SpeedAutopilot, Roll Autopilots for Aircraft, Rockets, and Entry Vehicles, Planar TrackingSystems for Rockets and Entry Vehicles, Pitch Stabilization of Gravity GradientSpacecraft, Spacecraft Single Axis Maneuvers).5. Multivariable Linear Optimal Control(Linear Optimal Control, Linear Quadratic Regulator, Kalman Filter, OptimalCompensation and Multivariable Tracking, Longitudinal Autopilots for Aircraft, Banktoturn Missiles, and Entry Vehicles, LateralDirectional Autopilots for AtmosphericFlight Vehicles, Attitude Stabilization of Spacecraft, Reaction Wheel Control Systems,Magnetic Torquer/Reaction Wheel Control Systems, Control Moment Gyroscopes ,Variable Speed Control Moment Gyroscopes, ThrustVectoring Attitude Control ofRockets).6. Terminal Time Weighted Linear Optimal Control(Time Varying Tracking Systems, Guidance and Control of Rockets and EntryVehicles, Automated Orbital Rendezvous).7. Digital Implementation of Linear Flight Control Systems. **References/Text Books:** 1. Tewari, A , Modern Control Design with MATLAB and Simulink, John Wiley & Sons,Chichester, 2002.1 ,. 2. Tewari, A, Atmospheric and Space Flight Dynamics, Springer (Birkhauser), Boston,2006.	AUTOMATIC CONTROL OF AIRCRAFT ROCKETS AND SPACECRAFT
AE649A	3-0-0-0-9		**Course Contents:** 1. Introduction to Automatic Control Systems.(Plant Models, Control Algorithms, Sensors, Actuators, Control SystemsClassification.)2. Introduction to Rigid Body Dynamics and Flight Models.3. Linear	AUTOMATIC CONTROL OF AIRCRAFT ROCKETS AND SPACECRAFT

			Systems(Analog and Digital Systems, Transfer Function and FrequencyResponse, State Space Representations, Stability, Performance, and Robustness).4. Single Variable Linear Control(Proportional, Integral, Derivative Control, Rate and RateIntegrating Gyros,Single Input Regulation by Pole Placement, Linear Observers, SISO Compensationand Tracking, Single Axis Attitude Control, Aircraft Heading Autopilot, Aircraft SpeedAutopilot, Roll Autopilots for Aircraft, Rockets, and Entry Vehicles, Planar TrackingSystems for Rockets and Entry Vehicles, Pitch Stabilization of Gravity GradientSpacecraft, Spacecraft Single Axis Maneuvers).5. Multivariable Linear Optimal Control(Linear Optimal Control, Linear Quadratic Regulator, Kalman Filter, OptimalCompensation and Multivariable Tracking, Longitudinal Autopilots for Aircraft, Banktoturn Missiles, and Entry Vehicles, LateralDirectional Autopilots for AtmosphericFlight Vehicles, Attitude Stabilization of Spacecraft, Reaction Wheel Control Systems,Magnetic Torquer/Reaction Wheel Control Systems, Control Moment Gyroscopes ,Variable Speed Control Moment Gyroscopes, ThrustVectoring Attitude Control ofRockets).6. Terminal Time Weighted Linear Optimal Control(Time Varying Tracking Systems, Guidance and Control of Rockets and EntryVehicles, Automated Orbital Rendezvous).7. Digital Implementation of Linear Flight Control Systems. **References/Text Books:** Course Reference : 1. Tewari, A , Modern Control Design with MATLAB and Simulink, John Wiley & Sons,Chichester, 2002.1 ,. 2. Tewari, A, Atmospheric and Space Flight Dynamics, Springer (Birkhauser), Boston,2006.	
AE650	3-0-0-0-4		**Course Contents:** ntroduction to propulsion, conservation equations, basic thermodynamics,dynamics and thermodynamics of 1 D flows, 1 D isentropic flows, normal andoblique shocks, compressible flows, Rayleigh flow, Fanno flow, elements ofcombustion, thermochemistry , adiabatic flame temperature, premixed flames,diffusion flames, rocket propulsion, thrust equation, solid rockets, liquid rockets,hybrid rockets, gas turbine cycles. **References/Text Books:**	FUNDAMENTAL OF AEROSPACE PROPULSION - I
AE650A	3-0-0-0-9		**Course Contents:** Introduction to propulsion, conservation equations, basic thermodynamics,dynamics and thermodynamics of 1 D flows, 1 D isentropic flows, normal andoblique shocks, compressible flows, Rayleigh flow, Fanno flow, elements ofcombustion, thermochemistry , adiabatic flame temperature, premixed flames,diffusion flames, rocket propulsion, thrust equation, solid rockets, liquid rockets,hybrid rockets, gas turbine cycles. **References/Text Books:**	FUNDAMENTAL OF AEROSPACE PROPULSION - I
AE652	3-0-0-0-4		**Course Contents:** Gas turbine engines, performance analysis, subsonic and supersonic diffusers,centrifugal and axial compressors, stage dynamics, compressor stall, axialturbines, compressorturbine matching, gas turbine combustors and afterburners,nozzles, ramjets, scramjets. **References/Text Books:**	AIRCRAFT PROPULSION
AE652A	3-0-0-0-9		**Course Contents:** Gas turbine engines, performance analysis, subsonic and supersonic diffusers,centrifugal and axial compressors, stage dynamics, compressor stall, axialturbines, compressorturbine matching, gas turbine combustors and afterburners,nozzles, ramjets, scramjets. **References/Text Books:**	AIRCRAFT PROPULSION
AE653	3-0-0--4	#	**Course Contents:** Axial compressors, stage dynamics, degree of reaction, pressure rise limitations,secondary flows, performance: design and offdesign, starting problems, centrifugalcompressors; inlet flow, slip, sweep,	THERMAL TURBOMACHINERY

			diffuser design. Axial turbines: stagedynamics, three dimensional flows, loss estimation, blade cooling. **References/Text Books:**	
AE653A	3-0-0-0-9		**Course Contents:** Axial compressors, stage dynamics, degree of reaction, pressure rise limitations,secondary flows, performance: design and offdesign, starting problems, centrifugalcompressors; inlet flow, slip, sweep, diffuser design. Axial turbines: stagedynamics, three dimensional flows, loss estimation, blade cooling. **References/Text Books:**	THERMAL TURBOMACHINERY
AE657	3-0-0-0-4	AE 341 / AE652	**Course Contents:** Introduction and overview. Comparison of ramjet propulsion with other typesof missile propulsion. Types of ram propulsion. Specific impulse. Propellants. Ramjet air induction system for missile application. Ducted rocket performancewith single and multiple inlet systems. Engine and airframe integration for ramjetand ram rocket powered missiles. Ramjet with solid fuel. Solid propellant ramrockets. Supersonic combustion ramjet. Inlet, combustor and nozzle analysis. **References/Text Books:**	AIRBREATHING MISSILE PROPULSION
AE657A	3-0-0-0-9	AE 341 / AE652	**Course Contents:** Introduction and overview. Comparison of ramjet propulsion with other typesof missile propulsion. Types of ram propulsion. Specific impulse. Propellants.Ramjet air induction system for missile application. Ducted rocket performancewith single and multiple inlet systems. Engine and airframe integration for ramjetand ram rocket powered missiles. Ramjet with solid fuel. Solid propellant ramrockets. Supersonic combustion ramjet. Inlet, combustor and nozzle analysis. **References/Text Books:**	AIRBREATHING MISSILE PROPULSION
AE658	3-1-0-0-5		**Course Contents:** Introduction, Governing equations, Modeling of laminar premixed and nonpremixed flames,Modeling of turbulent premixed and nonpremixed flames, Advanced modeling aspect.Introduction (3 hrs) Motivation and aim Governing equations for reacting flowsModeling of Laminar Premixed flames (7 hrs) Introduction Conservation equations and numerical solutions Steady 1 D flames Theoretical solution methods Calculation of flame speed, thickness and stretchModeling of Laminar nonpremixed flames (6 hrs) Nonpremixed flame configuration Theoretical tools Flame structure for irreversible infinite fast chemistry and solutions Theory of other flame structuresModeling of turbulent premixed flames (10 hrs) Phenomenological description Premixed turbulent combustion regime RANS modeling LES modeling DNS modelingModeling of turbulent nonpremixed flames (10 hrs) Phenomenological description Turbulent nonpremixed combustion regime RANS modeling LES modeling DNS modelingAdvanced modeling aspect (4 hrs) Combustion in twophase flows Boundary conditions Flame/wall interactions Flame/acoustics interaction **References/Text Books:** * Peters, N., Turbulent Combustion, Cambridge University Press, 2000.* Warnatz, J., Mass, U., Dibble, R.W., Combustion: Physical and ChemicalFundamentals, Modeling and Simulation, Experiments, Pollutant Formation,Springer, 4111 Edition, 2006.* Kuo, Kenneth, Principles of Combustion, John Wiley and Sons, Inc, 2"d Edition,2005.* Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2002.* Law, C. K., Combustion Physics, Cambridge University Press, 2006.	NUMERICAL MODELING OF CHEMICALLY REACTING FLOWS
AE658A	3-0-0-0-9		**Course Contents:** Introduction, Governing equations, Modeling of laminar premixed and nonpremixed flames,Modeling of turbulent premixed and nonpremixed flames, Advanced modeling aspect.Introduction (3 hrs) Motivation and aim Governing equations for reacting flowsModeling of Laminar Premixed flames (7 hrs) Introduction	NUMERICAL MODELING OF CHEMICALLY REACTING FLOWS

			Conservation equations and numerical solutions Steady 1 D flames Theoretical solution methods Calculation of flame speed, thickness and stretchModeling of Laminar nonpremixed flames (6 hrs) Nonpremixed flame configuration Theoretical tools Flame structure for irreversible infinite fast chemistry and solutions Theory of other flame structuresModeling of turbulent premixed flames (10 hrs) Phenomenological description Premixed turbulent combustion regime RANS modeling LES modeling DNS modelingModeling of turbulent nonpremixed flames (10 hrs) Phenomenological description Turbulent nonpremixed combustion regime RANS modeling LES modeling DNS modelingAdvanced modeling aspect (4 hrs) Combustion in twophase flows Boundary conditions Flame/wall interactions Flame/acoustics interaction **References/Text Books:** Course Reference : * Peters, N., Turbulent Combustion, Cambridge University Press, 2000.* Warnatz, J., Mass, U., Dibble, R.W., Combustion: Physical and ChemicalFundamentals, Modeling and Simulation, Experiments, Pollutant Formation,Springer, 4111 Edition, 2006.* Kuo, Kenneth, Principles of Combustion, John Wiley and Sons, Inc, 2"d Edition,2005.* Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2002.* Law, C. K., Combustion Physics, Cambridge University Press, 2006.	
AE660	2-0-3-0-4		**Course Contents:** 1. Introduction to: design process, design goals, types of rotorcraft (2 Lec.)2. Understanding mission requirements, use of Analytical Hierarchy Process in configuration selection (2 Lec.) (1 Lab.)3. Concept selection methodology: collection of statistical data, Pugh's method, key performance indices, life cycle costs (2 Lec.) (1 Lab.)4. Generating design alternatives: preliminary sizing using Tischenko's Method, preliminaryweight estimation, rotor propulsive efficiency, Lift/Drag ratio, engine performance, main ro tor blade weight estimation, rotor hub and swash plate (3 Lec.) (1 Lab.)5. Performance: power required for hover, climb, level flight, maximum level speed, speed forbest endurance, best range, autorotative per formance (3 Lec.) (2 Lab.)6. Main rotor configuration design: rotor struc tural and aerodynamic design (number ofblades, rotor diameter, blade chord, rotor iner tia, blade twist, blade taper, blade tip shape, sweep, root cutout, tip speed, hinge offset, air foils, frequency placement, material selection) (5 Lec.) (3 Lab.)7. Rotor component design: hub design, control power, helicopter stability considerations (3 Lec.) (2 Lab.)8. Tail rotor/ antitorque systems: diameter, tip speed, disk area, number of blades, pusher vstractor (2 Lec.) (1 Lab.)9. Fuselage and landing gear design (4 Lec.) (2 Lab.) 10. Vibration sources, vibration reduction (2 Lec.) (1 Lab.) 11. Life cycle cost estimation: environmental cost, purchase cost. operating cost(2 Lec.) (1 Lab.) **References/Text Books:** * Leishman, J. G., Principles of Helicopter Aerodynamics, Cambridge Aerospace Series,2000.* Prouty, R. W., Helicopter Performance, Stability, and Control, Krieger Publishing Company, Florida, 1986.* Stepniewski, W. Z., and Keys, C. N., Rotary Wing Aerodynamics, Dover, New York,1984.* Venkatesan, C., "Lecture Notes on Helicopter Technology," Department of AerospaceEngineering, liT Kanpur, 2000.* Filippone, A., Flight Performance of Fixed and Rotary Wing Aircraft, AIAA EducationSeries, 2006.	PRELIMINARY DESIGN OF HELICOPTER
AE660A	2-0-3-0-9		**Course Contents:** 1. Introduction to: design process, design goals, types of rotorcraft (2 Lec.)2. Understanding mission requirements, use of Analytical Hierarchy Process in configuration selection (2 Lec.) (1 Lab.)3. Concept selection methodology: collection of statistical data, Pugh's method, key performance indices, life cycle costs (2 Lec.) (1 Lab.)4. Generating design alternatives: preliminary sizing using Tischenko's Method, preliminaryweight estimation, rotor propulsive efficiency, Lift/Drag ratio, engine performance, main ro tor blade weight estimation, rotor hub and swash plate (3 Lec.) (1 Lab.)5. Performance: power required for hover, climb, level flight, maximum level speed, speed forbest endurance, best range, autorotative per formance (3 Lec.) (2 Lab.)6. Main rotor configuration design: rotor struc tural and aerodynamic design (number ofblades, rotor diameter, blade chord, rotor iner tia, blade twist, blade taper, blade tip shape, sweep, root cutout, tip speed, hinge offset, air foils, frequency placement, material selection) (5 Lec.) (3 Lab.)7. Rotor component design: hub design, control power, helicopter stability considerations (3 Lec.) (2 Lab.)8. Tail rotor/ antitorque systems: diameter, tip speed, disk area, number of blades, pusher vstractor (2 Lec.) (1 Lab.)9. Fuselage and landing gear design (4 Lec.) (2 Lab.) 10. Vibration sources, vibration reduction (2 Lec.)	PRELIMINARY DESIGN OF HELICOPTER

			(1 Lab.) 11. Life cycle cost estimation: environmental cost, purchase cost. operating cost(2 Lec.) (1 Lab.) **References/Text Books:** Course Reference : * Leishman, J. G., Principles of Helicopter Aerodynamics, Cambridge Aerospace Series,2000.* Prouty, R. W., Helicopter Performance, Stability, and Control, Krieger Publishing Company, Florida, 1986.* Stepniewski, W. Z., and Keys, C. N., Rotary Wing Aerodynamics, Dover, New York,1984.* Venkatesan, C., "Lecture Notes on Helicopter Technology," Department of AerospaceEngineering, liT Kanpur, 2000.* Filippone, A., Flight Performance of Fixed and Rotary Wing Aircraft, AIAA EducationSeries, 2006.	
AE662	2-0-3--4	AE651/AE342	**Course Contents:** Introduction to rocket propulsion, Types of rocket engines, Elements of combustion,Chemical propellants and their burning characteristics, Aerothermodynamic designanalysis of solid propellant rocket engine, Liquid propellant rocket engine, Design ofthrust chamber, Design of cooling system; Design of rocket Nozzle. **References/Text Books:** 1. Sutton G.P and Ross D. M. "Rocket Propulsion Elements", John Wiley & Sons,New York, 1985.2. Barrere M, Jaumotte A and Vandenkerckhove 1. "Rocket Propulsion", ElsevierPublishing Company, New York, 1960.3. Hill, P.G. and Peterson C.R., "Mechanics and Thennodynamics ofPropulsion", Addison Wesiey Publishing Company, 1965.4. Oater G.C, "Aerothermodynamics of Gas Turbine and Rocket Propulsion", 3rdEdition, AIAA education Seria, 1998.5. Mishra D.P. "Fundamental of Combustion" Prentice Hall oflndia, New Delhi6. Kuo K. K. and Summerfield, " Fundamentals Of Solid Propellant, combustion"progress in Astronautics and Aeronautics, Vol. 90, AIAA New York.	ROCKET ENGINE DESIGN
AE662A	2-0-3-0-9		**Course Contents:** Introduction to rocket propulsion, Types of rocket engines, Elements of combustion,Chemical propellants and their burning characteristics, Aerothermodynamic designanalysis of solid propellant rocket engine, Liquid propellant rocket engine, Design ofthrust chamber, Design of cooling system; Design of rocket Nozzle. **References/Text Books:**	ROCKET ENGINE DESIGN
AE663A	3-0-0-0-9		**Course Contents:** Introduction, Combustion and Thermochemistry: Motivation and objective, Property relations, Thermodynamic laws, Reactant & Product mixtures, Adiabatic flame temperature, Chemical equilibrium and equilibrium products Kinetics and Mechanism:Introduction, Global versus elementary reactions, Rates of reaction for multistep mechanismsConservation equations: Simplified governing equations, Momentum, energy, mass conservation, Multicomponent diffusion, Concept of conserved scalar Laminar Premixed and Nonpremixed flames: Physical description, Simplified and detailed analysis, Flame speed, thickness, quenching, flammability limits, Flame stabilization, Nonremixed flames, laminar jets, Droplet Combustion, Solid fuel Combustion **References/Text Books:**	FUNDAMENTALS OF COMBUSTION
AE670	3-0-0-0-4		**Course Contents:** Free body diagram, equilibrium equations, examples from three dimensionaltruss problems; bending moment, shear force. Introduction to theory of elasticity,stress, strain, stressstrain relations, constitutive relations, basic equations ofelasticity. Bending of beams, symmetrical and unsymmetrical sections, temperatureeffects, nonhomogeneous materials, modulus weighted sectional properties, thinwalled sections. Deflection of beams.Torsion of circular and noncircular sections,thin walled sections, single and multiple closed cell sections. Shear in thin walledsections, shear center, single and multiple cell sections, combined	AEROSPACE STRUCTURAL ANALYSIS - I

			bending andtorsion. Plane strain and plane stress problems in elasticity. Eulers bucklingof columns. **References/Text Books:**	
AE670A	3-0-0-0-9		**Course Contents:** Free body diagram, equilibrium equations, examples from three dimensionaltruss problems; bending moment, shear force. Introduction to theory of elasticity,stress, strain, stressstrain relations, constitutive relations, basic equations ofelasticity. Bending of beams, symmetrical and unsymmetrical sections, temperatureeffects, nonhomogeneous materials, modulus weighted sectional properties, thinwalled sections. Deflection of beams.Torsion of circular and noncircular sections,thin walled sections, single and multiple closed cell sections. Shear in thin walledsections, shear center, single and multiple cell sections, combined bending andtorsion. Plane strain and plane stress problems in elasticity. Eulers bucklingof columns. **References/Text Books:**	AEROSPACE STRUCTURAL ANALYSIS - I
AE672	3-0-0--4		**Course Contents:** Introduction. Material behaviour of idealized bodies, mathematical preliminaries,tensor analysis, partial derivatives, etc. Analysis of stress and strain measures.Laws of conservation, eqn. of motion, conservation of energy. Thermodynamicand mechanical equilibrium. Constitutive laws : viscoelastic materials. **References/Text Books:**	SOLID MECHANICS
AE672A	3-0-0-0-9		**Course Contents:** Introduction. Material behaviour of idealized bodies, mathematical preliminaries,tensor analysis, partial derivatives, etc. Analysis of stress and strain measures.Laws of conservation, eqn. of motion, conservation of energy. Thermodynamicand mechanical equilibrium. Constitutive laws : viscoelastic materials. **References/Text Books:**	SOLID MECHANICS
AE673	3-0-0--4	#	**Course Contents:** Mission analysis, design approaches, analytical techniques, rocket grain analysis,structural types and optimization, honeycomb and sandwich construction,structural materials, aeroelasticity of cylindrical and conical shells, reentryproblems, ablation analysis, design examples, future trends, inflatable andexpandable structure. **References/Text Books:**	ROCKET AND MISSILE STRUCTURES
AE673A	3-0-0-0-9	#	**Course Contents:** Mission analysis, design approaches, analytical techniques, rocket grain analysis,structural types and optimization, honeycomb and sandwich construction,structural materials, aeroelasticity of cylindrical and conical shells, reentryproblems, ablation analysis, design examples, future trends, inflatable andexpandable structure. **References/Text Books:**	ROCKET AND MISSILE STRUCTURES
AE675	3-0-0--4		**Course Contents:** Discussion on mathematical models, reliability of computer aided engineeringanalysis. Model problem of linear elastostatics in onedimension, principle ofminimum potential energy, beam bending problem. Finite element discretisationin onedimension. Onedimensional h/p code, Finite Element Formulation anddevelopment of twodimensional code. Convergence analysis in two dimensions.Characterizational of solution smoothness, rate of convergence in energy norm,a posteriori error estimation. Direct computation of stresses and strains,postprocessing, superconvergent extraction techniques, nonlinear and timedependent	INTRODUCTION TO FINITE ELEMENT METHODS

			problems. **References/Text Books:**	
AE675A	3-0-0-0-9		**Course Contents:** Discussion on mathematical models, reliability of computer aided engineeringanalysis. Model problem of linear elastostatics in onedimension, principle ofminimum potential energy, beam bending problem. Finite element discretisationin onedimension. Onedimensional h/p code, Finite Element Formulation anddevelopment of twodimensional code. Convergence analysis in two dimensions.Characterizational of solution smoothness, rate of convergence in energy norm,a posteriori error estimation. Direct computation of stresses and strains,postprocessing, superconvergent extraction techniques, nonlinear and timedependent problems. **References/Text Books:**	INTRODUCTION TO FINITE ELEMENT METHODS
AE676	3-0-0--4	#	**Course Contents:** Influence coefficients and function. Formulation of static and dynamic aeroelasticequations. Static aeroelasticity; divergence, aileron reversal & controleffectiveness, solutions by matrix and energy methods. Unsteady aerodynamics,oscillating airfoil in incompressible flow, experimental methods, Dynamic aeroelasticity,flutter calculation, panel flutter. **References/Text Books:**	AEROELASTICITY
AE676A	3-0-0-0-9		**Course Contents:** Influence coefficients and function. Formulation of static and dynamic aeroelasticequations. Static aeroelasticity; divergence, aileron reversal & controleffectiveness, solutions by matrix and energy methods. Unsteady aerodynamics,oscillating airfoil in incompressible flow, experimental methods, Dynamic aeroelasticity,flutter calculation, panel flutter. **References/Text Books:**	AEROELASTICITY
AE678	3-0-0--4	#	**Course Contents:** Introd. Hamiltons principles, Lagranges eqn, Eigenvalue problem (EVP), discrete& continuous system. Boundary value problem formulation. General EVP, positivedefinite system, self adjoint property. Vibration of strings, rods, beams,membranes and plates. Rayleighs quotient. Integral formulation of EVP, naturalmodes of vibration, approximate methods. Response to excitation. **References/Text Books:**	THEORY OF VIBRATIONS
AE678A	3-0-0-0-9		**Course Contents:** Introd. Hamiltons principles, Lagranges eqn, Eigenvalue problem (EVP), discrete& continuous system. Boundary value problem formulation. General EVP, positivedefinite system, self adjoint property. Vibration of strings, rods, beams,membranes and plates. Rayleighs quotient. Integral formulation of EVP, naturalmodes of vibration, approximate methods. Response to excitation. **References/Text Books:**	THEORY OF VIBRATIONS
AE681	3-0-0--4	#	**Course Contents:** Introduction, Definition, classification, behaviors of unidirectional composites:prediction of strength, stiffness, factors influencing strength & stiffness, failuremodes, analysis of lamina; constitutive classical laminate theory, thermalstresses. Design consideration, analysis of laminates after initial failure,interlaminar stresses, fracture mechanics, joints, experimental characterization.Performance under adverse environment.	COMPOSITE MATERIALS

			References/Text Books:	
AE681A	3-0-0-0-9		**Course Contents:** Introduction, Definition, classification, behaviors of unidirectional composites:prediction of strength, stiffness, factors influencing strength & stiffness, failuremodes, analysis of lamina; constitutive classical laminate theory, thermalstresses. Design consideration, analysis of laminates after initial failure,interlaminar stresses, fracture mechanics, joints, experimental characterization.Performance under adverse environment. **References/Text Books:**	COMPOSITE MATERIALS
AE683	3-0-0--4	#	**Course Contents:** Intro. to probability theory, random process. Excitation response relations forstationary random processessingle and multidegree of freedom system withlinear and nonlinear characteristics, continuous systems. Failure due to randomvibration, application to aero, civil & mechanical systems. **References/Text Books:**	RANDOM VIBRATIONS
AE683A	3-0-0-0-9		**Course Contents:** Intro. to probability theory, random process. Excitation response relations forstationary random processessingle and multidegree of freedom system withlinear and nonlinear characteristics, continuous systems. Failure due to randomvibration, application to aero, civil & mechanical systems. **References/Text Books:**	RANDOM VIBRATIONS
AE684	3-0-0--4	#	**Course Contents:** Definition of various terms used for classification of materials. Mechanicalproperties. Testing of aircraft materials. Classification of alloys of aluminium,steel, titanium etc. High temperature problems; aerodynamic heating, designconsiderations, ceramic coating etc. Plastics, fibrereinforced composites,transparent materials. **References/Text Books:**	AIRCRAFT MATERIALS AND PROCESSES
AE684A	3-0-0-0-9		**Course Contents:** Definition of various terms used for classification of materials. Mechanicalproperties. Testing of aircraft materials. Classification of alloys of aluminium,steel, titanium etc. High temperature problems; aerodynamic heating, designconsiderations, ceramic coating etc. Plastics, fibrereinforced composites,transparent materials. **References/Text Books:**	AIRCRAFT MATERIALS AND PROCESSES
AE685	3-0-0--4	#	**Course Contents:** Free and forced vibration of discrete multidegree of freedom systems with andwithout viscous damping; impulse and frequency response methods. Continuoussystems; natural modes, free & forced vibration. Random vibrations: intro. toprobability theory, random variables & processes, properties of random processes,response of system to random excitations **References/Text Books:**	DETERMINISTIC & RANDOM VIBRATION
AE685A	3-0-0-0-9		**Course Contents:** Free and forced vibration of discrete multidegree of freedom systems with andwithout viscous damping; impulse and frequency response methods. Continuoussystems; natural modes, free & forced vibration. Random vibrations: intro. toprobability theory, random variables & processes, properties of random processes,response of system to random excitations **References/Text Books:**	DETERMINISTIC & RANDOM VIBRATION

AE686	3----4		**Course Contents:** Historical development, configurations of helicopters, rotor system, flight controlmechanism, momentum theory and blade element theory in hover, vertical flightand forward flight. Idealization of rotor blades, Flaplag and torsional dynamicsof the blade. Trim and equilibrium analysis, aeroelastic stability of rotor blades.Flappitch, lagpitch and flaplag coupling, simple model of rotor fuselagedynamics, longitudinal and lateral stability and control of helicopters. **References/Text Books:**	HELICOPTER THEORY : DYNAMICS AND AEROELASTICITY
AE686A	3-0-0-0-9		**Course Contents:** Historical development, configurations of helicopters, rotor system, flight controlmechanism, momentum theory and blade element theory in hover, vertical flightand forward flight. Idealization of rotor blades, Flaplag and torsional dynamicsof the blade. Trim and equilibrium analysis, aeroelastic stability of rotor blades.Flappitch, lagpitch and flaplag coupling, simple model of rotor fuselagedynamics, longitudinal and lateral stability and control of helicopters. Course Reference : **References/Text Books:**	HELICOPTER THEORY : DYNAMICS AND AEROELASTICITY
AE687	3-0-0--4		**Course Contents:** General loads on aircraft, load factor, Vn diagram, effect of gust loading. Energyprinciples, potential and complementary potential; deflection analysis,indeterminate structures. Analysis of plates, Kirchhoff and first order sheardeformation plate theories, buckling of plates, buckling of stiffened plates, localbuckling of composite shapes. **References/Text Books:**	AEROSPACE STRUC ANALYSIS II
AE687A	3-0-0-0-9		**Course Contents:** General loads on aircraft, load factor, Vn diagram, effect of gust loading. Energyprinciples, potential and complementary potential; deflection analysis,indeterminate structures. Analysis of plates, Kirchhoff and first order sheardeformation plate theories, buckling of plates, buckling of stiffened plates, localbuckling of composite shapes. **References/Text Books:**	AEROSPACE STRUC ANALYSIS II
AE688	3-0-0--4		**Course Contents:** Rigid body dynamics: Newtons second law, impulse and momentum, momentof a force and angular momentum, work and energy, system of particles, rigidbodies, Eulers equations. Analytical mechanics: degrees of freedom, generalizedcoordinates, virtual work, Hamiltons principle, Lagranges equations. Linearsystem theory: frequency response, transform methods, transfer function,transition matrix, Eigen value problem, Modal analysis. Lumped parametersystems: single degree of freedom system, two degrees of freedom system,multiple degrees of freedom system. Continuous system: introduction, longitudinal,transverse and torsional vibrations of slender members. **References/Text Books:**	DYNAMICS AND VIBRATION
AE688A	3-0-0-0-9		**Course Contents:** Rigid body dynamics: Newtons second law, impulse and momentum, momentof a force and angular momentum, work and energy, system of particles, rigidbodies, Eulers equations. Analytical mechanics: degrees of freedom, generalizedcoordinates, virtual work, Hamiltons principle, Lagranges equations. Linearsystem theory: frequency response, transform methods, transfer function,transition matrix, Eigen value problem, Modal analysis. Lumped parametersystems: single degree of freedom system, two degrees of freedom system,multiple degrees of freedom system. Continuous system: introduction,	DYNAMICS AND VIBRATION

			longitudinal,transverse and torsional vibrations of slender members. **References/Text Books:**	
AE689	3-0-0-0-4		**Course Contents:** Introduction to smart materials, piezo, pyro and ferro electric effects; hysteresiseffects:electric field in solids: fundamentals of continuum mechanics; basicconservation laws; thermodynamic principles; constitutive modelling for smartmaterials; electrothermoelastic formulation and analysis of smart structures;control of smart structures; applications to aerospace vehicles. **References/Text Books:**	INTRODUCTION TO THE THEORY OF SMART STRUCTURES
AE689A	3-0-0-0-9		**Course Contents:** Introduction to smart materials, piezo, pyro and ferro electric effects; hysteresiseffects:electric field in solids: fundamentals of continuum mechanics; basicconservation laws; thermodynamic principles; constitutive modelling for smartmaterials; electrothermoelastic formulation and analysis of smart structures;control of smart structures; applications to aerospace vehicles. **References/Text Books:**	INTRODUCTION TO THE THEORY OF SMART STRUCTURES
AE690	3-0-0--4	#	**Course Contents:** Nature of high temperature flows, perfect and real gas, Gibbs free energy andentropy production, microscopic description of gases, thermodynamic properties,equilibirum properties kinetic theory, inviscid high temp. equilibrium and nonequilibriumflow, transport properties **References/Text Books:**	HIGH TEMPERATURE GAS DYNAMICS
AE690A	3-0-0-0-9		**Course Contents:** Nature of high temperature flows, perfect and real gas, Gibbs free energy andentropy production, microscopic description of gases, thermodynamic properties,equilibirum properties kinetic theory, inviscid high temp. equilibrium and nonequilibriumflow, transport properties **References/Text Books:**	HIGH TEMPERATURE GAS DYNAMICS
AE692	3-0-0-0-4		**Course Contents:** Definition of large deformation of structures as large deflection, large rotation with small strains.Linear and nonlinear structural responses. Theory of elastica with exact and numerical solutions.Elements of large deformation mechanics: Reference and deformed configurations, Lagrangestrain, Cauchy and PiolaKirchoff stress, work conjugate stress and strain measures. Governingequations in strong and weak form. Hyperelastic material constitutive law. Incrementalnumerical solution oflarge deformation boundary value problems: tangent stiffness, explicit andimplicit methods, NewtonRaphson method. Elastic and geometric stiffness. Total Lagrangianmethod. Corotational scheme. **References/Text Books:** * JamesF. Doyle. Nonlinear analysis of thin walled structures. Springer Verlag. 2001 .* M. A. Crisfield. Nonlinear finite element analysis of solids and structures. Vols. I and II. JohnWiley& Sons. 1991 .* M.A. Biot. Mechanics of incremental deformations. John Wiley& Sons. 1965.	MECHANICS OF HIGHLY DEFORMABLE STRUCTURES
AE692A	3-0-0-0-9		**Course Contents:** Definition of large deformation of structures as large deflection, large rotation with small strains.Linear and nonlinear structural responses. Theory of elastica with exact and numerical solutions.Elements of large deformation mechanics: Reference and deformed configurations, Lagrangestrain, Cauchy and PiolaKirchoff stress, work conjugate stress and strain measures. Governingequations in strong and weak form. Hyperelastic	MECHANICS OF HIGHLY DEFORMABLE STRUCTURES

			material constitutive law. Incrementalnumerical solution oflarge deformation boundary value problems: tangent stiffness, explicit andimplicit methods, NewtonRaphson method. Elastic and geometric stiffness. Total Lagrangianmethod. Corotational scheme. **References/Text Books:** Course Reference : * JamesF. Doyle. Nonlinear analysis of thin walled structures. Springer Verlag. 2001 .* M. A. Crisfield. Nonlinear finite element analysis of solids and structures. Vols. I and II. JohnWiley& Sons. 1991 .* M.A. Biot. Mechanics of incremental deformations. John Wiley& Sons. 1965.	
AE694A	3-0-0-0-9		**Course Contents:** Itroduction to the course. Fundamentals of acoustics: Derivation of wave equation, speed of sound, harmonic waves, acoustic energy/intensity, decibel scale, acoustic impedance, reflection and transmission at the interface of two media. Wave propagation: Rectangular and circular ducts, cutoff frequency, free field propagation. Acoustics of resonantors: Travelling and standing waves, boundary conditions, eigenfrequency and eigenmodes, effects of area variation, reflection and transmission of waves in pipes. Acoustic sources: Inhomogeneous wave equation, acoustic sources: monopole, bipole & quadrupole sources, acoustic reciprocity, aeroacoustic analogies. Attention of sound: Viscous and thermal conduction losses, absorption coefficient, sound absorption in pipes. Application of principles of acoustics: Aeroacoustic jet noise, combustion instability noise. **References/Text Books:** 1. Lawrence E. Kinsler, Austin R. Frey, and Alan B. Coppens, 2000. Fundamentaals of acoustics, 4th edn. JohnWiley & Sons, Inc. 2. Philip M. Morse and K. Uno Ingard, 1986. Fundamentals of acoustics. 1st edn. Priceton University Press. 3. S.W. Rienstra & A. Hirschberg, 2000. An introduction to acoustics. http://www.win.tue.nl/sjoerder/papers/boek.pdf 4. S.W. Rienstra & A. Hirschberg, 2004. An introduction to aeroacoustics. http://www.win.tue.nl/sjoerder/papers/lesswrmh.pdf	ACOUSTICS IN FLUIDS
AE696	3----4	#	**Course Contents:** Need and objective, fundamentals of fluid mechanics, wind tunnels, visualization,HWA, pressure and noise measurements, temperature, wall shear stress, flowmeasurements, geophysical flows, spin up and spin down, data acquisition andprocessing, uncertainty analysis. **References/Text Books:**	INSTRUMENTATION, MEASUREMENTS AND EXPERIMENTS IN FLUIDS
AE696A	3-0-0-0-9		**Course Contents:** Need and objective, fundamentals of fluid mechanics, wind tunnels, visualization,HWA, pressure and noise measurements, temperature, wall shear stress, flowmeasurements, geophysical flows, spin up and spin down, data acquisition andprocessing, uncertainty analysis. **References/Text Books:**	INSTRUMENTATION, MEASUREMENTS AND EXPERIMENTS IN FLUIDS
AE698	2-0-3-0-4		**Course Contents:** Introduction to VI, typical applications, functional systems, graphical programming,data flow techniques, advantages of VI techniques. VI programming techniques;VIs and subVIs, loops and charts, arrays, clusters and graphs, case and sequencestructures, formula nodes, string and file I/O, DAQ methods, code interfacenodes and DLL links. Sensors, transducers and signal conditioning; commontransducers for displacement, temperature, load, pressure, flow etc. Singleended, floating and differential inputs, grounding, noise and filtering. Dataacquisition basics; AD DAC, DIO, counters and timers, PC Hardware structure,timing, interrupts, DMA, operating system, PCI buses. Bus based instrumentation;instrumentation buses, GPIB, RS232C. **References/Text Books:**	INTRO TO VIRTUAL INSTRUMENTATION

AE698A	2-0-3-0-9		**Course Contents:** Introduction to VI, typical applications, functional systems, graphical programming,data flow techniques, advantages of VI techniques. VI programming techniques;VIs and subVIs, loops and charts, arrays, clusters and graphs, case and sequencestructures, formula nodes, string and file I/O, DAQ methods, code interfacenodes and DLL links. Sensors, transducers and signal conditioning; commontransducers for displacement, temperature, load, pressure, flow etc. Singleended, floating and differential inputs, grounding, noise and filtering. Dataacquisition basics; AD DAC, DIO, counters and timers, PC Hardware structure,timing, interrupts, DMA, operating system, PCI buses. Bus based instrumentation;instrumentation buses, GPIB, RS232C. **References/Text Books:**	INTRO TO VIRTUAL INSTRUMENTATION
AE699	0-0-0-0-0		**Course Contents:** Units : As arranged **References/Text Books:**	M TECH THESIS
AE699.	0-0-0--9		**Course Contents:** M TECH THESIS (FOR DUAL DEGREE ONLY) **References/Text Books:**	M TECH THESIS (FOR DUAL DEGREE ONLY)
AE701	3-0-0--4		**Course Contents:** Overview of nonlinear problems in structural analysis geometric and materialnonlinearities, non linear forces and boundary conditions; nature of forcedeflectioncurves, critical points. Single degree of freedom system withgeometric non linearity Incremental solution, iterative solution using directand Newton Raphson approaches; combined incremental and iterativesolution with full or modified Newton Raphson or initial stress method. One dimensional continuum problem: Axial bar under compression, variousstrain measures, weak and variational formulations based on Green strainmeasure. l D Finite element formulation : Total and Updated Lagrangianapproaches : derivation of stiffness and tangent stiffness matrices, limitpoint and bifurcation; traversal of critical points. Two dimensional problems: Strain measures in two and three dimensions, stress measures (Cauchyand Piola Kirchhoff), objectivity, Updated Lagrangian formulation stressincrements. 2D Incremental formulation with updates, derivation ofstiffness and tangent stiffness matrices. Advanced Solution Procedures:Line search, arc length quasi Newton and Secant methods. NonlinearDynamics: Direct Integration techniques : explicit and implicit solutiontechniques. Stability of time integration schemes. Newmarks scheme. The method; energy conserving and automatic time stepping methods. **References/Text Books:** (1) Nonlinear finite element analysis of solids and structures, Vols. I and II, M.A. Crisfield,John Wiley and Sons (1994).(2) Finite Element Procedures, K.J. Bathe, Prentice Hall (1996).(3) Suggested journal papers	NONLINEAR FINITE ELEMENT METHOD
AE701A	3-0-0-0-9		**Course Contents:** Overview of nonlinear problems in structural analysis geometric and material nonlinearities, non linear forces and boundary conditions; nature of forcedeflectioncurves, critical points. Single degree of freedom system withgeometric non linearity Incremental solution, iterative solution using directand Newton Raphson approaches; combined incremental and iterativesolution with full or modified Newton Raphson or initial stress method. One dimensional continuum problem: Axial bar under compression, variousstrain measures, weak and variational formulations based on Green strainmeasure. l D Finite element formulation : Total and Updated Lagrangianapproaches : derivation of stiffness and tangent stiffness matrices, limitpoint and bifurcation; traversal of critical points. Two dimensional problems: Strain measures in two and three dimensions, stress measures (Cauchyand Piola Kirchhoff), objectivity, Updated Lagrangian formulation stressincrements. 2D Incremental formulation with updates, derivation ofstiffness and tangent stiffness	NONLINEAR FINITE ELEMENT METHOD

			matrices. Advanced Solution Procedures:Line search, arc length quasi Newton and Secant methods. NonlinearDynamics: Direct Integration techniques : explicit and implicit solutiontechniques. Stability of time integration schemes. Newmarks scheme. The method; energy conserving and automatic time stepping methods. **References/Text Books:** Course Reference : (1) Nonlinear finite element analysis of solids and structures, Vols. I and II, M.A. Crisfield,John Wiley and Sons (1994).(2) Finite Element Procedures, K.J. Bathe, Prentice Hall (1996).(3) Suggested journal papers	
AE747	3-0-0-0-4		**Course Contents:** The molecular model; binary elastic collisions: basic kinetic theory; referencestates & boundary conditions; collisionless flow; transition regime flows. Directsimulation Monte Carlo method. One dimensional flows of a simple monatomicgas. Measurements in low density flows. **References/Text Books:**	MOLECULAR GAS DYNAMICS
AE747A	3-0-0-0-9		**Course Contents:** The molecular model; binary elastic collisions: basic kinetic theory; referencestates & boundary conditions; collisionless flow; transition regime flows. Directsimulation Monte Carlo method. One dimensional flows of a simple monatomicgas. Measurements in low density flows. **References/Text Books:**	MOLECULAR GAS DYNAMICS
AE751	3-0-0-0-4		**Course Contents:** Introduction to atomization, Physical processes in atomization, Types of atomizers,Classical Theories of atomization, Numerical modeling of atomization process,Theory of multiphase flows, Atomizer design: Single Fluid and Twin Fluid, SprayCharacterization Measurement techniques in Spray Characterization, Applicationsof Atomizers Metal forming Chemical Industry Combustion. **References/Text Books:**	FUNDAMENTALS OF LIQUID ATOMIZATION
AE751A	3-0-0-0-9		**Course Contents:** Course Details: Introduction to atomization, Physical processes in atomization, Types of atomizers,Classical Theories of atomization, Numerical modeling of atomization process,Theory of multiphase flows, Atomizer design: Single Fluid and Twin Fluid, SprayCharacterization Measurement techniques in Spray Characterization, Applicationsof Atomizers Metal forming Chemical Industry Combustion. **References/Text Books:**	FUNDAMENTALS OF LIQUID ATOMIZATION
AE752	3-0-0-4-4		**Course Contents:** a. Wave theory of sound: Plane waves, Harmonic waves and complex Algebra, Speed ofsound, Energy, Intensity and Power, Spherical wavesb. Quantitative measurement of sound: Frequency content and bands, Decibel scale,Multiple frequency signals, coherence, Frequency domain representation of transientsignalsc. Propagation of Plane waves: Reflection from a rigid surface, Propagation in a tube,Radiation due to waves on the wall, Oblique reflection and transmission at a planarinterfaced. Radiation from Vibrating Bodies: Oscillating spheres, Monopoles and Multipoles. **References/Text Books:**	PRINCIPLES OF ACOUSTICSV
AE752A	3-0-0-0-9		**Course Contents:** Wave theory of sound: Plane waves, Harmonic waves and complex Algebra, Speed ofsound, Energy, Intensity and Power, Spherical wavesb. Quantitative measurement of sound: Frequency content and bands,	PRINCIPLES OF ACOUSTICSV

			Decibel scale,Multiple frequency signals, coherence, Frequency domain representation of transientsignalsc. Propagation of Plane waves: Reflection from a rigid surface, Propagation in a tube,Radiation due to waves on the wall, Oblique reflection and transmission at a planarinterfaced. Radiation from Vibrating Bodies: Oscillating spheres, Monopoles and Multipoles. **References/Text Books:**	
AE753	3-0-0-0-4		**Course Contents:** Introduction to combustion : Types of flames, role of chemical kineticsChemical Kinetics : Formulation of chemical kinetics equations, reactionmechanisms, steady state approximation, Arrhenius Law : Formulation ofArrhenius law, Microscopic consideration of reaction rates. Explosions : Thermalexplosions, Chain branching explosions, Chemical equilibrium Conservationequations for reacting flows : Shvab Zeldovich formulation. Laminar premixedcombustion : Flame speed Thermal theory (Mallard and Le Chatellier), DiffusionTheory (Zeldovich, Frank Kamenstakii and Semenov), Flame stabilization,Quenchingt and Flammability limits micro combustion. Detonation andDeflagration : Chapman Hugoniot relations, Chapman Jouguet points Liminarnon premixed conbustion: Burke Schuman Analysis, Phenomenological AnalysisIgnition, Extinction and Flammability. Turbulet premixed combustion : Theories,Time and length scales, thin flame approach, stirred reactor. Turbulent nonpremixedcombustion : Conserved scalar approach, two variable approach,flamelet model, direct closure. **References/Text Books:**	THEORY OF COMBUSTION
AE753A	3-0-0-0-9		**Course Contents:** Introduction to combustion : Types of flames, role of chemical kineticsChemical Kinetics : Formulation of chemical kinetics equations, reactionmechanisms, steady state approximation, Arrhenius Law : Formulation ofArrhenius law, Microscopic consideration of reaction rates. Explosions : Thermalexplosions, Chain branching explosions, Chemical equilibrium Conservationequations for reacting flows : Shvab Zeldovich formulation. Laminar premixedcombustion : Flame speed Thermal theory (Mallard and Le Chatellier), DiffusionTheory (Zeldovich, Frank Kamenstakii and Semenov), Flame stabilization,Quenchingt and Flammability limits micro combustion. Detonation andDeflagration : Chapman Hugoniot relations, Chapman Jouguet points Liminarnon premixed conbustion: Burke Schuman Analysis, Phenomenological AnalysisIgnition, Extinction and Flammability. Turbulet premixed combustion : Theories,Time and length scales, thin flame approach, stirred reactor. Turbulent nonpremixedcombustion : Conserved scalar approach, two variable approach,flamelet model, direct closure. **References/Text Books:**	THEORY OF COMBUSTION
AE754	3-0-0-0-4		**Course Contents:** Introduction, Governing equations, Statistical description of turbulence, Turbulent scales andcorrelations, Reynoldsaveraged equations, Mixing, Flows with premixed and nonpremixedreactants, Numerical and experimental methods for reacting flows.Introduction Motivation and objective Governing equationsTurbulence Introduction Turbulent scales Spatial and temporal correlations Reynoldsaveraged equations Wallbounded shear flows Free shear flows Statistical descriptionTurbulence modeling and Mixing Introduction Turbulence modeling Molecular mixing Turbulent mixing Reactiondiffusion systemsFlows with premixed and nonpremixed reactants Introduction to premixed and nonpremixed mixtures Moment methods Wellstirred reactor Conserved scale methodsNumerical and experimental methods for Reacting flows Combustion CFD Numerical solvers for stiff differential equations General concepts about experimental methods Measurement techniques **References/Text Books:** * A first course in Turbulence, Tennekes and Lumley* An introduction to combustion, Stephen Turns* Turbulent Combustion, N. Peters* Combustion Theory, F. Williams* Theoretical and Numerical Combustion, Poinsot and Veynante	TURBULENT COMBUSTION

AE754A	3-0-0-0-9		**Course Contents:** Introduction, Governing equations, Statistical description of turbulence, Turbulent scales andcorrelations, Reynoldsaveraged equations, Mixing, Flows with premixed and nonpremixedreactants, Numerical and experimental methods for reacting flows.Introduction Motivation and objective Governing equationsTurbulence Introduction Turbulent scales Spatial and temporal correlations Reynoldsaveraged equations Wallbounded shear flows Free shear flows Statistical descriptionTurbulence modeling and Mixing Introduction Turbulence modeling Molecular mixing Turbulent mixing Reactiondiffusion systemsFlows with premixed and nonpremixed reactants Introduction to premixed and nonpremixed mixtures Moment methods Wellstirred reactor Conserved scale methodsNumerical and experimental methods for Reacting flows Combustion CFD Numerical solvers for stiff differential equations General concepts about experimental methods Measurement techniques **References/Text Books:** * A first course in Turbulence, Tennekes and Lumley* An introduction to combustion, Stephen Turns* Turbulent Combustion, N. Peters* Combustion Theory, F. Williams* Theoretical and Numerical Combustion, Poinsot and Veynante	TURBULENT COMBUSTION
AE777	3-0-0-0-4		**Course Contents:** 1. Control Systems (Basic definitions, notation, tracking systems.)2. Guidance and navigation(Basic concepts, linear regulation and tracking, proportional navigation, crossproduct steering). 3. Optimal control techniques (Multivariable optimization, constrained minimization, optimal control of dynamic systems, Hamiltonian and the minimum principle, HamiltonJacobiBellman formulation, endpoint constraints, EulerLagrange formulation, twopoint boundaryvalue solution techniques, optimal terminal control with interior constraints, singular control, neighbouring extremals, linear optimal control, stochastic systems, Kalman filtering, LQG/LTR and Hinfinity robust optimal control.) 4. Optimal guidance and control of rocket flight (Terminal guidance of interceptors, nonplanar tracking systems (3DPN),Goddards problem, 2PBVP solutions for gravityturn trajectories, attitude autopilots, pitch maneuver control of launch vehicles.) 5. Optimal spacecraft navigation and control (Introduction to orbital mechanics, HillClohesseyWiltshire model, autonomous rendezvous and docking, minimum energy transfer, Lamberts problem, optimal guidance of reentry vehicles, nonplanar orbital regulation, optimal threeaxis control by thrusters, reaction wheels and control moment gyros.) **References/Text Books:** 1. Tewari, A., Advanced Control of Aircraft, Spacecraft, and Rockets, John Wiley &Sons, Chichester, 2011.References:1. Tewari, A., Atmospheric and Space Flight Dynamics, Birkhuser, Boston, 2006.2. Bryson, A.E., Jr., and Ho, Y.C., Applied Optimal Control. Hemisphere, 1975.3. Athans, M., and Falb, P.L., Optimal Control. Dover, 2007.	OPTIMAL SPACE FLIGHT CONTROL
AE777A	3-0-0-0-9		**Course Contents:** 1. Control Systems (Basic definitions, notation, tracking systems.)2. Guidance and navigation(Basic concepts, linear regulation and tracking, proportional navigation, crossproduct steering). 3. Optimal control techniques (Multivariable optimization, constrained minimization, optimal control of dynamic systems, Hamiltonian and the minimum principle, HamiltonJacobiBellman formulation, endpoint constraints, EulerLagrange formulation, twopoint boundaryvalue solution techniques, optimal terminal control with interior constraints, singular control, neighbouring extremals, linear optimal control, stochastic systems, Kalman filtering, LQG/LTR and Hinfinity robust optimal control.) 4. Optimal guidance and control of rocket flight (Terminal guidance of interceptors, nonplanar tracking systems (3DPN),Goddards problem, 2PBVP solutions for gravityturn trajectories, attitude autopilots, pitch maneuver control of launch vehicles.) 5. Optimal spacecraft navigation and control (Introduction to orbital mechanics, HillClohesseyWiltshire model, autonomous rendezvous and docking, minimum energy transfer, Lamberts problem, optimal guidance of reentry vehicles, nonplanar orbital regulation, optimal threeaxis control by thrusters, reaction wheels and control moment gyros.)	OPTIMAL SPACE FLIGHT CONTROL

			References/Text Books: Textbook:1. Tewari, A., Advanced Control of Aircraft, Spacecraft, and Rockets, John Wiley &Sons, Chichester, 2011.References:1. Tewari, A., Atmospheric and Space Flight Dynamics, Birkhuser, Boston, 2006.2. Bryson, A.E., Jr., and Ho, Y.C., Applied Optimal Control. Hemisphere, 1975.3. Athans, M., and Falb, P.L., Optimal Control. Dover, 2007.	
AE799	-0-0--		**Course Contents:** Units : As arranged **References/Text Books:**	PHD THESIS
ESO204	3-1-0-1-4		**Course Contents:** Free body diagram with examples on modelling of typical supports and joints,Conditions for equilibrium in 3D and 2D, Friction: limiting and nonlimiting cases; Forcedisplacementrelationship and geometric compatibility (for small deformations) with illustrations through simpleproblems on axially loaded members and thinwalled pressure vessels; Concept of stress at a point,Plane stress case: transformation of stresses at a point, principal stresses and Mohr's circle,Displacement field, Concept of strain at a point, Plane strain case: transformation of strain at a point,principal strains and Mohr's circle, Strain Rosette; Discussion of experimental results on 1D materialbehaviour, Concepts of elasticity, plasticity, strainhardening, failure (fracture/yielding), Idealization of1D stressstrain curve, Generalized Hooke's law (without and with thermal strains) for isotropicmaterials, Complete equations of elasticity; Force analysis (axial force, shear force, bending moment,and twisting moment diagrams) of slender members (singularity functions nat to be used); Torsion ofcircular shafts and thinwalled tubes (plastic analysis and rectangular shafts not to be discussed);Moment curvature relationship for pure bending of beams with symmetric crosssection, bending stress,shear stress (Shear centre and plastic analysis not to be discussed); Cases of combined stresses, Conceptof strain energy, Yield criteria; Deflection due to bending, Integration of the momentcurvaturerelationship for simple boundary conditions, Method of superposition (singularity functions not to beused); Strain energy and complementary strain energy for simple structural elements (those under axialload, shear force, bending moment, and torsion), Castigliano's theorems for deflection analysis andindeterminate problems; Concept of elastic instability, Introduction to column buckling, Euler's formula(postbuckling behaviour not to be covered) **References/Text Books:** * Crandall, S.H., Dahl, N.C., and Lardner, T. J., An Introduction to the Mechanics of Solids, McGrawHill,Second Ed. with 51 Units, 1978.* Beer, F.P, Johnston, E.R. and DeWolf, J.T., Mechanics of Materials, Tata McGrawHill Edition2004 * Meriam, J.L. and Kraige, L.G., Engineering Mechanics, Vol. 1: Statics, John Wiley,Second Ed. with 51 Units, 1980. * Popov, E.P., Engineering Mechanics of Solids, PrenticeHall, First Ed., 1990	MECHANICS OF SOLIDS
SE371	3-0-0--4		**Course Contents:** Basics of Computing: discretization and numerical errors. ODEs and their computations. Stiff ODEs & parasitic error, solving stiff equation via orthogonolization and compound matrix method. Governing PDEs for scientific computing and their classification. Wave mechanics: hyperbolic and dispersive waves. Dispersion relation and spacetime resolution. Finite difference methods for wave equation. Discretization of spatial derivatives by polynomial expansion and operators explicit methods. Spectral theory of discrete computing: stability analysis; Theory of signal and error propagation; dispersion relation preservation (DRP) property. Finite difference methods (FDM) for wave equation. Designing high accuracy, high fidelity methods via error control as anoptimization problem. Spectral method visvis discrete computing methods:Aliasing error and focusing; Capturing discontinuities and Gibbs phenomenon; qwavesin computing. **References/Text Books:** Numerical Methods for Partial Differential Equations WF AmesFundamentals of Computational Fluid	FOUNDATION OF SCIENTIFIC COMPUTING

			Dynamics: T. K. Sengupta.Waves in Fluids M. J. LighthillComputational Aeroacoustics: M. J. Lighthill.Linear and Nonlinear Waves: G. B. Whitham.	
SE422	3-0-0-0-3		**Course Contents:** Basics of Computing: discretization and numerical errors. ODEs and their computations. Stiff ODEs & parasitic error, solving stiff equation via orthogonolization and compound matrix method. Governing PDEs for scientific computing and their classification. Wave mechanics: hyperbolic and dispersive waves. Dispersion relation and spacetime resolution. Finite difference methods for wave equation. Discretization of spatial derivatives by polynomial expansion and operators explicit methods. Spectral theory of discrete computing: stability analysis; Theory of signal and error propagation; dispersion relation preservation (DRP) property. Finite difference methods (FDM) for wave equation. Designing high accuracy, high fidelity methods via error control as anoptimization problem. Spectral method visvis discrete computing methods:Aliasing error and focusing; Capturing discontinuities and Gibbs phenomenon; qwavesin computing. **References/Text Books:** Numerical Methods for Partial Differential Equations WF AmesFundamentals of Computational Fluid Dynamics: T. K. Sengupta.Waves in Fluids M. J. LighthillComputational Aeroacoustics: M. J. Lighthill.Linear and Nonlinear Waves: G. B. Whitham.	FOUNDATION OF SCIENTIFIC COMPUTING
TA101A	2-0-3-0-9		**Course Contents:** Introduction to sketching; Principal views, principles ofdimensioning Introduction to computeraidedgraphics Missing view, sectional view and assembly drawings Overview of pictorial representation, and isometricdrawing in detail Perspective drawing Lines, planes, auxiliary view Relationship between lines and planes intersection oflines and planes Intersections of solids and development of lateral surfaces **References/Text Books:**	ENGINEERING GRAPHICS
***** Department of BSBE *****				
BSE100	1-0-0--0		**Course Contents:** Biology in the 21st Century The brave new world in the post genome era. Past,present and future of our society, industry and life style: impact of discoveriesand technological innovations in biology. Challenges and excitement of researchin biology and bioengineering. Bioengineering as an emerging science at theintersection of biology, engineering, physics and chemistry. Career opportunitiesin biotechnology, biomedical engineering, pharmaceutical industry, agrobiotechnologyand in the diverse areas of basic science and medical research.Emerging trends of collaboration between industry and academia for developmentof entrepreneurship in biotechnology. Lab tours. **References/Text Books:**	INTRODUCTION TO BIOLOGICAL SCIENCES & BIOENGG.
BSE211A	3-0-0-0-9		**Course Contents:** Animal Tissues & Organ Systems: Concept of self assembly, energy and evolution, Basicstructure of the cell, Organization of the cells to from different tissue systems, Assembly ofdifferent tissue system to form organ system, Crosstalk of different organ system to form adynamic living systemHomeostasis: Acid, Base, Salt, Concept of pH, Intracellular & extracellular fluid,ThermoregulationTransport Phenomenon: Energy dependent and energy independent transport of molecules ina systemNervous System: Organizational assembly of the nervous network in the body and its cross talkwith different organ systemSensory System: Basic anatomy of the different sensory system of the body, Signal receptionfrom the outside environment by these different sensory modalities and relaying the informationto the nervous systemEndocrine System: Outline of the different endocrine system in the body and their functioning,Cross talk between endocrine and nervous system in carrying out physiological functions Circulatory System and Blood: Network of the blood vessel in the body and their fine structuralmodifications, Composition of the circulating fluid: Blood,	ORGAN SYSTEM, PHYSIOLOGY AND ANATOMY

			Different between blood and plasma,Structure of the pumping station: the heart, Functioning of the heart, ECG recordings, Controlsystem of the heartImmune System and Lymphatic System: Basic concept of immunity, Classification of immunesystem, Basic functioning of different components of immune system, Basic concept oflymphatic system, Crosstalk between immune systemnervous system and endocrine systemMuscoskeletal System: Anatomy of the muscoskeletal system, Tissue organization of thebone, cartilage and muscle, Role of the muscoskeletal system in movementRespiratory System: Structure of the lungs, Process of gas exchange (C02 and 02) in thelunQs to provide oxygen rich blood to the bodyDigestive System: Anatomy of the digestive system, Functioning of the individual orga **References/Text Books:** Biology Eight Edition, N. A. Campbell & J. B. Reece (2008)	
BSE212	3-0-0--4		**Course Contents:** Genome as the store house of information, DNA as the carrier of encodedmessages. Genomic diversity across organisms as a source of embeddedintelligence in nature. Intracellular transmission of genetic messages and theircellular translation; Cellcell communication and feedback; Selective transmissionof genetic messages regulation of gene expression; logic of building body plansdevelopmental translation of encoded messages. Techniques of DNA manipulationand engineering. **References/Text Books:**	MOLECULAR BIOLOGY
BSE216	3-0-0--4		**Course Contents:** Properties of water, Acids, Bases and Buffers. First and Second law ofthermodynamics; Free energy as an indicator of spontaneity; Chemical Equilibria.Amino Acids of Proteins; Optical Activity. Primary Structure Determination; ThreeDimensional Structures of Proteins: Secondary Structure; Fibrous Proteins;Globular Proteins; Quaternary Structure. Polysaccharides; Glycoproteins. Lipidsand Membranes; Mechanisms of enzyme action; Substrate Specificity; Coenzymes;Regulation of Enzymatic Activity: enzyme kinetics, inhibition; effects of pH.Catalytic mechanisms, Biosynthesis of amino acids, lipids and nucleotides. **References/Text Books:**	BIOCHEMISTRY
BSE221A	3-0-0-0-9		**Course Contents:** Enzymes: Concepts, kinetics, catalytic strategies and regulation: Free energy as athermodynamic function, formation of transition states, The MichaelisMenten model, enzymeinhibitors, coenzymes, proteases, oxygen transport, hemoglobin, allostery, isozymesMetabolism basic concepts and design: Introduction, coupled reactions and interconnectivities.Glycolysis and Gluconeogenesis: Energy conversion pathways in organisms, control ofglycolytic pathway, synthesis of glucose from noncarbohydrate precursors, reciprocalregulation of gluconeogenesis and glycolysisThe citric acid Cycle: Pathway, control, source of biosynthetic precursors, glyoxylate cycle.Oxidative phosphorylation and electron transport chain: Mitochondrial membrane, electrontransfer, proton pumps and physical link to citric acid cycle, regulation of cellular machineryGlycogen metabolism: Interplay of enzymes, epinephrine and glucagon signaling, reciprocalregulation of glycogen breakdown and synthesis.Fatty acid Metabolism: Triacylglycerols as energy stores, stages of processing, pathways ofsynthesis and degradation, acetyl Coenzyme ASynthesis of the molecules of life : Nitrogen fixation, amino acid synthesis, feedback inhibition,pyrimidine and purine synthesis, salvage pathway, synthesis of lipids and steroids, regulationof cholesterol biosynthesisProtein Folding and turnover: Stability, pathways of folding, chaperones, proteasomes, aminoacid degradation, urea formation. **References/Text Books:** *Biochemistry by Jermy M Berg, John L Tymoczko and Luber! Stryer, Publisher: W. H. Freeman; Seventh Edition (December 24, 201 0).*Principles of Biochemistry by Albert Lehninger, David L Nelson, Michael M Cox , Publisher: W. H.Freeman; Fifth Edition (June 15, 2008).	BIOCHEMISTRY

BSE222A	3-0-0-0-9		**Course Contents:** energetics of microbial metabolism; transport phenomena; enzyme catalyzed reactions andprocesses; bioreactor design and applications; sterilization; instrumentation and control.Bioseparations and Bioprocesses: Downstream processing; matrix design; pretreatmentmethods; separation of cell biomass; adsorption; filtration, precipitations; affinity precipitations;column chromatography; plate theory and principles of chromatography; different types ofchromatography, polishingcrystallization, drying, separation case studies; process integration;bioprocess integration for efficient production and recovery, scaleup consideration, processmonitoring and process economics.Environmental Bioprocesses: Interaction of mixed microbial population; aerobic and anaerobicprocesses; applications; biological wastewater treatment, bioremediation.Enzyme Technology: Enzyme catalyzed reactions. Cell and Enzyme immobilization. Industrialapplications and case studies. **References/Text Books:** *Blanch, H. W. and Clark, D. S. "Biochemical Engineering". Marcel Dekker, Inc.* Bailey, J. E. and Ollis, D. F. "Biochemical Engieering Fundamentals". McGrawHill, Inc.,* Belter, P. A., Cussler, E. L. and Hu, W. S. "Bioseparations: Downstream Processing forBiotechnology", John Wiley & Sons* Desai, Mohamed. A. Downstream Processing of Proteins: Methods and Protocols. HumanaPress* Shuler, M. L. and Kargi, F. Bioprocess Engineering Basic Concepts* Amersham Biosciences literature notes on chromatography	BIOCHEMICAL ENGINEERING
BSE223A	1-0-6-0-9		**Course Contents:** Fundamentals of Biochemistry: This section will deal with the experiments which can be 20used to determine the biomolecules both quantitatively and qualitatively. Experimentrelated to SpectrophotometryBeer Lambert Law. Experiment describing the preparation ofstandard plot for model protein such as bovine serum albumin (BSA). Quantifying theunknown protein using spectrophotometric measurements by UV adsorption, Lowrymethod, dye binding method, Bicinchoninic acid (BCA) method. Analysis of the presenceof glucose and quantifying the concentration using Dinitrosalicylic acid (DNSA) method.Enzyme activity, Enzyme kinetics, Starch conversion to glucose by salivary amylase.Paranitrophenyl 13Dglucopyranoside (pNPG) assay for 13glucosidase. Analysis ofproteins by SDSPAGE.Biochemical Engineering Bioseparations and Bioprocesses:Experiments related to 20upstream processing and downstream processing. Fermentation and microbial massculture. Downstream processing; harvesting of cell mass and extraction of protein/enzyme(adsorption, filtration}, cell sonication, precipitation, column chromatography, columnregeneration, affinity column preparation, purification, protein and enzyme activitymeasurements, SDSPAGE analysis, data compiling. Ethanol Fermentation. Bioreactoroperation (25 Its), tangential/cross flow filtration for cell harvesting, computer simulation,mass transfer phenomenon and cell growth kinetics. **References/Text Books:** *Introductory Practical Biochemistry by S. K. Sawhney and Randhir Singh, Publisher: Alpha ScienceInternational, Ltd (August 1, 2005.* Protein Purification ApplicationsPractical Approach by Simon Roe Oxford University Press* Bioprocess EngineeringBasic concepts by Michael L. Shuler and Fikret Kargi* Practical notes issued in the lab	BIOCHEMISTRY & BIOCHEMICAL ENGINEERING LAB
BSE292	0-0-4--2		**Course Contents:** Use of Transgenic organisms in the study of gene expression methodology toobtain high affinity antibodies. **References/Text Books:**	BSBE LAB-I MOLECUTAR BIOLOGY
BSE301A	0-0-2-0-2		**Course Contents:** Essential elements of written communication: discussion of a topic, identification of thekey elements, clarity of the rationale in a scientific and technical work, elaboration oftechnical details, key elements and highlights of a finding/project, identification of whatanswers have been obtained, what remains to be answered. How to underscore thesignificance of a project/finding, and its larger meaning, conclusionsEssential elements of verbal communication: what communication skills interestsaudience, how to navigate through complex set of information, the art of displaying thekey messages, overcoming language barriers, translation of scientific	SCIENTIFIC & PROFESSIONAL COMMUNICATION

			message for thelay audience, making new ideas understandable, how to engage with the audience. **References/Text Books:**	
BSE311A	3-0-0-0-9		**Course Contents:** Molecular Genetic Techniques and Genomics: Genetic analyses of mutations to indentify and 9study genes; DNA cloning and characterization; Genome wide analyses of gene structure andgene expression; Inactivating the function of specific genes in eukaryotes; Identifying andlocating human disease genesMolecular Structure of Genes and Chromosomes: Chromosomal organization genes and non coding DNA; Mobile DNA; Structural organization of eukaryotic chromosomes; organelle DNAsTranscriptional Control of Gene Expression: Eukaryotic gene control and RNA polymerase; regulatory sequences in protein coding genes; activators and repressors of transcription;mechanism of transcription activation and repression.Posttranscriptional Gene Control: Processing of eukaryotic premRNA; transport across nuclear envelope; cytoplasmic mechanism of posttranscriptional control; processing of rRNAand !RNA, regulation of protein synthesis.Cell signalling: Signalling molecules and cell surface receptors; intracellular signal transduction; G protein coupled receptorsMembrane trafficking:Translocation of secretory proteins across the ER membrane; protein modifications, folding and quality control in the ER; export and sorting of proteins.Eukaryotic cell cycle: Biochemical and genetics studies on cell cycle; mechanisms regulating mitotic events; meiosis a special type of cell division. **References/Text Books:** *Molecular Cell Biology, by Lodish et al (5'" edition or recent), W.H. Freeman and Company, New York*Molecular Biology of the Cell, by Alberts et al (4'" edition or later), Garland Sciences, New York	MOLECULAR CELL BIOLOGY
BSE312A	1-0-6-0-9		**Course Contents:** Microbiology: Introduction to sterilization techniques and certain equipment used for 15sterilization or maintenance of a sterile environment e.g. the autoclave and the laminarflow hood. Learning the basic principles of making solutions used for microbiological andmolecular biological experiments, such as buffers, medium for microbial culture etc.Measurement of pH and introduction to the pH meter. Learning how to make liquid andsolid medium for microbial culture and the various techniques for growing microbialcultures in liquid and solid medium. Learning the principles and application of a basicstaining technique to identify bacterial subtypes e.g. Gram staining. Collection of soilsamples and water samples from different locations on campus for identification andquantification of bacteria in these samples through Gram staining and other techniquesusing McConkey's medium and Triplesugar iron medium. Learning the basic principles oflight microscopy and the observation of bacterial cells under a compound microscope. **References/Text Books:**	MOLECULAR BIOLOGY LAB
BSE314	3-0-0-0-4		**Course Contents:** Introduction to biomechanics. Biosensors, actuators and control. Analysis ofbiosystem as a flexible structure. Aerodynamics, hydrodynamics and locomotion.Biostatics and Biodynamics I Mechanics of motion, friction, fracture.Biodynamics II Work, energy and power. Biodynamics III. Fluid Mechanics Examples of Archimedes principles, Pascal Law, Bernoullis theory and the livingworld, Viscosity and turbulence, Human circulatory system. **References/Text Books:**	BIOMECHANICS
BSE321A	2-0-2-2-10		**Course Contents:** Part I Principles of Protein Structure from primary sequence to three dimensional structure.Elementary ideas of bonding and structure. The building blocks. Motifs of Protein structure.Prediction, design and engineering of protein structures.Part II The Structural Basis of Protein Function. Four fundamental biochemical functions ofproteins, Recognition, Complementarity and Active Sites. Flexibility and Protein Function,Location and nature of Binding Sites , Functional Properties of, Structural Proteins,	STRUCTURAL BIOLOGY

			Catalysis:Overview, ActiveSite Geometry, Proximity and GroundState Destabilization, Stabilization ofTransition States, ActiveSite Chemistry. Control of Protein Function. Mechanisms ofRegulation.Part Ill Determination of 3DStructures using Xray crystallography an overview of themethod. Laboratory experiments protein preparation for crystallization experiments, proteincrystallization, Evaluating the quality of crystals, Cryoprotecting crystals at low temperature fordata collection. Xray diffraction data collection and processing a demonstration session. **References/Text Books:** *Protein Structure and Function, By Gregory A Petsko and Dagmar Ringe, New Science Press.* Introduction to Protein Structure, Branden & Tooze, Garland Publishing.* Outline of Crystallography for Biologists, David Blow, Oxford University Press.	
BSE322	3-0-0--4	BSE212/BSE216	**Course Contents:** Biological Databases; Global and local alignment; pair wise and multiple sequencealignment; Pattern searching in DNA & Protein sequences; Alignment tools, BLAST,FASTA, phylogenetic prediction, evolutionary tree construction, gene predictionin prokaryotes, eukaryotes; Protein structure classification; Structure predictionfrom sequence features, Comparative genomics. **References/Text Books:**	STRUCTURAL BIOLOGY & BIOINFORMATICS
BSE322A	3-0-0-1-10		**Course Contents:** Introduction to bioinformatics, biological databases and their growth, Concept ofhomology and definition of associated terms, pairwise sequence alignment,dotmatrix plot, dynamic programming algorithm, global (NeedlemanWunsch) andlocal (SmithWaterman) alignments, BLASTScoring matrices (PAM and BLOSUM families), gap penalty, statisticalsignificance of alignment Multiple sequence alignment, Sumofpairs method, CLUSTAL W, Genetic AlgorithmPattern finding in protein and DNA sequencing, Gibbs Sampler, Hidden MarkovModel, Profile construction and searching, PSIBLASTIntroduction to phylogeny, maximum parsimony method, distance method(neighborjoining), maximumlikelihood methodGene prediction in prokaryotes and eukaryotes, homology and abinitio methodsGenome analysis and annotation, comparative genomics **References/Text Books:** *Bioinformatics: Sequence and Genome Analysis by David W. Mount, Cold Spring Harbor LaboratoryPress (2001)* Developing Bioinformatics Computer Skills by C. Gibas and P. Jam beck, 0' Reilly (2001)* Biological Sequence Analysis: Probabilistic models of proteins and nucleic acids by R. Durbin, S.Eddy, A. Krogh and G. Mitchison, Cambridge University Press (1998)	BIOINFORMATICS & COMPUTATIONAL BIOLOGY
BSE341	3-0-0--4		**Course Contents:** Fundamentals of Biochemical engineering: Stoichiometry and energetics ofmicrobial metabolism, Transport phenomena, Enzyme catalyzed reactions andprocesses, Bioreactor design and applications, Sterilization, Instrumentation andcontrol, Bioseparations and bioprocesses: Downstream processing characteristicsof biological materials, pretreatment methods; separation of cell biomass,adsorption, filteration, reverse osmosis, isoelectroc focusing, affinity basedseparation, polishingcrystallization, drying, case studies; Process integrationBioprocess integration for efficient production and recovery, scaleup consideration,process monitoring and process economics; Environmental bioprocesses Interaction of mixed microbial population, applications, biological wastewatertreatment, anaerobic, digesters, bioremediation **References/Text Books:**	BIOCHEMICAL ENGINEERING
BSE391	0-0-9--5		**Course Contents:** Estimation of proteins by UV, Bradford and Lowry methods. SDSPAGE separationof proteins Enzyme Kinetics Salivary amylase different pH buffers andtemperature Chromatography Ion exchange/ HPLC/ GC/affinity Determinationof molecular weights by Gel chromatography. Estimation of sugars/blood	BSBE LAB-II BIOCHEMISTRY & BIOCHEM. ENGG.

			cholesterolRespiration of mitochondria and oxidative phosphorylation. Bioreactors andbioprocess engineering use computer simulation to explore mass transferphenomena and cell growth kinetics. Bioseparation using smart polymers. Yeastantibody library screening use stateofart combinatorial library screeningmethodology to obtain high affinity antibodies. **References/Text Books:**	
BSE392	0-0-4--2		**Course Contents:** De novo protein design and artificial proteins: approaches used in designingand constructing novel proteins. Structure based drug design: Virtual screeningtechniques, designing pharmacaphore models, scoring function and their relevancein downsizing hit lists. Determination of Protein structure by Xray crystallography:protein purification, current methods in protein crystallization. Evaluating thequality of crystals, crystal freezing at low temperature for data collection. Ademonstration session on Xray diffraction data collection and processing.Bioinformatics Training with Insight Molecular modeling package, Exercisesinvolving homology modeling of protein structures, Pairwise and multiplesequence alignments using tools such as BLAST, FASTA, CLUSTAL and from GCGsuite of programs. **References/Text Books:**	BSBE LAB III STRUCTURAL BIOL. & BIOINFORMATICS
BSE398A	0-0-0-0-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UG PROJECT (UGP-I)
BSE399A	0-0-2-0-9		**Course Contents:** UG PROJECT (UGPII) **References/Text Books:**	UG PROJECT (UGP-II)
BSE411A	3-0-2-0-11		**Course Contents:** Types I Classes of Materials used in medicine: Polymers, Metals, Ceramics, Natural Materialsand Composites.Degradable polymers and their use in medicine: Polymers, Hydrogels, Silicone biomaterialsand medical fibers. Degradation of materials in the biological environment. Types of polymerdegradation. Influence of polymer properties on degradation. Influence of biologicalenvironment on polymer degradation.Biological testing of biomaterials: In vitro assessment of materials for tissue compatibility. Invivo assessment of tissue compatibility.Host reactions to biomaterials and their evaluations: The role of adsorbed proteins in tissueresponse to biomaterials. Cell, extracellular matrix, and tissue interactions with biomaterials.Inflammation, wound healing and foreign body response to biomaterials. Immune response toforeign materials. Toxicity, tumorigenesis and biomaterials.Specific examples of applications of biomaterials in medicine. **References/Text Books:** Biomaterial Science: An Introduction to Materials in Medicine. Second Edition. Edited by: Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons. Publisher: Elsevier Academic Press.	BIOMATERIALS
BSE412A	1-0-6-0-9		**Course Contents:** Synthesis of biomaterials: Nanomaterials fabrication1' Particles (electrospraying & single emulsion solvent evaporation)2. Fiber (electrospinning) systems.Synthesis of biomaterials: Micro/Macromaterials fabricationMicroporous polymeric hydrogel systems.Characterization of biomaterials: Morphology and size characterization (fibers, particlesand hydrogels) of fabricated samples using scanning electron microscopy (SEM).Characterization of biomaterials: Physical properties of fabricated samples (fibers andhydrogels) Mechanical properties using Bose Electroforce Mech. Testing System.Characterization of biomaterials: Physical properties of fabricated samples (hydrogels)Swelling kinetics.Blood: Blood collection, Blood count,	BIOMATERIAL, PHYSIOLOGY & BIO-MEMS LABORATORY

			Blood component separation (traditional methodsand modern biomaterials developed in BSBE like biofilters, cryogels and hydrogels),Microscopic analysis of blood components, Understanding blood clotting using differentbiomaterials developed in the department.Urine analysis, Fabricating an inhouse dialysis setup for blood purification usingavailable tools in the departmentBlood pressure measurement: Concept of diastolic and systolic pressure and how tomeasure blood pressure and pulse rate. **References/Text Books:**	
BSE441	3-0-0--4		**Course Contents:** Living body as an examples of finest designs for diverse activities, functionse.g., flying, swimming, reproduction, sensing, eating, etc. Evolution and naturalselection as the means of optimization of biological machines at diverse scales:molecular, cellular, organismal and population. Principles of micro and macroevolution. Theories of evolution and Darwanian selection. Principles of generatingdiverse body plan and design in nature. **References/Text Books:**	EVOLUTION OF BIOLOGICAL MACHINES
BSE452	3-0-0-0-4		**Course Contents:** Introduction to Materials Science: Bulk and surface properties of materials;Polymeric materials; synthesis, characterization, and fabrication methodsInert, biodegradable, hydrogels, Natural, Genetically engineered and Bioactive;Ceramics and glasses; Metals; Surface modification techniques. Biocompatibilityof Biomaterials: Protein structure, interaction of proteins with synthetic materialsCharacterization of cellmaterial interactions; inflammatory responses; acuteinflammation, chronic inflammation, foreign body response, assessment ofmaterial performance. **References/Text Books:**	BIOMATERIALS
BSE454	3-0-0-0-4		**Course Contents:** What is tissue engineering? Scope and objective of tissue engineering; Principlesof tissue engineering; Essential components of tissue engineering; MaterialsScience/Engineering aspects (degradable materials); Design and characterizationof scaffolds (porosity, mechanical strength and 3D architecture); Cell Biologyaspects (choice of cell type, progenitor cells and cell differentiations); Molecularbiology aspects (cell signaling moleculesgrowth factors, cell attachmentintegrins);Drug delivery in tissue engineering; Commercial developments of tissue engineering;Future of tissue engineering. **References/Text Books:**	INTRODUCTION TO TISSUE ENGG.
BSE491	0-0-6--4		**Course Contents:** Biomechanics: Human body motion analysis. Control of artificial arms/legs usingbiological principles. Rehabilitation applications of biomechanics. Biosensors andMEMS: Development of sensors for measuring pressure, temperature, force atthe fingertips and soles of the feet. Polymer spinners and micro lithography.Testing of synthetic materialsBiomaterials: Biodegradable polymers synthesis, fabrication test theircharacteristic, computational simulation of biomaterial for their mechanicalstrength, tissue compatibility and prosthetic devices. Modeling natural materiallike wood, bamboo, fishbone, plant stem etc.. Modeling human tissue and tissuebiomaterial interactions. **References/Text Books:**	BSBE LAB IV BIOMECHANICS & BIOMATERIALS
BSE498	0-0-0-0-5		**Course Contents:** PROJECT I **References/Text Books:**	PROJECT I

BSE498A	0-0-9-0-9		**Course Contents:** UG PROJECT (UGPIII) **References/Text Books:**	UG PROJECT (UGP-III)
BSE499	0-0-0-0-4		**Course Contents:** PROJECT II **References/Text Books:**	PROJECT II
BSE499A	0-0-0-0-9		**Course Contents:** UP PROJECT (UGP II) **References/Text Books:**	UNDER GRADUATE PROJECT II
BSE601	1-0-0-0-0		**Course Contents:** 1. CRITICAL READING : Context, How is the text argued, Central claims, Kinds of reasoning, Examine Evidence, Examine Interpretations, Evaluations,Limitation of study2. CRITICAL WRITING : Learning to write through building of arguments, Hypothesis building, Conference Abstracts, Manuscripts, Reviews / Book chapters / Books, Proposals,Patents.3.ORAL PRESENTATION : Conference, Scientific, Teaching, Popular, 4. ETHICS : Experimentation, Writing **References/Text Books:** No prescribed textbook.	PROFESSIONAL COMMUNICATION
BSE601A	1-0-0-0-0		**Course Contents:** 1. CRITICAL READING : Context, How is the text argued, Central claims, Kinds of reasoning, Examine Evidence, Examine Interpretations, Evaluations,Limitation of study2. CRITICAL WRITING : Learning to write through building of arguments, Hypothesis building, Conference Abstracts, Manuscripts, Reviews / Book chapters / Books, Proposals,Patents.3.ORAL PRESENTATION : Conference, Scientific, Teaching, Popular, 4. ETHICS : Experimentation, Writing **References/Text Books:** No prescribed textbook.	PROFESSIONAL COMMUNICATION
BSE602	2-0-0-0-0		**Course Contents:** Demonstration based course. Usage of different equipments will be demonstrated. **References/Text Books:** Demonstration based course. No text book.	LABORATORY METHODS
BSE602A	2-0-0-0-0		**Course Contents:** Demonstration based course. Usage of different equipments will be demonstrated. **References/Text Books:** Demonstration based course. No text book.	LABORATORY METHODS
BSE611	3-0-0-0-4		**Course Contents:** 1. Applications of spectroscopic and other techniques to the study of biomolecules: UVVis spectroscopy, Circular dichroism, Fluorescence, NMR, Mass, IR and Raman spectroscopy, XRay diffraction. 2. Analysis of Proteins: Electrophoretic separation of proteins (single dimension native and denaturing gels, 2D and digital electrophoretic analysis), detection (staining, blotting and immunedetection) specialized applications (in vitro synthesis of protein, labeling and Mass spectrometry), ultracentrifugation. 3. Techniques with Radioisotopes:	MODERN INSTRUMENTAL METHODS IN BIOLOGICAL SCIENCES

			Introduction Isotopes and Radioactivity Ionization Effects, Measurement Units, Measurement Techniques, Autoradiography, Biological Uses of Radioisotopes, Tracer Dilution Technique, Radioimmunoassay4. Cellular Imaging Techniques: Microscopy: Phase contrast, Fluorescence, Atomic Force and confocal. 5. Electron Microscopy: Negative staining, cryo EM, Transmission EM and Scanning EM **References/Text Books:**	
BSE611A	3-0-0-0-9		**Course Contents:** 1. Applications of spectroscopic and other techniques to the study of biomolecules: UVVis spectroscopy, Circular dichroism, Fluorescence, NMR, Mass, IR and Raman spectroscopy, XRay diffraction. 2. Analysis of Proteins: Electrophoretic separation of proteins (single dimension native and denaturing gels, 2D and digital electrophoretic analysis), detection (staining, blotting and immunedetection) specialized applications (in vitro synthesis of protein, labeling and Mass spectrometry), ultracentrifugation. 3. Techniques with Radioisotopes: Introduction Isotopes and Radioactivity Ionization Effects, Measurement Units, Measurement Techniques, Autoradiography, Biological Uses of Radioisotopes, Tracer Dilution Technique, Radioimmunoassay4. Cellular Imaging Techniques: Microscopy: Phase contrast, Fluorescence, Atomic Force and confocal. 5. Electron Microscopy: Negative staining, cryo EM, Transmission EM and Scanning EM **References/Text Books:**	MODERN INSTRUMENTAL METHODS IN BIOLOGICAL SCIENCES
BSE612	3-0-0-0-4		**Course Contents:** A. Introduction to biochemical engineering, bioprocesses, bioproducts and biochemical technology with specific examples Three lectures.B. Upstream process: Microbial, mammalian and plant systems for bioprocess technology. Sterilization. Stoichiometry and energetics of microbial metabolism. Transport phenomena Five lectures.C. Enzyme catalyzed reactions and processes. Cell and enzyme immobilization. Bioreactor design and applications. Instrumentation and control Six lectures. D. Downstream process: Bioseparations, characteristics of biological materials, pretreatment methods, separation of cell biomass, adsorption, filtration, centrifugation, precipitation and extraction Four lectures. E. Liquid chromatography principles, plate and rate theory, ion exchange, gel filtration, affinity chromatography, hydrophobic interaction and reverse phase chromatography Six lecturesF. Integrated bioprocesses Bioprocess integration for efficient production and recovery, expanded bed separations, affinity precipitations, aqueous twophase processes, monolithic chromatographic separations Six lectures. G. Polishing, crystallization, drying, scaleup consideration, process monitoring and process economics Three lecturesH. Environmental bioprocesses Interaction of mixed microbial population, biological wastewater treatment, anaerobic digesters, bioremediation Three lectures.I. Case studies and new developments of bioprocesses paper readings and presentations Four lectures **References/Text Books:** 1.Blanch, H. W. and Clark, D. S. Biochemical Engineering. Marcel Dekker, Inc., 2.Bailey, J. E. and Ollis, D. F. Biochemical Engieering Fundamentals. McGrawHill, Inc., 3.Belter, P. A., Cussler, E. L. and Hu, W. S. Bioseparations: Downstream Processing for Biotechnology, John Wiley & Sons 4.Desai, Mohamed. A. Downstream Processing of Proteins: Methods and Protocols. Humana Press5.Shuler, M. L. and Kargi, F. Bioprocess Engineering Basic Concepts	BIOCHEMICAL ENGINEERING
BSE612A	3-0-0-0-9		**Course Contents:** A. Introduction to biochemical engineering, bioprocesses, bioproducts and biochemical technology with specific examples Three lectures.B. Upstream process: Microbial, mammalian and plant systems for bioprocess technology. Sterilization. Stoichiometry and energetics of microbial metabolism. Transport phenomena Five lectures.C. Enzyme catalyzed reactions and processes. Cell and enzyme immobilization. Bioreactor design and applications. Instrumentation and control Six lectures. D. Downstream process: Bioseparations, characteristics of biological materials, pretreatment methods, separation of cell biomass, adsorption, filtration, centrifugation, precipitation and extraction Four lectures. E. Liquid chromatography principles, plate and rate theory, ion exchange, gel filtration, affinity chromatography, hydrophobic	BIOCHEMICAL ENGINEERING

			interaction and reverse phase chromatography Six lecturesF. Integrated bioprocesses Bioprocess integration for efficient production and recovery, expanded bed separations, affinity precipitations, aqueous twophase processes, monolithic chromatographic separations Six lectures. G. Polishing, crystallization, drying, scaleup consideration, process monitoring and process economics Three lecturesH. Environmental bioprocesses Interaction of mixed microbial population, biological wastewater treatment, anaerobic digesters, bioremediation Three lectures.I. Case studies and new developments of bioprocesses paper readings and presentations. **References/Text Books:** .Blanch, H. W. and Clark, D. S. Biochemical Engineering. Marcel Dekker, Inc., 2.Bailey, J. E. and Ollis, D. F. Biochemical Engieering Fundamentals. McGrawHill, Inc., 3.Belter, P. A., Cussler, E. L. and Hu, W. S. Bioseparations: Downstream Processing for Biotechnology, John Wiley & Sons 4.Desai, Mohamed. A. Downstream Processing of Proteins: Methods and Protocols. Humana Press5.Shuler, M. L. and Kargi, F. Bioprocess Engineering Basic Concepts	
BSE613	3-0-0--4		**Course Contents:** Introduction to Materials Science: Bulk and surface properties of materials; Polymeric materials; synthesis, characterization, and fabrication methods Inert, biodegradable, hydrogels, Natural, Genetically engineered and Bioactive; Ceramics and glasses; Metals; Surface modification techniques. Biocompatibility of Biomaterials: Protein structure, interaction of proteins with synthetic material; characterization of cellmaterial interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance. **References/Text Books:**	BIOMATERIALS
BSE613A	3-0-0-2-11		**Course Contents:** Introduction to Materials Science: Bulk and surface properties of materials; Polymeric materials; synthesis, characterization, and fabrication methods Inert, biodegradable, hydrogels, Natural, Genetically engineered and Bioactive; Ceramics and glasses; Metals; Surface modification techniques. Biocompatibility of Biomaterials: Protein structure, interaction of proteins with synthetic material; characterization of cellmaterial interactions; inflammatory responses; acute inflammation, chronic inflammation, foreign body response, assessment of material performance. **References/Text Books:**	BIOMATERIALS
BSE614	3-0-0-0-4		**Course Contents:** What is tissue engineering? Scope and objective of tissue engineering; Principles of tissue engineering; Essential components of tissue engineering; Materials Science/Engineering aspects (degradable materials); Design and characterization of scaffolds (porosity, mechanical strength and 3D architecture); Cell Biology aspects (choice of cell type, progenitor cells and cell differentiations); Molecular biology aspects (cell signaling moleculesgrowth factors, cell attachmentintegrins); Drug delivery in tissue engineering; Commercial developments of tissue engineering; Future of tissue engineering. **References/Text Books:**	TISSUE ENGINEERING
BSE614A	3-0-0-0-9		**Course Contents:** What is tissue engineering? Scope and objective of tissue engineering; Principles of tissue engineering; Essential components of tissue engineering; Materials Science/Engineering aspects (degradable materials); Design and characterization of scaffolds (porosity, mechanical strength and 3D architecture); Cell Biology aspects (choice of cell type, progenitor cells and cell differentiations); Molecular biology aspects (cell signaling moleculesgrowth factors, cell attachmentintegrins); Drug delivery in tissue engineering; Commercial developments of tissue engineering; Future of tissue engineering.	TISSUE ENGINEERING

			References/Text Books:	
BSE617	3-0-0-0-9		**Course Contents:** Physicochemical Principles of Drug Action; Partition Coefficients; ReceptorEffector Theories;Role of Second Messengers in Drug Action; Methods of Receptor Isolation,Characterization and Modeling (5)Principles of Drug Design: Random Screening, Analogue Synthesis, Rational Design,Combinatorial Libraries; Enantiopure Drugs and Regulatory Implications; TheoreticalApproaches: QSAR, Topliss Tree, MSA, CoMFA (2)Neuroactive Drugs: Neurons and Neurotransmitters; Brainrelated Disorders andChemotherapy; Drugs Interacting with Cholinergic, Adrenergic, Dopaminergic andHistaminic Receptors and Receptorsubtypes (5)Anticancer, Antimalarial, Antiviral, and Cardiovascular Drugs; Emerging Trends in DrugDesign: Inhibitors of DNA Topoisomerase and Protein Farnesylation & Prenylation; GeneBased Medicines (8)Biopharmaceuticals: Recombinant Proteins as Medicines and Vaccines (2)Drug Delivery: Passive, Assisted and VectorBased Delivery of Conventional and GeneticDrugs; TissueSpecific Delivery of Antitumor Agents (8)Drug Administration, Distribution, Metabolism and Elimination (ADME); Pathways of DrugMetabolism: Enzymology and Molecular Mechanisms; Detoxification of Diverse DrugClasses; Dose Formulation (10)Induction and Inhibition of Drug Metabolism; Toxicological Aspects of Metabolism: MetabolicActivation of Environmental Carcinogens and DNA Damage; Drug Pharmacokinetics andFinal Body Clearance (2) **References/Text Books:** 1. Medicinal Chemistry: A Biochemical Approach, Thomas Nogrady2. Principles of Medicinal Chemistry, William O. Foye3. The Pharmacological Basis of Therapeutics: Goodman and Gilman4. Introduction to Drug Metabolism, G. Gordon Gibson and Paul Skett	DRUG DESIGN AND METABOLISM
BSE621	3-0-0-0-4		**Course Contents:** Applications of spectroscopic and other techniques to the study of biomolecules:UVVis spectroscopy, Circular dichroism, Fluorescence, NMR, Mass, IR and Ramanspectroscopy, XRay diffraction. Cellular Imaging Techniques: Microscopy: Phasecontrast Nomarsky, Fluorescence, Atomic Force and confocal. Biophysical techniquesto purify and study proteins. Dialysis, salting out and precipitaion by organicsolvents, Ion exchange, gel filtration, reversed phase, affinity chromatography,ultracentrifugation, gel electrophoresis. Analysis of Proteins: Electrophoreticseparation of proteins (single dimension native and denaturing gels, 2D anddigital electrophoretic analysis), detection (staining, blotting and immunodetection)and purification (various chromatograpy, HPLC, immunoprecipitation)of proteins, and specialized applications (in vitro synthesis of protein, labeling,microsequence analysis, and Mas spectrometry) **References/Text Books:**	MODERN INSTRUMENTAL METHODS IN BIOLOGICAL SCIENCES
BSE621A	3-0-0-0-9		**Course Contents:** Applications of spectroscopic and other techniques to the study of biomolecules:UVVis spectroscopy, Circular dichroism, Fluorescence, NMR, Mass, IR and Ramanspectroscopy, XRay diffraction. Cellular Imaging Techniques: Microscopy: Phasecontrast Nomarsky, Fluorescence, Atomic Force and confocal. Biophysical techniquesto purify and study proteins. Dialysis, salting out and precipitaion by organicsolvents, Ion exchange, gel filtration, reversed phase, affinity chromatography,ultracentrifugation, gel electrophoresis. Analysis of Proteins: Electrophoreticseparation of proteins (single dimension native and denaturing gels, 2D anddigital electrophoretic analysis), detection (staining, blotting and immunodetection)and purification (various chromatograpy, HPLC, immunoprecipitation)of proteins, and specialized applications (in vitro synthesis of protein, labeling,microsequence analysis, and Mas spectrometry) **References/Text Books:**	MODERN INSTRUMENTAL METHODS IN BIOLOGICAL SCIENCES
BSE629	3-0-0-0-4		**Course Contents:** Cell and molecular biology of neurons. Membrane potential, local signaling andgeneration of action potential. Mechanism of synaptic transmission. Sensorypereception : Vision, hearing, taste, touch and smell.	NEUROBIOLOGY

			Movements : The motorsystems, reflexes, Voluntary control of motion etc. Functions of hypothalamuslimbic system and the Cerebral cortex learning and memory, sleep and dream. **References/Text Books:**	
BSE629A	3-0-0-0-9		**Course Contents:** Cell and molecular biology of neurons. Membrane potential, local signaling andgeneration of action potential. Mechanism of synaptic transmission. Sensorypereception : Vision, hearing, taste, touch and smell. Movements : The motorsystems, reflexes, Voluntary control of motion etc. Functions of hypothalamuslimbic system and the Cerebral cortex learning and memory, sleep and dream. **References/Text Books:**	NEUROBIOLOGY
BSE631	3-0-0--4		**Course Contents:** A. Protein structure and folding : Building blocks of biopolymers, conformational studies of biomolecules, Ramachandran map, protein secondary and supersecondary structures, different classes of tertiary structures, overview of different experimental techniques to determine biomolecular structures, intermolecular interactions, protein foldingB. Enzymes and the structurefunction relationship: Enzyme kinetics, structural basis of catalytic activity, MichaelisMenten kinetics, Enzyme inhibitors and complex reaction schemes, protein and RNA enzymes, basic concepts of metabolism and designC. Nucleic acid structures: Doublehelical structures of RNA and DNA, functional versatility of RNA, proteinDNA interactionsD. Membrane proteins: Lipids, bilayer assembly, biological membranes as solvent for membrane proteins, structural principles of membrane proteins, channels and receptors, signal transduction and GPCRs **References/Text Books:** The Molecules of Life: Physical and Chemical Principles. John Kurian, Boyana Konforti and David Wemmer, Garland Science, New York (2013)Biochemistry. L. Stryer W. H. Freeman & Company, New York (4th Edition)Introduction to Protein Structure. Carl Branden & John Tooze, Garland Science (2nd Edition)	BIOCHEMISTRY STRUCTURAL BIOLOGY
BSE631A	3-0-0-0-9		**Course Contents:** Basic concepts and historical account. Model systems. Animal body plan: Axesand germ layers. Organizers. Morphogenesis. Cell fate determination and celldifferentiation. Cellcell communication during development. Genes and development:gene expression and their regulation. Regeneration and aging. Environmentalregulation of animal development. **References/Text Books:**	BIOCHEMISTRY STRUCTURAL BIOLOGY
BSE632	3-0-0--4		**Course Contents:** Conformational studies of biomolecules, protein secondary structure, 3Dstructuresof proteins, DNA structures, membrane proteins. Xray and NMR techniques,electron crystallography, other spectroscopic techniques used to deduce structuralinformation (CD, IR, FTIR, Raman, Solid State NMR, ESR etc.), Homologymodeling, computational studies to understand the structurefunction relationshipsof proteins, molecular mechanics and dynamics, force fields, biomolecularsimulation programs. Structural genomics, highthroughput structuredetermination. **References/Text Books:**	STRUCTURAL BASIC OF PROTEIN FUNCTION
BSE632A	3-0-0-0-9		**Course Contents:** Conformational studies of biomolecules, protein secondary structure, 3Dstructuresof proteins, DNA structures, membrane proteins. Xray and NMR techniques,electron crystallography, other spectroscopic techniques used to deduce structuralinformation (CD, IR, FTIR, Raman, Solid State NMR, ESR etc.), Homologymodeling, computational studies to understand the structurefunction relationshipsof proteins,	STRUCTURAL BASIC OF PROTEIN FUNCTION

			molecular mechanics and dynamics, force fields, biomolecularsimulation programs. Structural genomics, highthroughput structuredetermination. **References/Text Books:**	
BSE633	2-0-0-0-4		**Course Contents:** Introduction to Molecular Genetics, The Human Genome Project, Biologicaldatabases, Gene prediction, Analysis of genomic sequences, Pair wise andmultiple sequence alignments, Bioinformatics tools, Hidden Markov Models,Conformational studies of biomolecules, Globular and membrane proteins, Proteinfolding problem, Homology modeling, Simulation studies of proteins and nucleicacids. **References/Text Books:**	BIOINFORMATICS AND COMPUTATIONAL BIOLOGY
BSE633A	3-0-0-0-9		**Course Contents:** Introduction to Molecular Genetics, The Human Genome Project, Biologicaldatabases, Gene prediction, Analysis of genomic sequences, Pair wise andmultiple sequence alignments, Bioinformatics tools, Hidden Markov Models,Conformational studies of biomolecules, Globular and membrane proteins, Proteinfolding problem, Homology modeling, Simulation studies of proteins and nucleicacids. **References/Text Books:**	BIOINFORMATICS AND COMPUTATIONAL BIOLOGY
BSE634	3-0-0--4		**Course Contents:** Introduction; The impact of genomics on biological research; Identification ofa large set of genes involved in a biological process; Highthroughput expressionanalysis; Genomewide search for interacting partners; Identification ofalternatively spliced genes; Sequence variations and disease susceptibility;Pharmacogenomics; Proteomics; Functional genomics in model organisms; Highthroughputphenotypic analysis; Recent developments in genomics. **References/Text Books:**	FUNCTIONAL GENOMICS
BSE634A	3-0-0-0-9		**Course Contents:** Introduction; The impact of genomics on biological research; Identification ofa large set of genes involved in a biological process; Highthroughput expressionanalysis; Genomewide search for interacting partners; Identification ofalternatively spliced genes; Sequence variations and disease susceptibility;Pharmacogenomics; Proteomics; Functional genomics in model organisms; Highthroughputphenotypic analysis; Recent developments in genomics. **References/Text Books:**	FUNCTIONAL GENOMICS
BSE636	2-0-0--4	BSE613/BSE212	**Course Contents:** Simple Mendelian traits; Lossoffunction mutations; Gainoffunction mutations;Gene interactions; Dynamic mutations; Genetics of neoplasia; Genomic imprintingand human disease; Xinactivation and DNA methylation; Gene mapping andpositional cloning; Mutifactorial inheritance; Genetics of behavioral disorders;Pharmacogenetics and biochemical genetics; Animal models in human genetics:Methods used for diagnosis and detection of gene mutations; Gene Therapy. **References/Text Books:**	HUMAN MOLECULAR GENETICS
BSE636A	3-0-0-0-9		**Course Contents:** Simple Mendelian traits; Lossoffunction mutations; Gainoffunction mutations;Gene interactions; Dynamic mutations; Genetics of neoplasia; Genomic imprintingand human disease; Xinactivation and DNA methylation; Gene mapping andpositional cloning; Mutifactorial inheritance; Genetics of behavioral disorders;Pharmacogenetics and biochemical genetics; Animal models in human genetics:Methods used for	HUMAN MOLECULAR GENETICS

			diagnosis and detection of gene mutations; Gene Therapy. **References/Text Books:**	
BSE651	3-0-0-0-4		**Course Contents:** A. Molecular Genetic Techniques and Genomics: Genetic analyses of mutations to indentify and study genes; DNA cloning and characterization; Genome wide analyses of gene structure and gene expression; Inactivating the function of specific genes in eukaryotes; Identifying and locating human disease genesB. Molecular Structure of Genes and Chromosomes: Chromosomal organization genes and noncoding DNA; Mobile DNA; Structural organization of eukaryotic chromosomes; organelle DNAsC. Transcriptional Control of Gene Expression: Eukaryotic gene control and RNA polymerase; regulatory sequences in protein coding genes; activators and repressors of transcription; mechanism of transcription activation and repression.D. Posttranscriptional Gene Control: Processing of eukaryotic premRNA; transport across nuclear envelope; cytoplasmic mechanism of posttranscriptional control; processing of rRNA and tRNA.E. Cell signalling: Signalling molecules and cell surface receptors; intracellular signal transduction; G protein coupled receptorsF. Membrane trafficking: Translocation of secretory proteins across the ER membrane; protein modifications, folding and quality control in the ER; export and sorting of proteins.G. Eukaryotic cell cycle: Biochemical and genetics studies on cell cycle; mechanisms regulating mitotic events; meiosis a special type of cell division. **References/Text Books:** Molecular Cell Biology, by Lodish et al (5th edition or recent), W.H. Freeman and Company, New YorkMolecular Biology of the Cell, by Alberts et al (4th edition or later), Garland Sciences, New York	CELLULAR MOLECULER BIOLOGY
BSE651A	3-0-0-0-9		**Course Contents:** A. Molecular Genetic Techniques and Genomics: Genetic analyses of mutations to indentify and study genes; DNA cloning and characterization; Genome wide analyses of gene structure and gene expression; Inactivating the function of specific genes in eukaryotes; Identifying and locating human disease genesB. Molecular Structure of Genes and Chromosomes: Chromosomal organization genes and noncoding DNA; Mobile DNA; Structural organization of eukaryotic chromosomes; organelle DNAsC. Transcriptional Control of Gene Expression: Eukaryotic gene control and RNA polymerase; regulatory sequences in protein coding genes; activators and repressors of transcription; mechanism of transcription activation and repression.D. Posttranscriptional Gene Control: Processing of eukaryotic premRNA; transport across nuclear envelope; cytoplasmic mechanism of posttranscriptional control; processing of rRNA and tRNA.E. Cell signalling: Signalling molecules and cell surface receptors; intracellular signal transduction; G protein coupled receptorsF. Membrane trafficking: Translocation of secretory proteins across the ER membrane; protein modifications, folding and quality control in the ER; export and sorting of proteins.G. Eukaryotic cell cycle: Biochemical and genetics studies on cell cycle; mechanisms regulating mitotic events; meiosis a special type of cell division. **References/Text Books:** Molecular Cell Biology, by Lodish et al (5th edition or recent), W.H. Freeman and Company, New YorkMolecular Biology of the Cell, by Alberts et al (4th edition or later), Garland Sciences, New York	CELLULAR MOLECULER BIOLOGY
BSE652	3-0-0--4		**Course Contents:** 1. Concepts in Developmental Biology :A. Axis specification and patterning SIX lecturesB. Cell fate Determination, Specification, Commitment, Differentiation, Proliferation Vs Differentiation, Induction, Competence, Lateral inhibition TEN lecturesC. Migration THREE lectures2. Methods of studying Developmental Biology :A. Classical techniques e.g. Cell labeling, grafting ONE lectureB. Candidate gene approach i. Saturated mutagenesis screens FOUR lectures ii. Lessons from other species/contexts FOUR lectures3. Development and disease SIX lectures4. Developmental mechanisms of evolutionary change SIX lectures	DEVELOPMENTAL BIOLOGY

			References/Text Books: Recommended Text Book Developmental Biology, Scott F. Gilbert Ninth Edition	
BSE652A	3-0-0-0-9		**Course Contents:** 1. Concepts in Developmental Biology :A. Axis specification and patterning SIX lecturesB. Cell fate Determination, Specification, Commitment, Differentiation, Proliferation Vs Differentiation, Induction, Competence, Lateral inhibition TEN lecturesC. Migration THREE lectures2. Methods of studying Developmental Biology :A. Classical techniques e.g. Cell labeling, grafting ONE lectureB. Candidate gene approach i. Saturated mutagenesis screens FOUR lectures ii. Lessons from other species/contexts FOUR lectures3. Development and disease SIX lectures4. Developmental mechanisms of evolutionary change **References/Text Books:** Recommended Text Book Developmental Biology, Scott F. Gilbert Ninth Edition	DEVELOPMENTAL BIOLOGY
BSE653	3-0-0-0-4		**Course Contents:** Introduction; The impact of genomics on biological research; Identification of a large set of genes involved in a biological process; Highthroughput expression analysis; Genomewide search for interacting partners; Identification of alternatively spliced genes; Sequence variations and disease susceptibility; Pharmacogenomics; Proteomics; Functional genomics in model organisms; High throughput phenotypic analysis; Recent developments in genomics. **References/Text Books:**	FUNCTIONAL GENOMICS
BSE653A	3-0-0-0-9		**Course Contents:** Introduction; The impact of genomics on biological research; Identification of a large set of genes involved in a biological process; Highthroughput expression analysis; Genomewide search for interacting partners; Identification of alternatively spliced genes; Sequence variations and disease susceptibility; Pharmacogenomics; Proteomics; Functional genomics in model organisms; High throughput phenotypic analysis; Recent developments in genomics. **References/Text Books:**	FUNCTIONAL GENOMICS
BSE654	3-0-0-0-4		**Course Contents:** Simple Mendelian traits; Lossoffunction mutations; Gainoffunction mutations;Gene interactions; Dynamic mutations; Genetics of neoplasia; Genomic imprintingand human disease; Xinactivation and DNA methylation; Gene mapping andpositional cloning; Mutifactorial inheritance; Genetics of behavioral disorders;Pharmacogenetics and biochemical genetics; Animal models in human genetics:Methods used for diagnosis and detection of gene mutations; Gene Therapy. **References/Text Books:**	HUMAN MOLECULAR GENETICS
BSE654A	3-0-0-0-9		**Course Contents:** Simple Mendelian traits; Lossoffunction mutations; Gainoffunction mutations;Gene interactions; Dynamic mutations; Genetics of neoplasia; Genomic imprintingand human disease; Xinactivation and DNA methylation; Gene mapping andpositional cloning; Mutifactorial inheritance; Genetics of behavioral disorders;Pharmacogenetics and biochemical genetics; Animal models in human genetics:Methods used for diagnosis and detection of gene mutations; Gene Therapy. **References/Text Books:**	HUMAN MOLECULAR GENETICS
BSE656	3-0-0-0-4		**Course Contents:** Cell and molecular biology of neurons. Membrane potential, local signaling andgeneration of action potential. Mechanism of synaptic transmission. Sensorypereception : Vision, hearing, taste, touch and smell. Movements : The motorsystems, reflexes, Voluntary control of motion etc. Functions of hypothalamuslimbic	NEUROBIOLOGY

			system and the Cerebral cortex learning and memory, sleep and dream. **References/Text Books:**	
BSE656A	3-0-0-0-9		**Course Contents:** Cell and molecular biology of neurons. Membrane potential, local signaling andgeneration of action potential. Mechanism of synaptic transmission. Sensorypereception : Vision, hearing, taste, touch and smell. Movements : The motorsystems, reflexes, Voluntary control of motion etc. Functions of hypothalamuslimbic system and the Cerebral cortex learning and memory, sleep and dream. **References/Text Books:**	NEUROBIOLOGY
BSE699	----		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M.TECH THESIS
BSE701	----0		**Course Contents:** Seminar **References/Text Books:**	SEMINAR
BSE702	----0		**Course Contents:** Seminar **References/Text Books:**	SEMINAR
BSE799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
ESO206A	3-0-0-0-9		**Course Contents:** Introduction to coordinate system and phase space, review of vectors and tensors, dynamics ofsystem of particles, steady mass flow and variable mass problems, coordinate transformationinvolving 3d rotations and the concept of angular velocity, kinematics of rigid bodies, kineticsof rigid bodies, general planar motions, general 3D motions, advanced examples. **References/Text Books:** (1) Engineering Mechanics, Dynamics, vol. 2, J.L. Meriam and L.G. Kraige.(2) Engineering Mechanics Dynamics, R.C. Hibbeler.(3) Engineering Mechanics, Den Hartog.(4) Principles of Dynamics, Donald T. Greenwood (Advanced Text).	PRINCIPLES OF BIOTECHNOLOGY
ESO219	3----4		**Course Contents:** Chemical Foundation for Cells : Carbon Compounds in Cells, Cell Structure andFunction. Principles of Cell structure and function : Cell Division and Mitosis,Meiosis. Flow of information : Chromosome and DNA, DNA to protein, Controlof genes, recombinant DNA and genetic engineering Tissue, Organs andHomeostasis Nervous Systems, Sensory Reception, Endocrine Control, Protection,Support, and Movement, Circulation, Immunity, Respiration, Digestion andHuman Nutrition, Reproduction and Development. Round Rules of Metabolism,How Cells Acquire Energy, and How Cells release stored energy. **References/Text Books:**	INTRODUCTION TO BIOLOGY
LIF101A	2-0-0-0-6		**Course Contents:**	INTRODUCTION TO

			Part I Principles of Cellular LifeEffects of waters polarity: importance of cohesion of water molecules for life; moderation of Earths temperature; Suitability of water as a solvent for life.Carbon and the molecular diversity of life.Polymer principles: most macromolecules of life are polymers; variety from a small set of monomers.Carbohydrates structure and functionProteins structure and functionLipids structure and functionNucleic acids structure and functionIntroduction to metabolism: pathways; energy transformation in organisms follow the laws of thermodynamics; life at the expense of free energy; enzymes as biocatalysts; regulation of metabolismB. Cell: Structural and functional unit of life (5 lectures)Structure: how we study cells; birds eye view of cell structure; subcellular structures; organelles; cytoskeleton; cell surface and junctionsMembrane structure and function; traffic across membranesCellular respiration; photosynthesis; cell communication; cell cyclePart II Principles of Inheritance: Information processing in living systemsIntroduction to heredity: inheritance of chromosomes; comparison of asexual and sexual reproduction; meiosis and sexual life cycles; origins of genetic variationMendels discoveries; extending Mendelian genetics; Mendelian inheritance in humanChromosomal basis of inheritance: Relating Mendels principles to chromosomes; Sex chromosomes and sexlinked inheritance; errors and exceptions in chromosomal inheritanceDNA as the genetic material; DNA replication and repairGene to protein: connection between genes and proteins; synthesis and processing of RNA; synthesis of proteinOrganization and control of prokaryotic genomesOrganization and control of eukaryotic genomes: chromatin structure; control of gene expressionDNA technology and genomics: DNA cloning; DNA analysis and genomics; practical applications of DNA technologyGenetic basis of development: single cell to multicellular organism; **References/Text Books:**	BIOLOGY
***** Department of CE *****				
CE213A	3-0-0-0-9		**Course Contents:** Introduction: Define environmental science as a subject that draws on learning's from natural sciences to investigathe human impact on the natural environment. Present concept of hydrosphere, atmosphere, biosphere, and ecosystem. Explain how the scientific method is used to investigate natural phenomena, particularly the inter relationships between organisms and among organisms and their environments. Water: Hydrologic Cycle and Water Bodies, Water Availability and Use, Water Pollution, Water Management. Environmental legislation and Policy Development: Examine the need and rationale for environmental legislation and the basis on which they are formulated. Air Pollution and Contrlo; : Classify sources and types of airpollution. Pollution monitoring setup including standards for regulated pollutants. Effect of pollution on human health. Noise Pollution and Control. Climate, Weather, and Air Pollution: Explain the components of the atmosphere and the processes that form climate and climate change. **References/Text Books:** Nazaroff, Jerald L. Environmental Engineering and Science, 2004, John Wiley & Sons, Inc. Environmental Science Towards a Sustainable Future by R.T. Wright and D.F. Boorse, PHI Learning. Environmental Science: Working with the Earth by Miller, G. Tyler, 11th Edition. Enger, Eldon D. and radley F. Smith. Environmental Science: A Study of Interrelationships, 12th edition, McGrawHill, 2009.	INTRODUCTION TO ENVIRONMENTAL SCIENCE
CE241A	3-0-0-0-9		**Course Contents:** Module 1: Description of Earth and environment. Earth and Environment Definition of environment; origin of earth, lithosphere, hydrosphere, atmosphere, biosphere. Earth structure, Plate Tectonics theory,Geomorphological features, Geological structures (folds, faults, discontinuity, dike); Engineering and Genetic classifiation of soils, Weathering and Soils; Rocks, rock ecycle, Igneous Rocks, Sedimentary Rocks, Metamorphic Rocks, Rock Properties, Rockwater interaction. Natural disasters: Cyclone, Tornado, Volcanic Eruption, Earthquakes Generation mechanism, different terminologies, earthquake monitoring and measurements, seismic region of the world, Tsunami, Land Slides; Sustainability and resilience for natural disasters. Hydrosphere; water cycle, surface and groundwater origin and its quality, occeans, ocean currents, ocean water quality.	SUSTAINABLE BUILT ENVIRONMENT

			References/Text Books: Loftness, V.; Haase, D. (Eds.) Sustainable Built Environments, Springer, 2013. Yao, R. (Ed). Design and Management of Sustainable Built Environments, Springer, 2013. Zetter, R.; Watson, G.B. (Eds.) Designing Sustainable Cities in the Developing World, Ashgate Publishing Ltd., 2006. Graham, P. Building Ecology, WileyBlackwell, 2002.	
CE242A	3-0-2-0-11		**Course Contents:** Earth System: Lithosphere, Hydrosphere, Cryosphere and atmosphere and theiriinteractionsSolid Earth : Shape, size, interior of the solid earth. Geological materials: rocks,soils, minerals (clay mineralogy), Engineering and Genetic classification of soils,rocks, rock cycle, rockwater interaction. Earth Processes and their consequences,Geomorphological features, structures (folds, faults)Earthquakes: Causes, classification, magnitude, intensity, Historical earthquakes,Seismic hazards zoning, strong ground motion, earthquake predictionLandslides and Subsidence: Causes, classification and monitoring;Groundwater: Groundwater resources and quality of ground waterGeology of India : Physiographic and fectonic divisions; Minral resources.Geophysical mapping: seismic, resistivity, radar, geotomography, loggingRemote sensing, GIS and GPS : Basic principles and their applications in monitoring Lithosphere, Hydrosphere, Cryosphere and Atmosphere; Criteria forsite selections for Dam, tunnels, waste/radioactive disposal sites **References/Text Books:**	CIVIL ENGINEERING MATERIALS
CE262A	2-0-2-0-8	ESO204A	**Course Contents:** Introduction. Review of the basic equations: continuity, momentum, and energy. Flow through closed conduits: Laminar flow, Turbulent flow, Pipes in Series and Parallel, Pipe Networks, Unsteady flow. Flow through openchannels: Uniform flow, Critical flow, Gradually Varied flow, Rapidly Varied flow, Spatially Varied flow, Unsteady flow. Flow Measurement:Pressure, Velocity and Discharge measurements. Forces on immersed bodies:Drag and Lift. Basics of Irrigation Engineering: Crop water requirements, Irrigation methods. **References/Text Books:**	ENGINEERING HYDRAULICS
CE272A	3-0-0-0-9	ESO202A	**Course Contents:** Stability and Determinacy of Structures. Review of shear force and bending moment diagrams in beams and frames. Plane trusses: method of joints and method of sections. Deflection of trusses: method of virtual work. Deflection of beams and frames: momentarea method, conjugate beam method, method of virtual work. Influence line diagrams and moving loads. Force and stiffness methods of analysis. Plane trusses by using method of consistent deformations. Beams and frames: method of consistent deformations, slopedeflection equation, moment distribution method. Plane trusses and beams by using direct stiffness method. **References/Text Books:** TEXT : Norris, C.H., Wilbur, J.B., and Utku, S., Elementary Structural Analysis, McGraw Hill, Hibbeler, R. C. (2002). Structural Analysis, 6/e, Pearson EducationREFERENCE : Hsieh, Y., Elementary Theory of Structures, PrenticeHall.Sack, R.L. (1989) Matrix Structural Analysis, Waveland Press, Inc.Wang, C.K., Intermediate Structural Analysis, McGrawHill.Wang, C.K., Statically Indeterminate Structures, McGrawHill.West, H.H., Analysis of Structures, John Wiley.	STRUCTURAL ANALYSIS
CE331A	3-0-2-0-11		**Course Contents:** Preview of Geotechnical Problems in Civil Engineering and InfrastructureDevelopment, Description of soil, Engineering geology of soils and theirformation, earthquakes and their effects, Stresses within a soil, effective stressprinciple, stress point and stress path, Soil water systems capillarity, flow,Darcys law, permeability, and tests for its determination, different heads,piping, quicksand condition, seepage, flownets, flow through dams, filters,Compressibility and consolidation characteristics, maximum past stress, OCR,determination of coefficients of consolidation and secondary compression(creep), consolidation under construction loading, Strength and direct and triaxialshear tests, Mohr Coulomb strength criterion, drained,	GEOINFORMATICS

			consolidated undrainedand undrained tests, strength of loose and dense sands, NC and OC soils, dilation,pore pressures, Skemptons coefficients, etc. Compaction characteristics, watercontent dry unit weight relationships, OMC, max. dry unit weight, fieldcompaction control, etc. Introduction to Geosynthetics, classification, functions,properties physical, mechanical, hydraulic, environmental, etc. Stability ofslopes, limit equilibrium methods, ordinary methods of slices and simplifiedBishop method, factors of safety. **References/Text Books:**	
CE332A	0-0-0-0-4	CE331A CE321A	**Course Contents:** Introduction, examples of foundation problems case studies, Characterisationof ground, site investigations, methods of drilling, sampling, in situ test SPT,CPT, plate load and dynamic tests, groundwater level, etc. Bearing capacity,general, local and punching shear failures, corrections for size, shape, depth,water table, compressibility, etc., ultimate and allowable stresses, methodsbased on in situ tests, Settlements of foundations, stress in soils (Boussinesq,Westergaard, Mindlin solutions), one and two dimensional cases, immediate,consolidation and creep settlements, methods based on in situ tests, Limit StateDesign, stability and serviceability states, load and strength factors, Types offoundations shallow/deep, isolated, combined, mat, etc., contact pressuredistributions, soil foundation interactions, basics of structural design, GroundImprovement Techniques, methods for difficult or problematic ground conditionssoftsoils, loose sands, seismic conditions, expansive or collapsible soils, etc.,preloading, vertical drains, stone columns, heavy tamping, grouting, etc. EarthPressure theories, Coulomb and Rankine approaches, cf soils, smooth and roughwalls, inclined backfill, depth of tension crack, Retaining structures, gravity,cantilever, counterfort, reinforced earth, etc., design and checks for stability,Deep foundations, piles, pile groups, well foundations, underreamed piles, precast,driven cast in situ and bored piles, shaft and base resistances, downdrag,pile load tests, Selected Topicsmachine foundations/introduction to environmentalgeotechnique/application of geosynthetics, etc **References/Text Books:**	SURVEY AND GEOLOGY CAMP
CE341A	0-0-2-0-2	COM200	**Course Contents:** CIVIL ENGINEERING COMMUNICATION SKILLS **References/Text Books:**	CIVIL ENGINEERING COMMUNICATION SKILLS
CE351A	2-0-2-0-8	CE242A ESO202A	**Course Contents:** Stresses within a soil, effective stress principle, stress point and stress path, Soil water systems capillarity, flow(4)Darcys law, permeability, and tests for its determination, different heads, piping, quicksand condition, seepage, flow nets(6)Compressibility and consolidation characteristics(4)Strength of loose and dense sands, NC and OC soils, dilation, pore pressures, Skemptons coefficients, etc.(10) Compaction characteristics, water content dry unit weight relationships, OMC, max. dry unit weight, field compaction control, etc.(2) **References/Text Books:** Craig RF., Craigs Soil Mechanics., 2004, Taylor and Francis, New York, USA.Das BM., Advanced Soil Mechanics., 2008, Taylor and Francis, New York, USA.LambeTW., and Whitman RV., Soil Mechanics., 2000, John Wiley and Sons (Asia), Singapore.	SOIL MECHANICS
CE352A	2-0-1-0-7	CE351A	**Course Contents:** Ideal and nonideal VLE (TxyPxy plots, Azeotrope): Computation of 2+2VLE data (Temperaturecomposition, Pressurecomposition plots) using (i)ideal mixture assumption and (ii) using various activity coefficient modelssuch as VanLaar model, UNIFAC etc. Special emphasis on VLE ofazeotropic mixtures. Examples: Benzeneethanol, Furfuralwater, benzenecyclohexanemixtures.Twofilm model for mass transfer between gas and Iiguid (e.g. C02 absorption using K2C03 solution, NH3 absorption in dilute acid solution) :Study of the absorption, reaction and diffusion processes in a contactreactor/bubble absorber/packed tower/plate column through the twofilmmodel. Formulation of the steadystate problem in terms of differentialequations for gas	FOUNDATION DESIGN

			and liquid phase species using Fick's law, the gasliquidequilibrium relations, and reaction rate expressions. Effect of limitingdiffusion and reaction steps. Numerical solution methods. **References/Text Books:** Introduction to chemical engineering computing by B. A. Finlayson; Indian edition by JohnWiley* Chemical Process Modelling and Computer Simulation by A. K. Jana; PHI learning, 2008* Luyben W.L.,Heuristic Design of Reaction/Separation Processes, Ind. Eng. Chern. Res., 49,11564 (2010).	
CE361A	2-0-0-0-6		**Course Contents:** Introduction: Hydrologic cycle, water budget, world waterquantitiesPrecipitation and Abstractions: Forms of precipitation, dataanalysis, raingauge networks; Infiltration process, infiltration indices and Horton's equation; Evaporation and Evapotranspiration Pan evaporation, empirical equations forestimating evaporation and evapotranspiration; TranspirationRunoff and Hydrographs: Rainfall runoff relations, time area concept, flow duration curve, mass curve, flow hydrograph, Unit Hydrograph (UH), its analysis, Scurve hydrographFloods and Routing: Concepts of return period, flood frequencyanalysis, Gumbel's and LogPearson TypeIII distributions,Rational method, risk, reliability, and safety factor; Hydrologicstorage routingGroundwater Hydrology: Types of aquifers and properties, Darcy's law, steady flow in a confined and unconfined aquifer _(_without recharge), steady flow to a well **References/Text Books:** I. Engineering Hydrology by K Subramanya, Tata McGraw Hill, New DeihL2. Applied Hydrology by V. T. Chow, David Maidment, and Larry Mays, TataMcGraw Hill, New Delhi, India.	ENGINEERING HYDROLOGY
CE371A	2-0-0-0-6	ESO202A	**Course Contents:** Steel structures, Limit states and design philosophy; partial safetyfactors and load combinations; Analysis and design methods; Design of tensionmembers based on net section including shear lag effects, staggered holes and blockshear; Design of compression members for flexural and flexuraltorsional buckling,Column formula, Local buckling and buckling class, End restraints and effectivelength factor; Role of plate buckling, Plastic hinge, Classification of section: plastic,compact, semicompact, slender, Design strength of laterally supported beams, Shearbuckling strength Postcritical method, Shearmoment interaction, Design strength oflaterally unsupported beams, Lateral torsional buckling, Effect of restraints andeffective length; Effect of axial load on flexure behaviour, Crosssection yielding andmember instability, PM interaction and moment amplification, Biaxial bending;Design of Bolts and Welds, Strength under combined stresses, Prying action,Common simple and eccentric joints and frame connections, Column bases. **References/Text Books:** Subramanian, N. (2008). Design of Steel Structures, OxfordUniversity Press.Bhavikatti, S. S. (20 10). Design of Steel Structures (by LimitState Method as Per IS: 8002007), IK International.Segui, W.T. (2007). Design of Steel Structures, CengageLearning	DESIGN OF STEEL STRUCTURES
CE372A	2-0-0-0-6	CE242A ESO202A	**Course Contents:** Reinforced concrete (RC) structures, Loadings, analytical models for analysis and design of RC structures, Design Methodologies: Working Stress Method and Limit State Method; Behaviour of RC members under flexure; Working stress design for common flexural members; Limit state design of beams and slabs (oneway and two way) for flexure; Singly and doubly reinforced sections; rectangular and flanged sections; S hear and torsion; Bond and anchorage; Short columns under axial compression, Short columns under axial compression with uniaxial bending, Short columns under axial compression with biaxial bending. Slender columns Types of footings; design of isolated / combined footing. **References/Text Books:** Text : Sinha, S.N., Reinforced Concrete Design, Tata McGraw HillPillai, S.U., and Menon, D., Reinforced Concrete Design, Tata McGraw Hill, 2009References : Nilson, A.H., and Winter, G., Design of Concrete Structures, McGraw Hill, New DelhiPark, R. and Paulay, T., Reinforced Concrete Structures, John	REINFORCED CEMENT CONCRETE DESIGN

			WileyFerguson, P.M., Bren, J.E. and Jirsa, J.O., Reinforced Concrete Fundamentals, John Wiley and Sons, New YorkMcGregor, J.M., Reinforced Concrete Mechanics and Design, Prentice Hall, New York	
CE373.	0-0-0--2	0	**Course Contents:** Survey Camp: Reconnaissance and establishing the stations; Base linemeasurements, Triangulation readings on various stations; computation andpreparation of triangulation map; contouring; preparation of map; preparationof report.Geology Camp: Reconnaissance of the area; Elementary geological field mappingof rock formations and structural details; Geomorphic processes Preparationof report. **References/Text Books:**	SURVEY AND GEOLOGY CAMP
CE382A	3-0-0-0-9	CE242A,CE351A	**Course Contents:** Introduction, transportation engineering elements, geometric design, traffic flow fundamentals, uninterrupted traffic flow, pavement analysis, highway maintenance. **References/Text Books:** *Chakraborty, P. and Das, A., "Principles of Transportation Engineering",Prentice Hall of India, 2003 *Garder, N.J. and Hoel, L.A., "Traffic & Highway Engineering", 3rd Ed.,Brooks/Cole, Pacific Grove, 2001 * McShane W.R, Roess R.P., Prassas, E.S., "Traffic Engineering", 2nd Ed.,Prentice Hall 1998	INTRODUCTION TO TRANSPORTATION ENGINEERING
CE412A	3-0-2-0-11	CE211A	**Course Contents:** Introduction and Scope; Analysis and Design of Water TreatmentSystems; Design of Water Distribution Networks; Analysis and Designof wastewater Collection Systems; Analysis and Design of Wastewater TreatmentSystems; Rural Water Supply and Sanitation; **References/Text Books:** Enviro11111ental Engineering. Authors: H. Peavy, D. Row and G. Tchobanoglous.Publisher: Tata McGrawHill.Water Supply and Pollution Control. Authors: Warren Viessman Jr. and Mark J.Hammer. 7'h Edition 2005. Publisher: Pearson Education (Indian Edition Available).Wastewater Engineering; Treatment, Disposal, Reuse. Editors: Metcalf & Eddy. 3'dEdition (1995). Publisher: Tala McGrawHill (Indian Edition Available).Additional class notes and reference material will be provided during lectures, eitherin softcopy or hardcopy f6m1s.	WATER SUPPLY AND WASTEWATER DISPOSAL SYSTEMS
CE451A	3-0-0-2-11	CE351A, CE352A	**Course Contents:** Earth and Earth retaining structures: Slope stability analysis, flexible and rigid retaining wall, gravity, cantilever, counter fort, reinforced earth etc., design and check for stability. Introduction to ground improvement techniques: methods for difficult or problematic ground conditions for soft clays, loose sands, expansive or collapsible soils etc., preloading, vertical drains, stone columns, heavy tamping, grouting etc., Machine foundation and design. **References/Text Books:** Das BM., Principles of Geotechnical Engineering, 2007, Thomson, IndiaDas BM., Theoretical Foundation Engineering, 20087, Cengage Learning India Private limited, India.Bowles JE., Foundation Analysis and Design, 1997, McGrawHill Companies, Singapore.Swami Saran., Reinforced soil and its Engineering applications, 2010, I.K. International publishing house private limited, India.Mittal S., An introduction to Ground Improvement Engineering, 2013, Scientific International private limited, India.Research papers from Journals and Conference proceedings.	APPLICATION OF GEOTECHNICAL ENGINEERING
CE462A	3-1-0-0-11	CE262A CE361A	**Course Contents:** Synthetic design storms & Estimation of peak discharge, Urbanstorm drainage design, Culvert design, Detention storage design, Watershedmodeling, Flood frequency analysis and hydrologic design under uncertainty; Designof water distribution network, Analysis and design . of rigid boundary channels,Tractive force concepts in channel design, Design of canal headworks, distributionworks, and crossdrainage works,	HYDRAULIC AND HYDROLOGIC DESIGN

			Design of gravity dams, spillways, and energydissipators. **References/Text Books:** I. Hydrologic Analysis and Design by Richard H. McCuen, Prentice Hall, NewJersey, USA.2. Applied Hydrology by V. T. Chow, David Maidment, and Larry Mays, TataMcGraw Hill, New Delhi, India.3. Hydraulic Design Handbook by Larry W. Mays, McGraw Hill.	
CE471A	3-0-0-2-11	CE272A, CE371A, CE372A	**Course Contents:** Elements of Prestressed concrete; Introduction to seismic design;Introduction to design of masonry structures; Case studies in design of RC Structures(RC water tank, Building frame, etc.), Case studies in design of steel structuresIndustrial buildings, towers, chimneys, Plate girder, chimneys) **References/Text Books:** 1 Pillai, S.U., and Menon, D., Reinforced Concrete Design, Tata McGraw Hill, 20092 Sinha, S.N., Reinforced Concrete Design, Tata McGraw Hill.3 Subramanian N. (2008). Design of Steel Structures, Oxford University Press.4 Bhavikatti, S. S. (201 0). Design of Steel Structures (by Limit State Method as Per IS:8002007), IK International5 Krishna Raju N. (1995). Prestressed Concrete, Tata McGraw Hill6 Dayaratnam, P., "Brick and Reinforced Brick Structures", Oxford & IBH PublishingHouse, 1997	SPECIAL TOPICS IN STRUCTURAL DESIGN
CE481A	3-0-0-2-11	CE382A	**Course Contents:** Any two of the three modules listed below will be taught in any semester :Module 1Traffic Design : Introduction, freeway and toll booths, intersections/interchanges, signs and lighting, arterials/ weaving section, congestion mitigation.Module 2Pavement Design : Introduction, design parameters, bituminous pavement, concrete pavement, composite pavement.Module 3Geometric Design: Introduction, design controls and criteria, freeway design, arterial/collector design, atgrade intersections, terminals. **References/Text Books:** Chakroborty, P. and Das, A., "Principles of Transportation Engineering", Prentice Hall of India, 2003Garder, N.J. and Hoel, L.A., "Traffic & Highway Engineering", 3rd Ed., Brooks/Cole, Pacific Grove, 2001McShane W.R., ROess R.P., Prassas, E.S., "Traffic Engineering", 2nd Ed., Prentice Hall 1998Americal Association of State Highway and Transportation Officals (AASHTO), "A Policy on Geometric Design of Highways and Streets", 5th Ed., AASHTO, 2004	TRANSPORTATION FACILITIES DESIGN
CE491.	0-0-6-2-0		**Course Contents:** PROJECT I **References/Text Books:**	PROJECT - I
CE491A	0-0-0-0-9		**Course Contents:** UNDER GRADUATE RESEARCH I **References/Text Books:**	UNDER GRADUATE RESEARCH -I
CE492A	0-0-0-0-9		**Course Contents:** UNDER GRADUATE RESEARCH II **References/Text Books:**	UNDER GRADUATE RESEARCH -II
CE601	3-0-0--4		**Course Contents:** 1. Basic Concept of Probability and Distributions2. Experimental Error and their Characteristics(a) Random error(b) Bias(c) Propagation of random error(d) Error due to roundingoff(e) Calibration3. Adjustment Computations(a) Condition method (b) Observation method (c) Combined method4. Sampling(a) Population and sample(b) Sample designs(c) Sample statistics(d) Sampling distribution of mean and variance(e)	STATISTICAL ANALYSIS FOR CIVIL ENGINEERS

			Question of sample size5. Estimation and Hypothesis Testing(a) Properties of good estimates(b) Interval estimation(c) Maximum likelihood estimates(d) Sample size determination(e) Basic fonnat of hypothesis testing(f) 'fype I and Type II errors(g) One and two tailed tests(h) Tests on mean and variance from samples under different assumptions and knowledge of the underlying distribution6. Regression Analysis and Hypothesis Testing(a) OLS estimates(b) Assumptions and proof of BLUE(c) Detection, effect, and remedy of multicollinearity(d) Detection, effect, and remedy ofheteroskedasticity(e) Detection, effect, and remedy of autocorrelation(f) Misspecification errors and regression model building(g) Hypothesis testing onOLS estimates(h) GIS(i) Comparison of regression modelU) Use of dummy independent variables(k) Robust regression and effect of outliers7. Miscellaneous Topics(a) Fitting theoretical distributions to observed frequency distributions (b) Tests of goodnessoffit (chisquare test, KolmogorovSmirnov test) (c) Identification of outliers(d) Cluster analysis8. Practical applications with (Civil) engineering data **References/Text Books:** 1 . Experimentation and Uncertainty Analysis: Hugh M. Coleman and W.G. Steele2. Handbook of statistical Methods for Scientists and Engineers: H.M. Wadsworth3. Statistical Treatment of Experimental Data: J.R. Green and D. Margerison4. Basic Econometrics: Damodar Gujarati	
CE601A	3-0-0-0-9		**Course Contents:** 1. Basic Concept of Probability and Distributions2. Experimental Error and their Characteristics(a) Random error(b) Bias(c) Propagation of random error(d) Error due to roundingoff(e) Calibration3. Adjustment Computations(a) Condition method (b) Observation method (c) Combined method4. Sampling(a) Population and sample(b) Sample designs(c) Sample statistics(d) Sampling distribution of mean and variance(e) Question of sample size5. Estimation and Hypothesis Testing(a) Properties of good estimates(b) Interval estimation(c) Maximum likelihood estimates(d) Sample size determination(e) Basic fonnat of hypothesis testing(f) 'fype I and Type II errors(g) One and two tailed tests(h) Tests on mean and variance from samples under different assumptions and knowledge of the underlying distribution6. Regression Analysis and Hypothesis Testing(a) OLS estimates(b) Assumptions and proof of BLUE(c) Detection, effect, and remedy of multicollinearity(d) Detection, effect, and remedy ofheteroskedasticity(e) Detection, effect, and remedy of autocorrelation(f) Misspecification errors and regression model building(g) Hypothesis testing onOLS estimates(h) GIS(i) Comparison of regression modelU) Use of dummy independent variables(k) Robust regression and effect of outliers7. Miscellaneous Topics(a) Fitting theoretical distributions to observed frequency distributions (b) Tests of goodnessoffit (chisquare test, KolmogorovSmirnov test) (c) Identification of outliers(d) Cluster analysis8. Practical applications with (Civil) engineering data **References/Text Books:** 1 . Experimentation and Uncertainty Analysis: Hugh M. Coleman and W.G. Steele2. Handbook of statistical Methods for Scientists and Engineers: H.M. Wadsworth3. Statistical Treatment of Experimental Data: J.R. Green and D. Margerison4. Basic Econometrics: Damodar Gujarati	STATISTICAL ANALYSIS FOR CIVIL ENGINEERS
CE602	3-0-0--4		**Course Contents:** Linear differential equations; Fourier integrals and transforms; Partial differentialequations; Numerical methods in general; Numerical methods for differentialequations; Linear algebra; Numerical methods in linear algebra; Data analysis,Probability theory; Mathematical statistics. **References/Text Books:**	ADVANCED MATHEMATICS FOR CIVIL ENGINEERS
CE602A	3-0-0-0-9		**Course Contents:** Linear differential equations; Fourier integrals and transforms; Partial differentialequations; Numerical methods in general; Numerical methods for differentialequations; Linear algebra; Numerical methods in linear algebra; Data analysis,Probability theory; Mathematical statistics. **References/Text Books:**	ADVANCED MATHEMATICS FOR CIVIL ENGINEERS

CE602N	3-0-0--4		**Course Contents:** Linear differential equations; Fourier integrals and transforms; Partial differentialequations; Numerical methods in general; Numerical methods for differentialequations; Linear algebra; Numerical methods in linear algebra; Data analysis,Probability theory; Mathematical statistics. **References/Text Books:**	ADVANCED MATHEMATICS FOR CIVIL ENGINEERS
CE606A	3-0-0-0-5	MTH101A MTH102A	**Course Contents:** Introductionto the course and its importance. Optimization methods: problem formulation, solution techniques for linear and integer problems (both unconstrained and constrained), sensitivity analysis. Brief introduction to nonlinear problems. Introduction to non traditional optimization methods. Case studies from Civil Engineering. **References/Text Books:** 1. Deb K, Optimization for Engineering Design: Algorithms and Examples, PHI, Second Edition. 2. Rao, S.S. "Engineering Optimization: Theory and Practice", 4th Edition, Wiley. 3. Hamdy A. Taha. Operations Research: An Introduction. McMillan. 4. Richard de Neufville. Applied Systems Analysis. McGraw Hill. 5. Chong, E. K.P. and Zak, S. H. An Introduction to Optimization: Second Edition, Wiley Student Edition.	OPTIMIZATION METHODS FOR CIVIL ENGINEERS
CE610	3-0-0-0-4		**Course Contents:** Hydrologic cycle, systems concept, hydrologic model classification; Reynold'sTransport Theorem, continuity, momentum, and energy equations; Atmospheric hydrology:atmospheric circulation, water vapor, formation and forms of precipitation, precipitablewater, monsoon characteristics in India, Thunderstorm Cell model, IDF relationships; factorsaffecting evaporation, estimation and measurement of evaporation, energy balance method,aerodynamic method, PriestleyTaylor method, and pan evaporation; Surface Water:Catchment storage concept, Hortonian and saturation overland flow, streamflow hydrographs,baseflow separation, index, ERH & DRH, algorithm for abstraction using GreenAmptequation, SCS method, overland and channel flow modeling, time area concepts, and streamnetworks; Unit Hydrograph: General hydrologic system model, response functions of a linearhydrologic systems and their interrelationships, convolution equation; definition andlimitations of a UH; UH derivation from single and complex storms; UH optimization usingregression, matrix, and LP methods; Synthetic unit hydrograph, SCurve, IUH; SubsurfaceWater: Soil moisture, porosity, saturated and unsaturated flow; Richards' equation,infiltration, Horton's, Philip's, and Green Ampt methods, parameter estimation, ponding timeconcepts; Groundwater Hydrology: Occurrence of groundwater, aquifers & their properties,Darcy's law, permeability, transmissibility, stratification, confined groundwater flow,unconfined groundwater flow under Dupit's assumptions; Well hydraulics, steady flow intoconfined and unconfined wells; Unsteady flow in a confined aquifer. **References/Text Books:**	ADVANCED HYDROLOGY
CE610A	3-0-0-0-9		**Course Contents:** Hydrologic cycle, systems concept, hydrologic model classification; Reynold'sTransport Theorem, continuity, momentum, and energy equations; Atmospheric hydrology:atmospheric circulation, water vapor, formation and forms of precipitation, precipitablewater, monsoon characteristics in India, Thunderstorm Cell model, IDF relationships; factorsaffecting evaporation, estimation and measurement of evaporation, energy balance method,aerodynamic method, PriestleyTaylor method, and pan evaporation; Surface Water:Catchment storage concept, Hortonian and saturation overland flow, streamflow hydrographs,baseflow separation, index, ERH & DRH, algorithm for abstraction using GreenAmptequation, SCS method, overland and channel flow modeling, time area concepts, and streamnetworks; Unit Hydrograph: General hydrologic system model, response functions of a linearhydrologic systems and their interrelationships, convolution equation; definition andlimitations of a UH; UH derivation from single and complex storms; UH optimization usingregression, matrix, and LP methods; Synthetic unit hydrograph, SCurve, IUH; SubsurfaceWater: Soil moisture, porosity, saturated and unsaturated flow; Richards' equation,infiltration, Horton's, Philip's, and Green Ampt methods, parameter estimation, ponding timeconcepts; Groundwater Hydrology: Occurrence of	ADVANCED HYDROLOGY

			groundwater, aquifers & their properties,Darcy's law, permeability, transmissibility, stratification, confined groundwater flow,unconfined groundwater flow under Dupit's assumptions; Well hydraulics, steady flow intoconfined and unconfined wells; Unsteady flow in a confined aquifer. **References/Text Books:**	
CE611A	3-0-0-0-9		**Course Contents:** Basics: dimensional analysis, equations of continuity, motion, and energy,irrotational flow, drag and lift of immersed bodies; Pipe flow: laminar flow,turbulent flow, boundary layer theory, wall turbulent shear flow, free turbulentshear flow; Open Channel flow: energydepth relationships, uniform flow,gradually varied flow, hydraulic jump, rapidly varied flow, spatially varied flow,unsteady flow. **References/Text Books:**	ENGINEERING HYDRAULICS
CE611N	3-0-0--4		**Course Contents:** Basics: dimensional analysis, equations of continuity, motion, and energy,irrotational flow, drag and lift of immersed bodies; Pipe flow: laminar flow,turbulent flow, boundary layer theory, wall turbulent shear flow, free turbulentshear flow; Open Channel flow: energydepth relationships, uniform flow,gradually varied flow, hydraulic jump, rapidly varied flow, spatially varied flow,unsteady flow. **References/Text Books:**	ENGINEERING HYDRAULICS
CE612	2-0-3-0-4		**Course Contents:** Verification of momentum equation; Friction loss in pipes; Rainfallrunoffrelationship; Flow over sharp crested weir; Flow in pipe networks; Bernoullitheorem; Fall velocity of objects; Point velocity measurement by ADV; Reynoldsapparatus; Venturimeter and orifice meter; Energy loss in bends; Ground waterflow/ well abstraction; Hydrogen bubble flow visualization; Hydraulic jump; Flowpast a cylinder **References/Text Books:**	FLUID MECHANICS LABORATORY
CE612A	2-0-3-0-9		**Course Contents:** Verification of momentum equation; Friction loss in pipes; Rainfallrunoff relationship; Flow over sharp crested weir; Flow in pipe networks; Bernoulli theorem; Fall velocity of objects; Point velocity measurement by ADV; Reynolds apparatus; Venturimeter and orifice meter; Energy loss in bends; Ground water flow/ well abstraction; Hydrogen bubble flow visualization; Hydraulic jump; Flow past a cylinder. **References/Text Books:**	FLUID MECHANICS LABORATORY
CE612N	2-0-3-0-4		**Course Contents:** Verification of momentum equation; Friction loss in pipes; Rainfallrunoffrelationship; Flow over sharp crested weir; Flow in pipe networks; Bernoullitheorem; Fall velocity of objects; Point velocity measurement by ADV; Reynoldsapparatus; Venturimeter and orifice meter; Energy loss in bends; Ground waterflow/ well abstraction; Hydrogen bubble flow visualization; Hydraulic jump; Flowpast a cylinder **References/Text Books:**	FLUID MECHANICS LABORATORY
CE613	2-0-3-0-4		**Course Contents:** Basic: Introduction to computer programming and computation with Matlab. (02 lectures)Open channel flow : Estimation of normal and critical depth; uniform flow computations; computation ofwater surface profile (WSP) gradually varied flow estimation using standard step and direct stepmethods, WSP in presence of hydraulic structures; unsteady flow SaintVenant equation, kinematicwave routing, diffusion routing, overland flow; steady and unsteady modelling using HECRAS. (07 lectures)Closed conduit flow: Steady and unsteady state modelling; pipe network analysis; introduction toEPANET/WaterCAD. (05 lectures)Surface water	COMPUTER METHODS IN HYDRAULICS AND HYDROLOGY

			hydrology: Estimation of Unit hydrographs; lumped and distributed flow routing;hydrologic statistics parameter estimation, time series analysis, frequency analysis, geostatistics;hydrologic modelling using HECHMS. (05 lectures)Groundwater hydrology: Solving groundwater flow equation saturated and unsaturated flow, Richards'equation, GreenAmpt infiltration model; introduction to MODFLOW. (05 lectures)Application of soft computing methods and GIS in Hydraulic and Hydrologic modelling. (03 lectures)Laboratory: Programming exercises for the related topics. (I 0 lab classes) **References/Text Books:** 1. Chow V.T., Maidment D.R. and Mays L.W. (1988), Applied Hydrology, McGrawHill2. Chaudhry M.H. (2007), OpenChannel Flow, 2"d Edition, Springer3. Deb K. (1995), Optimization for engineering design: Algorithm and examples, Prentice Hall India4. Heywood I., Cornelius S. and Carver S. (2006), An Introduction to Geographical InformationSystems, 3'd Edition, Prentice Hall5. Mathews J.H. and Fink K.D. (2006), Numerical Methods using Matlab, 4th Edition, Prentice Hall6. Press eta!., Numerical Recipes (C, C++, FORTRAN or Pascal), Cambridge University Press7. Todd O.K. and Mays L.W. (2008), Groundwater Hydrology, 3'd Edition, John Wiley & Sons8. Wasserman P.O. (1989), Neural computing, theory and practice, Van Nostrand Reinhold, New York	
CE613A	2-0-3-0-9	CE262A/CE611A CE361A/CE10A	**Course Contents:** Basic: Introduction to computer programming and computation with Matlab. (02 lectures)Open channel flow : Estimation of normal and critical depth; uniform flow computations; computation ofwater surface profile (WSP) gradually varied flow estimation using standard step and direct stepmethods, WSP in presence of hydraulic structures; unsteady flow SaintVenant equation, kinematicwave routing, diffusion routing, overland flow; steady and unsteady modelling using HECRAS. (07 lectures)Closed conduit flow: Steady and unsteady state modelling; pipe network analysis; introduction toEPANET/WaterCAD. (05 lectures)Surface water hydrology: Estimation of Unit hydrographs; lumped and distributed flow routing;hydrologic statistics parameter estimation, time series analysis, frequency analysis, geostatistics;hydrologic modelling using HECHMS. (05 lectures)Groundwater hydrology: Solving groundwater flow equation saturated and unsaturated flow, Richards'equation, GreenAmpt infiltration model; introduction to MODFLOW. (05 lectures)Application of soft computing methods and GIS in Hydraulic and Hydrologic modelling. (03 lectures)Laboratory: Programming exercises for the related topics. (I 0 lab classes) **References/Text Books:** 1. Chow V.T., Maidment D.R. and Mays L.W. (1988), Applied Hydrology, McGrawHill2. Chaudhry M.H. (2007), OpenChannel Flow, 2"d Edition, Springer3. Deb K. (1995), Optimization for engineering design: Algorithm and examples, Prentice Hall India4. Heywood I., Cornelius S. and Carver S. (2006), An Introduction to Geographical InformationSystems, 3'd Edition, Prentice Hall5. Mathews J.H. and Fink K.D. (2006), Numerical Methods using Matlab, 4th Edition, Prentice Hall6. Press eta!., Numerical Recipes (C, C++, FORTRAN or Pascal), Cambridge University Press7. Todd O.K. and Mays L.W. (2008), Groundwater Hydrology, 3'd Edition, John Wiley & Sons8. Wasserman P.O. (1989), Neural computing, theory and practice, Van Nostrand Reinhold, New York	COMPUTER METHODS IN HYDRAULICS AND HYDROLOGY
CE614	3-0-0-0-4		**Course Contents:** The hydrologic processes: precipitation, evaporation, infiltration, groundwater,and stream flow; Hydrologic measurements and networks; Analysis of discreteand continuous hydrologic data: harmonic analysis, statistical analysis includingfrequency analysis, correlation, and regression analysis and multivariate analysis,time series analysis and its applications; System analysis and synthesis; Linearand non linear, lumped and distributed parameter systems; Queing models,simulation analysis; Hydrologic design of water resources systems **References/Text Books:**	STOCHASTIC HYDROLOGY
CE614A	3-0-0-0-9		**Course Contents:** Statistical methods in hydrology, probability distribution of hydrologic variables, hypothesis testing and	STOCHASTIC HYDROLOGY

			goodness of fit, flood frequency analysis, single and multiple regression analysis, classification of time series, characteristics of hydrologic time series, statistical principles and techniques for hydrologic time series modelling, time series modelling of annual and periodic hydrologic time series (including AR, ARMA, ARIMA, and DARMA models), multivariate modelling of hydrologic time series, practical considerations in time series modelling applications. **References/Text Books:**	
CE615	3-0-0-0-4		**Course Contents:** Expert Systems (ES): history of ES, basic concepts of ES, definition and components of ES, inference engines and reasoning mechanisms e.g. forward reasoning, backward reasoning, and mixed reasoning, knowledge representation methods and development of the rule based knowledge base, dealing with uncertainty, and selected case studies of ES applications to engineering and sciences; Artificial Neural Networks (ANNs): background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial neural networks, feedforward and feedback networks, supervised and unsupervised learning methodsstandard backpropagation (BP), conjugate gradients BP, self organizing networks, etc., development of ANN models for specific problems and selected case studies; Genetic Algorithms (GAs): fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operatorsselection, crossover, and mutation, binary and realcoded GAs, constraint handling in GAs, and selected case studies involving GA applications to engineering. **References/Text Books:**	INTRODUCTION AI TECHNIQUES
CE616	3-0-0-0-4		**Course Contents:** Properties of sediment, incipient motion, bed load, suspended load, totalload, sediment measurements, regime concept, bed form mechanics, plan formand stream bed variations of rivers, reservoir sedimentation, erosion anddeposition, sediment control, sediment transport in pipes. **References/Text Books:**	SEDIMENT TRANSPORTATION
CE616A	3-0-0-0-9		**Course Contents:** Properties of sediment, incipient motion, bed load, suspended load, totalload, sediment measurements, regime concept, bed form mechanics, plan formand stream bed variations of rivers, reservoir sedimentation, erosion anddeposition, sediment control, sediment transport in pipes. **References/Text Books:**	SEDIMENT TRANSPORTATION
CE619	3-0-0-0-4		**Course Contents:** Introduction: Origin and scope of ecohydrology. (03 Lectures)Ecohydrological processes: Interactions between physical, chemical and biological processesat basin scale soil water dynamics, land surface energy budgets; scales of interactions;ecohydrological optimality theory; ecohydrological controls on nutrient cycle; Landscapeconnectivity morphological, ecological and hydrological connections. (12 Lectures)Techniques in ecohydrological measurements: Measuring energy and water fluxes inatmosphere, soil and vegetation; atmosphere latent, sensible and C02 fluxes, distribution ofwind, temperature and humidity; soil soil moisture, soil respiration and soil heat flux;vegetation leaf area index, stomatal conductance and transpiration. (08 Lectures)Ecohydrological modelling: Governing equations; mathematical models stochastic anddeterministic models; process based and empirical models; calibration and validation ofmodels; scale issues in ecohydrological modelling. (10 Lectures)Applications of ecohydrology: Use of ecohydrogical principles in paleohydrology and climatechange studies; ecohydrological approach for sustainable management of floods anddroughts; case studies from tropical river basins and dry land ecosystems. (08 Lectures) **References/Text Books:** 1. D'Odorico P., Porporato A. 2006. Dry/and Ecohydrology, Springer, Dordrecht, TheNetherlands.2.	ECOHYDROLOGY

			Eagleson P.S. 2002. Ecohydrology: Darwinian expression ofvegetationform andfimction, Cambridge University Press, Cambridge, UK.3. Harper D., Zalewski M., Pacini N. 2008. Ecohydrology: processes, models and casestudies: An approach to the sustainable management of water resources, CABInternational, Cromwell Press, Trowbridge, UK.4. Rodriguezlturbe 1., Porporato A. 2005. Ecohydrology of watercontrolled ecosystems:soil moisture and plant dynamics, Cambridge University Press, Cambridge, UK.5. Wood P.J., Hannah D.M., Sadler J.P. 2007. Hydroecology and Ecohydrology: past,present andfitture, John Wiley & Sons, Chichester, UK.	
CE620	3-0-0--4	#	**Course Contents:** Loading: nature of dynamic loading, harmonic, random, types of dynamic loading;Continuous systems: rods (axial vibrations), beams (shear, axial and axialshearflexuralvibrations); Discrete mass systems: SDOF (free and forced vibrations),MDOF (generalized coordinates, eigenvalue analysis, matrix and modal timehistory analysis); Introduction of random vibration: stochastic processes, stochasticanalysis of linear dynamical systems to Gaussian inputs, SDOF, MDOF. **References/Text Books:**	STRUCTURAL DYNAMICS
CE620A	3-0-0-0-9		**Course Contents:** Loading: nature of dynamic loading, harmonic, random, types of dynamic loading;Continuous systems: rods (axial vibrations), beams (shear, axial and axialshearflexuralvibrations); Discrete mass systems: SDOF (free and forced vibrations),MDOF (generalized coordinates, eigenvalue analysis, matrix and modal timehistory analysis); Introduction of random vibration: stochastic processes, stochasticanalysis of linear dynamical systems to Gaussian inputs, SDOF, MDOF. **References/Text Books:**	STRUCTURAL DYNAMICS
CE621	3-0-0-4-4		**Course Contents:** Stress analysis: forces and moments, theory of stress, principal stresses andstress invariants, compatibility equations, equilibrium equations; Strain:deformation and velocity gradients, Lagrangian and Eulerian description andfinite strain, small deformation theory, principal strains and strain invariants,compatibility conditions; Fundamental physical principles: conservation of mass,linear momentum, angular momentum, and energy, second law of thermodynamics;Constitutive theory: St. Venants principal, linear elasticity and generalizedHooks law, Stokesian and Newtonian fluids, NavierStokes equations, Bernoulliequation, linear viscoelasticity, yield criteria; Applications: Airy stress function,twodimensional elastostatics problems, torsion. **References/Text Books:**	Engineering Mechanics
CE621A	3-0-0-0-9		**Course Contents:** Stress analysis: forces and moments, theory of stress, principal stresses andstress invariants, compatibility equations, equilibrium equations; Strain:deformation and velocity gradients, Lagrangian and Eulerian description andfinite strain, small deformation theory, principal strains and strain invariants,compatibility conditions; Fundamental physical principles: conservation of mass,linear momentum, angular momentum, and energy, second law of thermodynamics;Constitutive theory: St. Venants principal, linear elasticity and generalizedHooks law, Stokesian and Newtonian fluids, NavierStokes equations, Bernoulliequation, linear viscoelasticity, yield criteria; Applications: Airy stress function,twodimensional elastostatics problems, torsion. **References/Text Books:**	ENGINEERING MECHANICS
CE621N	3-0-0--4		**Course Contents:** Stress analysis: forces and moments, theory of stress, principal stresses andstress invariants, compatibility equations, equilibrium equations; Strain:deformation and velocity gradients, Lagrangian and Eulerian	ENGINEERING MECHANICS

			description andfinite strain, small deformation theory, principal strains and strain invariants,compatibility conditions; Fundamental physical principles: conservation of mass,linear momentum, angular momentum, and energy, second law of thermodynamics;Constitutive theory: St. Venants principal, linear elasticity and generalizedHooks law, Stokesian and Newtonian fluids, NavierStokes equations, Bernoulliequation, linear viscoelasticity, yield criteria; Applications: Airy stress function,twodimensional elastostatics problems, torsion. **References/Text Books:**	
CE622	3-0-0-4-4		**Course Contents:** Criteria for Design of Structures: Stability, Strength, and StiffnessClassical Concept of StabilihjStabilihJ of Discrete Systems: Linear and nonlinear behaviourStabilihJ of Continuous Systems: Stability of Columns: axialflexural buckling, lateralbracing of columns, combined axialflexuraltorsion buckling. Stability of Frames:member buckling versus global buckling, slenderness ratio of frame members. Stabilityof Beams: lateraltorsion buckling. Stability of Plates: axialflexural buckling, shearflexural buckling, buckling under combined loadsIntroduction to Inelastic Buckling and Dynamic Stability **References/Text Books:**	Stability of Structures
CE622A	3-0-0-0-9		**Course Contents:** Criteria for design of structures: stability, strength, and stiffness; Classicalconcept of stability; Stability of discrete systems: linear and nonlinear behaviour;Stability of continuous systems: stability of columns: axialflexural buckling,lateral bracing of columns, combined axialflexuraltorsion buckling; Stabilityof frames: member buckling versus global buckling, slenderness ratio of framemembers; Stability of beams: lateraltorsion buckling; Stability of plates: axialflexural buckling, shear flexural buckling, buckling under combined loads;Introduction to inelastic buckling and dynamic stability. **References/Text Books:**	STABILITY OF STRUCTURES
CE622N	3-0-0--4		**Course Contents:** Criteria for design of structures: stability, strength, and stiffness; Classicalconcept of stability; Stability of discrete systems: linear and nonlinear behaviour;Stability of continuous systems: stability of columns: axialflexural buckling,lateral bracing of columns, combined axialflexuraltorsion buckling; Stabilityof frames: member buckling versus global buckling, slenderness ratio of framemembers; Stability of beams: lateraltorsion buckling; Stability of plates: axialflexural buckling, shear flexural buckling, buckling under combined loads;Introduction to inelastic buckling and dynamic stability. **References/Text Books:**	STABILITY OF STRUCTURES
CE623	2-0-3-0-4		**Course Contents:** Similitude and Structural Models: Dimensional analysis, Buckingham's Pi theorem, Scale factors and dynamicsimilitudeUses and Applications of Models: Types of model investigation, Indirect and direct models, Elastic and InelasticModels (steel, concrete and masomy), size effectsAnalysis of Experimental Data: Error and unce1tainty in experiment, Measurement systems, Accuracy in models and reliability of resultsTest Planning, Design and Implementation: Testing sequence and experimental plan, Loading systems, devices, actuators and their control, etc.Instrumentation: Mechanical, electrical, electronic system and their calibration, various types of sensors for displacement, velocity, acceleration, pressure, loads, strains, etc, fullfield measurements, .Data Acquisition System and Data Processing: Analog systems, digital systems using personal computers, dynamic measurement, numerical and graphical data processing and archivingLab Exercises: Experiments to illustrate buckling of stiUctural members; loaddefb1mation behaviour of beams, columns, joints, and fiames under various loads; mode shapes, natural frequency, damping factors fiom free andforced vibrations, shake table tests, etc.	EXPERIMENTAL METHODS IN STRUCTURL ENGINEERING

			References/Text Books: Dally, J. W. and Riley, W. F. (1978). Experimental Stress Analysis, McGraw HillHarris H. G. and Sabnis, G. M. (1999). Structural Modeling and Experimental Techniques, CRC Press 1999Nachtigal, C.L. (I990). Jnstrumentation and Control, Wiley & Sons, 1990Reese, R. T. and Kawahara, W. A. (1993), Handbook of Structural Testing, Prentice Hall I Fairmont PressHolman, J. P. (200 I). Experimental Methods for Engineers, McGraw Hill	
CE623A	2-0-3-0-9		**Course Contents:** Similitude and Structural Models: Dimensional analysis, Buckingham's Pi theorem, Scale factors and dynamicsimilitudeUses and Applications of Models: Types of model investigation, Indirect and direct models, Elastic and InelasticModels (steel, concrete and masomy), size effectsAnalysis of Experimental Data: Error and unce1tainty in experiment, Measurement systems, Accuracy in models and reliability of resultsTest Planning, Design and Implementation: Testing sequence and experimental plan, Loading systems, devices, actuators and their control, etc.Instrumentation: Mechanical, electrical, electronic system and their calibration, various types of sensors for displacement, velocity, acceleration, pressure, loads, strains, etc, fullfield measurements, .Data Acquisition System and Data Processing: Analog systems, digital systems using personal computers, dynamic measurement, numerical and graphical data processing and archivingLab Exercises: Experiments to illustrate buckling of stiUctural members; loaddefb1mation behaviour of beams, columns, joints, and fiames under various loads; mode shapes, natural frequency, damping factors fiom free andforced vibrations, shake table tests, etc. **References/Text Books:**	EXPERIMENTAL METHODS IN STRUCTURL ENGINEERING
CE623N	2-0-3--4		**Course Contents:** Similitude and Structural Models: Dimensional analysis, Buckingham's Pi theorem, Scale factors and dynamicsimilitudeUses and Applications of Models: Types of model investigation, Indirect and direct models, Elastic and InelasticModels (steel, concrete and masomy), size effectsAnalysis of Experimental Data: Error and unce1tainty in experiment, Measurement systems, Accuracy in models and reliability of resultsTest Planning, Design and Implementation: Testing sequence and experimental plan, Loading systems, devices, actuators and their control, etc.Instrumentation: Mechanical, electrical, electronic system and their calibration, various types of sensors for displacement, velocity, acceleration, pressure, loads, strains, etc, fullfield measurements, .Data Acquisition System and Data Processing: Analog systems, digital systems using personal computers, dynamic measurement, numerical and graphical data processing and archivingLab Exercises: Experiments to illustrate buckling of stiUctural members; loaddefb1mation behaviour of beams, columns, joints, and fiames under various loads; mode shapes, natural frequency, damping factors fiom free andforced vibrations, shake table tests, etc. **References/Text Books:** Dally, J. W. and Riley, W. F. (1978). Experimental Stress Analysis, McGraw HillHarris H. G. and Sabnis, G. M. (1999). Structural Modeling and Experimental Techniques, CRC Press 1999Nachtigal, C.L. (I990). Jnstrumentation and Control, Wiley & Sons, 1990Reese, R. T. and Kawahara, W. A. (1993), Handbook of Structural Testing, Prentice Hall I Fairmont PressHolman, J. P. (200 I). Experimental Methods for Engineers, McGraw Hill	EXPERIMENTAL METHODS IN STRUCTURAL ENGINEERNIG
CE625	3-0-0-0-4		**Course Contents:** Properties of constituents: units burnt clay, concrete blocks, mortar, grout,reinforcement; Masonry bonds and properties: patterns, shrinkage, differentialmovement, masonry properties compression strength ; Stresses in masonrywalls: vertical loads, vertical loads and moments eccentricity & kern distance,lateral loads inplane, outofplane; Behaviour of masonry walls and piers:axial and flexure, axial shear and flexure, Behaviour of Masonry Buildings:unreinforced masonry buildings importance of bands and corner & verticalreinforcement, reinforced masonry buildings cyclic loading & ductility of masonry walls; Behaviour of masonry infills in RC frames: strut action; Structuraldesign of masonry in buildings: methods of design WSD, USD, seismic design seismic loads, code provisions, infills, connectors, ties; Seismic evaluationand strengthening of	MASONARY STRUCTURES

			masonry buildings: methods insitu, nondestructivetesting; Construction practices and new materials. **References/Text Books:**	
CE625A	3-0-0-0-9		**Course Contents:** Properties of constituents: units burnt clay, concrete blocks, mortar, grout,reinforcement; Masonry bonds and properties: patterns, shrinkage, differentialmovement, masonry properties compression strength ; Stresses in masonrywalls: vertical loads, vertical loads and moments eccentricity & kern distance,lateral loads inplane, outofplane; Behaviour of masonry walls and piers:axial and flexure, axial shear and flexure, Behaviour of Masonry Buildings:unreinforced masonry buildings importance of bands and corner & verticalreinforcement, reinforced masonry buildings cyclic loading & ductility of masonry walls; Behaviour of masonry infills in RC frames: strut action; Structuraldesign of masonry in buildings: methods of design WSD, USD, seismic design seismic loads, code provisions, infills, connectors, ties; Seismic evaluationand strengthening of masonry buildings: methods insitu, nondestructivetesting; Construction practices and new materials. **References/Text Books:**	MASONARY STRUCTURES
CE627	3-0-0-0-4		**Course Contents:** Properties of steel: mechanical properties, hysteresis, ductility; HotRolledSections: compactness and noncompactness, slenderness, residual stresses;Design of steel structures: inelastic bending curvature, plastic moments, designcriteria stability , strength, drift; Stability criteria: stability of beams localbuckling of compression flange & web, lateraltorsional buckling, stability ofcolumns slenderness ratio of columns, local buckling of flanges and web,bracing of column about weak axis, method of design allowable stress design,plastic design, load and resistance factor design; Strength Criteria: beams flexure, shear, torsion, columns moment magnification factor, effective length,PM interaction, biaxial bending, joint panel zones; Drift criteria: P effect,deformationbased design; Connections: types welded, bolted, location beamcolumn,columnfoundation, splices. **References/Text Books:**	ADVANCED DESIGN OF STEEL STRUCTURES
CE628	3-0-0-0-4		**Course Contents:** Concrete and the environment: interaction; Overview of concrete deterioration:alkaliaggregate reaction, corrosion, carbonation; Permeability of concrete andits measurement: penetration of carbon dioxide and chlorides into concrete,corrosion of steel in concrete electrochemistry of corrosion, micro and macrocell corrosion, corrosion cells and currents, role of concrete, prevention ofcorrosion; Corrosion induced longitudinal cracks: nature and properties ofcorrosion products; Alkali aggregate reaction: reactive minerals, mechanism of deterioration, identification and tests; Codal provisions for durability;Nondestructive testing; repair/rehabilitation of structures. **References/Text Books:**	DURABILITY OF CONCRETE STRUCTURES
CE628A	3-0-0-0-9		**Course Contents:** Concrete and the environment: interaction; Overview of concrete deterioration:alkaliaggregate reaction, corrosion, carbonation; Permeability of concrete andits measurement: penetration of carbon dioxide and chlorides into concrete,corrosion of steel in concrete electrochemistry of corrosion, micro and macrocell corrosion, corrosion cells and currents, role of concrete, prevention ofcorrosion; Corrosion induced longitudinal cracks: nature and properties ofcorrosion products; Alkali aggregate reaction: reactive minerals, mechanism of deterioration, identification and tests; Codal provisions for durability;Nondestructive testing; repair/rehabilitation of structures. **References/Text Books:**	DURABILITY OF CONCRETE STRUCTURES
CE629	3-0-0--4	#	**Course Contents:**	EARTHQUAKE ANALYSIS

			Characteristics of earthquakes; Earthquake response of structures; Concept ofearthquake resistant design; Code provisions of design of buildings; Design ofliquid storage tanks; Liquefaction; Nonengineered construction; Special topics:bridges, dams, strengthening of existing buildings. **References/Text Books:**	AND DESIGN OF STRUCTURES
CE629A	3-0-0-0-9		**Course Contents:** Characteristics of earthquakes; Earthquake response of structures; Concept ofearthquake resistant design; Code provisions of design of buildings; Design ofliquid storage tanks; Liquefaction; Nonengineered construction; Special topics:bridges, dams, strengthening of existing buildings. **References/Text Books:**	EARTHQUAKE ANALYSIS AND DESIGN OF STRUCTURES
CE630	3-0-0--4		**Course Contents:** Physical properties and classification of intact rock and rock masses, rockexploration, engineering properties of rock, stresses in rock near undergroundopenings; Rock tunneling, rock slope stability, bolting, blasting, grouting androck foundation design. **References/Text Books:**	ROCK MECHANICS
CE630A	3-0-0-0-9		**Course Contents:** Physical properties and classification of intact rock and rock masses, rockexploration, engineering properties of rock, stresses in rock near undergroundopenings; Rock tunneling, rock slope stability, bolting, blasting, grouting androck foundation design. **References/Text Books:**	ROCK MECHANICS
CE631	3-0-0-4-4		**Course Contents:** Soil composition and soil structure, Steady State flow, 2D and 3D seepage, Transientflow; Compressibility and Rate of consolidation, One, two, and three dimensionalconsolidation theories; Shear strength and stressstrain relationships of soils; Stability ofslopes, Arching effects, Buried Structures **References/Text Books:**	ADVANCED GEOTECHNICAL ENGINEERING
CE631A	3-0-0-0-9		**Course Contents:** Soil composition and soil structure, Steady State flow, 2D and 3D seepage, Transientflow; Compressibility and Rate of consolidation, One, two, and three dimensionalconsolidation theories; Shear strength and stressstrain relationships of soils; Stability ofslopes, Arching effects, Buried Structures **References/Text Books:**	ADVANCED GEOTECHNICAL ENGINEERING
CE631N	3-0-0--4		**Course Contents:** Soil composition and soil structure, Steady State flow, 2D and 3D seepage, Transientflow; Compressibility and Rate of consolidation, One, two, and three dimensionalconsolidation theories; Shear strength and stressstrain relationships of soils; Stability ofslopes, Arching effects, Buried Structures **References/Text Books:**	ADVANCED GEOTECHNICAL ENGINEERING
CE632	3-0-0-4-4		**Course Contents:** Settlement and bearing capacity; shallow spread footings, mats, and deep foundations.Foundation models, Contact pressure distribution for footings, Rafts, Piles, RetainingStructures; Soilstructure intemction studies; Case studies.	FOUNDATION ANALYSIS AND DESIGN

			References/Text Books: Bowles, J. E.: Foundation Analysis and Design (5nd Edition),The McGraw Hill Companies Inc. (2001)	
CE632A	3-0-0-0-9	CE352A/CE631A	**Course Contents:** Settlement and bearing capacity; shallow spread footings, mats, and deep foundations.Foundation models, Contact pressure distribution for footings, Rafts, Piles, RetainingStructures; Soilstructure intemction studies; Case studies. **References/Text Books:** Bowles, J. E.: Foundation Analysis and Design (5nd Edition),The McGraw Hill Companies Inc. (2001)	FOUNDATION ANALYSIS AND DESIGN
CE632N	3-0-0-0-4		**Course Contents:** Settlement and bearing capacity; shallow spread footings, mats, and deep foundations.Foundation models, Contact pressure distribution for footings, Rafts, Piles, RetainingStructures; Soilstructure intemction studies; Case studies. **References/Text Books:** Bowles, J. E.: Foundation Analysis and Design (5nd Edition),The McGraw Hill Companies Inc. (2001)	FOUNDATION ANALYSIS AND DESIGN
CE633	3-0-0-4-4		**Course Contents:** Reinforcing materials, Advantage of RE, behaviour of Reinforced earth walls, Soilreinforcement interaction internal and external stability condition, field application of RE.Randomly reinforced earth and analysis of reinforced soils, testing of soil reinforcementsDevelopment, fabrication, design, and applications of geotextiles, geogrids, geonets, andgeomernbranes. **References/Text Books:** KoemerR. M.:Designing with Geosynthetics (4 u, Edition),Prentice Hall, New Jersey, (1997)	REINFORCED EARTH STRUCTURES
CE634	3-0-0-4-4		**Course Contents:** Engineering properties of soft, weak and compressible deposits, principles of treatmentloading(static and Dynamic), Accelerated flow, Reinforcement, Drainage and fillers,Injections, Thermal, electrical and Chemical Methods Preloading, Dynamic Consolidation,Vertical drains, Granular piles, soil nailing, Anchors, Design Methods and Case histories **References/Text Books:** Moseley and Kirsch: Designing with Geosynthetics (2"d Edition), Routledge, (2004), ISBN: 0415274559	GROUND IMPROVEMENT TECHNIQUES
CE634A	3-0-0-0-9		**Course Contents:** Engineering properties of soft, weak and compressible deposits; Principles of treatmentloading (static and Dynamic); Accelerated flow; Reinforcement; Drainage and filters, Injections, thermal, electrical and Chemical Methods; Preloading; Dynamic Consolidation; Vertical drains; Granular piles; Soil nailing; Anchors; Design methods and case studies. **References/Text Books:**	GROUND IMPROVEMENT TECHNIQUES
CE634N	3-0-0--4		**Course Contents:** Engineering properties of soft, weak and compressible deposits, principles of treatmentloading(static and Dynamic), Accelerated flow, Reinforcement, Drainage and fillers,Injections, Thermal, electrical and Chemical Methods Preloading, Dynamic Consolidation,Vertical drains, Granular piles, soil nailing, Anchors, Design Methods and Case histories **References/Text Books:** Moseley and Kirsch: Designing with Geosynthetics (2"d Edition), Routledge, (2004), ISBN: 0415274559	GROUND IMPROVEMENT TECHNIQUES

CE635	3-0-0--4		**Course Contents:** Dynamics of elastic systems; Single and multidegrees of freedom systems;Empirical and semiempirical approaches to the theory of soil dynamics; Elastictheories of soil dynamics; Wave propagation; Dynamic soil properties; Designof machine foundations; Vibration isolation; Pile dynamics. **References/Text Books:**	FOUNDATION DYNAMICS
CE635A	3-0-0-0-9		**Course Contents:** Dynamics of elastic systems; Single and multidegrees of freedom systems;Empirical and semiempirical approaches to the theory of soil dynamics; Elastictheories of soil dynamics; Wave propagation; Dynamic soil properties; Designof machine foundations; Vibration isolation; Pile dynamics. **References/Text Books:**	FOUNDATION DYNAMICS
CE636	3-0-0-0-4		**Course Contents:** Introduction; Seismic Hazards: Mitigation of Seismic Hazards, seismology andearthquakes, strong ground motion, seismic hazard analysis; Wave propagationin unbounded media: in semiinfinite bodies, in layered soils and attenuationof stress waves; Dynamic soil properties; Ground response analysis; Effect oflocal site conditions on ground motion; Liquefaction: evaluation of liquefactionhazards, effects of liquefaction; Case studies. **References/Text Books:**	GEOTECHNICAL EARTHQUAKE ENGINEERING
CE637	3-0-0--4		**Course Contents:** Role of constitutive modeling; Importance of laboratory testing with relationto constitutive modeling; Elasticity: linear, quasilinear, anisotropic; Plasticitybasics: yield criteria, flow rule, plastic potential, hardening/softening; RateIndependent Plasticity: mohrCoulomb, nonlinear failure criteria, DruckerPrager, and cap models; Critical state soil mechanics: critical state concept,camclay models, simulation of single element test using camclay, consolidation,drained and undrained triaxial test; Stressdilatancy theory; Work hardeningplasticity theory: formulation and implementation; Applications of elastoplasticmodels; Special Topics: hypoelasticityplasticity, disturbed state concept. **References/Text Books:**	CONSTITUTIVE MODELING OF FRICTIONAL MATERIALS
CE637A	3-0-0-0-9		**Course Contents:** Role of constitutive modeling; Importance of laboratory testing with relationto constitutive modeling; Elasticity: linear, quasilinear, anisotropic; Plasticitybasics: yield criteria, flow rule, plastic potential, hardening/softening; RateIndependent Plasticity: mohrCoulomb, nonlinear failure criteria, DruckerPrager, and cap models; Critical state soil mechanics: critical state concept,camclay models, simulation of single element test using camclay, consolidation,drained and undrained triaxial test; Stressdilatancy theory; Work hardeningplasticity theory: formulation and implementation; Applications of elastoplasticmodels; Special Topics: hypoelasticityplasticity, disturbed state concept. **References/Text Books:**	CONSTITUTIVE MODELING OF FRICTIONAL MATERIALS
CE638	2-0-2-0-4		**Course Contents:** Subsurface exploration planning, drilling and sampling techniques, field andlaboratory tests, instrumentation and monitoring of field data, report preparation. **References/Text Books:**	GEOTECHNICAL MEASUREMENTS AND EXPLORATION
CE638N	2-0-2-0-4		**Course Contents:** Subsurface exploration planning, drilling and sampling techniques, field andlaboratory tests, instrumentation	GEOTECHNICAL INVESTIGATIONS FOR

			and monitoring of field data, report preparation. **References/Text Books:**	CIVIL ENGINEERING PROJECTS
CE639	3----4		**Course Contents:** Finite difference, finite element and other analytical methods of solution to(i) Elasticity and stability problems in Geomechanics, (ii) Analysis of responseof soil media to applied loads, (iii) Limiting equilibrium, Failure theories, Methodof characteristics, (iv) Limit analysis, etc. **References/Text Books:**	ANALYTICAL AND NUMERICAL METHODS IN GEOMECHANICS
CE642	3-0-0--4		**Course Contents:** Geological hazards and environmental impact; Landslides: cause, classification,zonation and protection; Earthquakes: historical seismicity, classification, interplateand intraplate earthquakes, effect on ground structures, magnitude and intensityscales, seismic zonation; Floods: hydrology and types of floods, nature and extentof flood hazard, flood hazard zoning, flood control and protection; Landsubsidence; Snow avalanches; Rock bursts; Mapping, monitoring and managementof geological hazards. **References/Text Books:**	GEOLOGICAL HAZARDS
CE642A	3-0-0-0-9	MTH101A MTH102A	**Course Contents:** Geological hazards and environmental impact; Landslides: cause, classification,zonation and protection; Earthquakes: historical seismicity, classification, interplateand intraplate earthquakes, effect on ground structures, magnitude and intensityscales, seismic zonation; Floods: hydrology and types of floods, nature and extentof flood hazard, flood hazard zoning, flood control and protection; Landsubsidence; Snow avalanches; Rock bursts; Mapping, monitoring and managementof geological hazards. **References/Text Books:**	GEOLOGICAL HAZARDS
CE645	2-0-2--4	CE242	**Course Contents:** Introduction to physical and structural geology; Landforms and drainage patterns;Elements of photogeology; Stereoscopy; Elementary photogrammetry; Photographicsystems, types of cameras, films and filters; Photointerpretation key; Quantitativeinterpretation of toposheets and airphotos; Applications in engineering geology,landuse, land wastage, hydrogeology, mineral exploration and change detection. **References/Text Books:**	PHOTOGEOLOGY IN TERRAIN EVALUATION
CE646	3-0-0--4		**Course Contents:** Introduction to global climate; Global climatic models; Methods of reconstructingclimate; Quaternary climates, sea level changes, glacial/interglacial cycles;Geological records of climate change, sedimentology, stable isotopes, geochemistry;Geochronology relative and numerical methods; Vegetation dynamics, migrationhistory, response of vegetation to climatic reversals; Prequaternary climates,evolution of climate through geological time. **References/Text Books:**	GLOBAL CLIMATE CHANGE
CE647	3-0-0--4		**Course Contents:** Plate tectonic and its relation to earthquakes; Historical and modern seismicity;Mapping of active tectonic landforms in different tectonic environments; Fieldtechniques in paleoseismology, identification of old (prehistoric) earthquake bytrenching, estimation of magnitude, slip rates, and recurrence interval of faults,prediction of future earthquake, identification of paleoliquefaction features;Dating techniques; Correlation of paleoseismic data with existing geodetic andgeophysical data; Delineation of seismogenic	PALEOSEISMOLOGY AND TECTONIC GEOMORPHOLOGY

			faults and their related seismichazard; Seismic hazard assessment (SHA). **References/Text Books:**	
CE651	3-0-1-0-5		**Course Contents:** Production & properties of normal concrete : Introduction to portland cement concrete concrete production operations Indian Standard and ACI Mix design of concrete Fresh and hardened properties of concrete Durability of concrete Role of ingredients in concrete Physical and chemical characteristics of pozzolans Role of admixtures and additives in concrete Experimental test parameters and measurements during concrete testing, Special cements : Need Classifications Blended cements, modified hydraulic cements, calcium aluminate cements, calcium sulfate based binders, calcium sulfoaluminate cements, GGBS based cements, shrinkage compensating (or) expansive cements Other special cements: macrodefect free cements, phosphate cements, expansive cements, fastsetting cements, oil well cements Performance and prescriptive specifications, Special concretes : Importance and need high performance concrete and property based classifications. Special concretes: Mass concrete, selfcompacting or selfconsolidating concrete, fiber reinforced concrete, high strength concretes, highvolume fly ash concretes, geopolymer concrete, roller compacting concrete, pervious concrete, light weight concrete, aerated concrete, polymer or polymer modified concretes, ultrahigh performance concretes and others. Mixture proportioning and parameters in the development of special concretes. **References/Text Books:** [1] Neville, A.M., Properties of concrete, 5th Edition, Pitman Publishers, 1996.[2] Mehta, P.K., and Monteiro P.J.M., Concrete Structure, Properties and Materials, 2nd Edition, PrenticeHall, Inc., 2nd and 3rd Editions (1993 or 2006).[3] Kalousek, G. L. et al, Klein Symposium on Expansive Cement Concretes, 1973[4] Bapat, J.D., Mineral admixtures in cement and concrete, 2013[5] High Performance Concrete (Modern Concrete Technology)by PierreClaude Atcin(Aug 25, 1998)[6] High Performance Concrete: From material to structure (Modern Concrete Technology)by Y. Malier(Dec 31, 1990)	SPECIAL CONCRETES
CE651A	3-0-0-0-9		**Course Contents:** Production & properties of normal concrete : Introduction to portland cement concrete concrete production operations Indian Standard and ACI Mix design of concrete Fresh and hardened properties of concrete Durability of concrete Role of ingredients in concrete Physical and chemical characteristics of pozzolans Role of admixtures and additives in concrete Experimental test parameters and measurements during concrete testing, Special cements : Need Classifications Blended cements, modified hydraulic cements, calcium aluminate cements, calcium sulfate based binders, calcium sulfoaluminate cements, GGBS based cements, shrinkage compensating (or) expansive cements Other special cements: macrodefect free cements, phosphate cements, expansive cements, fastsetting cements, oil well cements Performance and prescriptive specifications, Special concretes : Importance and need high performance concrete and property based classifications. Special concretes: Mass concrete, selfcompacting or selfconsolidating concrete, fiber reinforced concrete, high strength concretes, highvolume fly ash concretes, geopolymer concrete, roller compacting concrete, pervious concrete, light weight concrete, aerated concrete, polymer or polymer modified concretes, ultrahigh performance concretes and others. Mixture proportioning and parameters in the development of special concretes. **References/Text Books:** Course Reference : [1] Neville, A.M., Properties of concrete, 5th Edition, Pitman Publishers, 1996.[2] Mehta, P.K., and Monteiro P.J.M., Concrete Structure, Properties and Materials, 2nd Edition, PrenticeHall, Inc., 2nd and 3rd Editions (1993 or 2006).[3] Kalousek, G. L. et al, Klein Symposium on Expansive Cement Concretes, 1973[4] Bapat, J.D., Mineral admixtures in cement and concrete, 2013[5] High Performance Concrete (Modern Concrete Technology)by PierreClaude Atcin(Aug 25, 1998)[6] High Performance Concrete: From material to structure (Modern Concrete Technology)by Y. Malier(Dec 31, 1990)	SPECIAL CONCRETES
CE671A	3-0-2-0-11		**Course Contents:**	INTRODUCTION TO

			Remote sensing system; Physics of remote sensing, EMR characteristics andinteraction in atmosphere and with ground objects; Sensor types characteristics:types of resolution, FOV, IFOV, PSF; RS satellites and data products; Imageprocessing, interpretation elements; Classification; Geometric and radiometricdistortions, Georeferencing, resampling methods; Atmospheric errors andremoval; Satellite orbits and characteristics; Applications of optical and microwaveremote sensing techniques in Civil Engineering. **References/Text Books:**	REMOTE SENSING
CE671N	3-0-2--5		**Course Contents:** Remote sensing system; Physics of remote sensing, EMR characteristics andinteraction in atmosphere and with ground objects; Sensor types characteristics:types of resolution, FOV, IFOV, PSF; RS satellites and data products; Imageprocessing, interpretation elements; Classification; Geometric and radiometricdistortions, Georeferencing, resampling methods; Atmospheric errors andremoval; Satellite orbits and characteristics; Applications of optical and microwaveremote sensing techniques in Civil Engineering. **References/Text Books:**	INTRODUCTION TO REMOTE SENSING
CE672	3-0-0--4		**Course Contents:** Image processing system; Preprocessing of remotely sensed data; Radiometricand Geometric distortions and corrections; Image enhancement; Imagetransformations; Pattern recognition. **References/Text Books:**	MACHINE PROCESSING OF REMOTELY SENSED DATA
CE672A	3-0-0-0-9		**Course Contents:** Image processing system; Preprocessing of remotely sensed data; Radiometricand Geometric distortions and corrections; Image enhancement; Imagetransformations; Pattern recognition. **References/Text Books:**	MACHINE PROCESSING OF REMOTELY SENSED DATA
CE673A	0-0-0-0-9		**Course Contents:** Use of automatic and digital levels, electronic theodolites, total stations, planetabling; Control surveys using GPS, Total station and triangulation methods(adjustment and computations of coordinates); Cartography and report writing. **References/Text Books:**	INSTRUMENTATION, LABORATORY AND FIELD PRACTICES IN GEOINFORMATICS
CE673N	3-0-0--3		**Course Contents:** Use of automatic and digital levels, electronic theodolites, total stations, planetabling; Control surveys using GPS, Total station and triangulation methods(adjustment and computations of coordinates); Cartography and report writing. **References/Text Books:**	INSTRUMENTATION, LABORATORY AND FIELD PRACTICES IN GEOINFORMATICS
CE674	2-0-2-0-4		**Course Contents:** GLOBAL NAVIGATION SATELLITE SYSTEMS(GNSS) Course Details: 1.Overview of GNSS and Introduction to GPS, GLONASS, GALILEO, COMPASS, IRNSS systems. 2. GPS: Basic concepts, signal structure and code modulation Pseudorange measurements and navigation position. 3. Errors and biases in GPS measurements, Accuracy of navigation position: UERE and DOP. Intentional degradation of GPS signals: Selective availability (SA) and Antispoofing (AS), Differential GPS: Space based augmentation systems (e.g., SBAS, GAGAN) and Ground based augmentation systems (e.g., WASS, EGNOS) 4. GPS Carrier Phase measurements: Signal Differencing, Double Differencing and Triple Differencing in GPS measurements. Ambiguity resolution, multi path and other observational errors, Doppler effect on GPS signals, Code and Phase combinations for Ionosphere free, Geometry free, Multipath reduction, Ambiguity	GLOBAL POSITIONING SYSTEMS (GNSS)

			resolution, Code smoothing, Cycle slip detection and repair. 5. GPS data processing, sequential solutions, Kalman filtering and adjustment computation for GPS. 6. Surveying with GNSS: Point positioning, Relative positioning, Static and Kinematic positioning. Planning and field observations, Networking, Data Post processing, GIS and GPS integration. 7. GNSS applications to Earth Systems, IGS and IERS services. **References/Text Books:** 1. Diggelen, Frank van, 2009, AGPS: Assisted GPS, GNSS, and SBAS, Artech House: Boston, pp: 400. 2. Guochang, X., 2007. GPS: Theory, Algorithms and Applications, Springer: Berlin, pp. 355. 3. Hafmann, B., Lichtenegger H. and Collins J., 2001. Global Positioning Systems: Theory and Practice (5th ed), Springer: Berlin, pp. 382. 4. Hafmann, B., Lichtenegger H. and Wasle, E., 2008, GNSS Global Navigation Satelite Systems: GPS, GLONASS, Galileo, and more, Springer: Berlin, pp.546. 5. International Committee on Global Navigation Satelite Systems, 2010, Current and Planned Global and Regional Navigation Satelite Systems and Satelitebased Augmentations Systems, United Nations: NY, pp.70.	
CE674A	2-0-2-0-8		**Course Contents:** 1.Overview of GNSS and Introduction to GPS, GLONASS, GALILEO, COMPASS, IRNSS systems. 2. GPS: Basic concepts, signal structure and code modulation Pseudorange measurements and navigation position. 3. Errors and biases in GPS measurements, Accuracy of navigation position: UERE and DOP. Intentional degradation of GPS signals: Selective availability (SA) and Antispoofing (AS), Differential GPS: Space based augmentation systems (e.g., SBAS, GAGAN) and Ground based augmentation systems (e.g., WASS, EGNOS) 4. GPS Carrier Phase measurements: Signal Differencing, Double Differencing and Triple Differencing in GPS measurements. Ambiguity resolution, multi path and other observational errors, Doppler effect on GPS signals, Code and Phase combinations for Ionosphere free, Geometry free, Multipath reduction, Ambiguity resolution, Code smoothing, Cycle slip detection and repair. 5. GPS data processing, sequential solutions, Kalman filtering and adjustment computation for GPS. 6. Surveying with GNSS: Point positioning, Relative positioning, Static and Kinematic positioning. Planning and field observations, Networking, Data Post processing, GIS and GPS integration. 7. GNSS applications to Earth Systems, IGS and IERS services. **References/Text Books:** 1. Diggelen, Frank van, 2009, AGPS: Assisted GPS, GNSS, and SBAS, Artech House: Boston, pp: 400. 2. Guochang, X., 2007. GPS: Theory, Algorithms and Applications, Springer: Berlin, pp. 355. 3. Hafmann, B., Lichtenegger H. and Collins J., 2001. Global Positioning Systems: Theory and Practice (5th ed), Springer: Berlin, pp. 382. 4. Hafmann, B., Lichtenegger H. and Wasle, E., 2008, GNSS Global Navigation Satelite Systems: GPS, GLONASS, Galileo, and more, Springer: Berlin, pp.546. 5. International Committee on Global Navigation Satelite Systems, 2010, Current and Planned Global and Regional Navigation Satelite Systems and Satelitebased Augmentations Systems, United Nations: NY, pp.70.	GLOBAL NAVIGATION SATELLITE SYSTEMS(GNSS)
CE676	2-0-3-0-4		**Course Contents:** Altimetric LiDAR: Physics of laser, spectral characteristics of laser, laserinteraction with objects; Airborne Altimetric LiDAR: principle: topographic andbathymetric LiDAR, multiple return, full wave digitization; Components of aLiDAR system, INS technology, INSGPS integration, measurement of laser range,calibration; Flight planning; LiDAR geolocation models; Accuracy of variouscomponents of LiDAR and error propagation, error analysis of data and errorremoval; Data classification techniques, raw data to bald earth DEM processing,uses of return intensity and full waveform in information extraction, LiDARdata integration with spectral data; LiDAR applications: building, tree, powerline extraction; LiDAR data visualization; Photogrammetry: metric and nonmetriccameras; Geometry of near vertical and tilted photographs, heights andtilt distortions; Rectification and orthophotographs; Stereoscopy, parallax equationand stereo measurements for height determination; Orientation interior,exterior, relative, and absolute, Mathematical model relating image, model andobject space; Collinearity and coplanarity conditions, DLT; Image matchingtechniques; Strip and block triangulation and adjustment; Automatic DTM andOrthophoto production.	LASER SCANNING AND PHOTOGRAMMETRY

			References/Text Books:	
CE676A	2-0-3-0-9	CE671A	**Course Contents:** Altimetric LiDAR: Physics of laser, spectral characteristics of laser, laserinteraction with objects; Airborne Altimetric LiDAR: principle: topographic andbathymetric LiDAR, multiple return, full wave digitization; Components of aLiDAR system, INS technology, INSGPS integration, measurement of laser range,calibration; Flight planning; LiDAR geolocation models; Accuracy of variouscomponents of LiDAR and error propagation, error analysis of data and errorremoval; Data classification techniques, raw data to bald earth DEM processing,uses of return intensity and full waveform in information extraction, LiDARdata integration with spectral data; LiDAR applications: building, tree, powerline extraction; LiDAR data visualization; Photogrammetry: metric and nonmetriccameras; Geometry of near vertical and tilted photographs, heights andtilt distortions; Rectification and orthophotographs; Stereoscopy, parallax equationand stereo measurements for height determination; Orientation interior,exterior, relative, and absolute, Mathematical model relating image, model andobject space; Collinearity and coplanarity conditions, DLT; Image matchingtechniques; Strip and block triangulation and adjustment; Automatic DTM andOrthophoto production. **References/Text Books:**	LASER SCANNING AND PHOTOGRAMMETRY
CE677A	3-0-0-0-9		**Course Contents:** Geodetic reference systems: ICRF and ITRF, Geodetic datums, Earth ellipsoid;basic geometric geodesy; Coordinate systems and transformation; Map projections,geoid and geoidal heights and undulations; Observations and mathematicalmodel, precision and accuracy, rejection of observations, weights and cofactors,correlation and covariance, propagation of errors and variancecovariance; Leastsquares adjustment computations; Sequential processing and Kalman Filtering;Variancecovariance of adjusted data, error ellipse and error ellipsoid; Statisticalanalysis of adjusted data; Introduction to GPS; Code and phase measurements;Models for single point positioning and relative positioning using code and phasedata; Methods of interpolation; Geostatistical tools: variogram and krigging. **References/Text Books:**	GEOSPATIAL DATA PROCESSING
CE677N	3-0-0--4		**Course Contents:** Geodetic reference systems: ICRF and ITRF, Geodetic datums, Earth ellipsoid;basic geometric geodesy; Coordinate systems and transformation; Map projections,geoid and geoidal heights and undulations; Observations and mathematicalmodel, precision and accuracy, rejection of observations, weights and cofactors,correlation and covariance, propagation of errors and variancecovariance; Leastsquares adjustment computations; Sequential processing and Kalman Filtering;Variancecovariance of adjusted data, error ellipse and error ellipsoid; Statisticalanalysis of adjusted data; Introduction to GPS; Code and phase measurements;Models for single point positioning and relative positioning using code and phasedata; Methods of interpolation; Geostatistical tools: variogram and krigging. **References/Text Books:**	GEOSPATIAL DATA PROCESSING
CE678	3-0-0-0-4		**Course Contents:** Geometric geodesy: DatumsHorizontal & Vertical, GRS80, WGS84, ITRF. Transformation of Coordinates from one datum to another. Mean Sea level, Geoid and MSL in India. Coordinate Systems in Geodesy, Geometry of Ellipsoid, level Surface and Plumb Line, Deflection of vertical, Geoidal Separation, Natural Coordinates, Astrogeodetic deflection.Physical geodesy: Fundamentals of potential theory, Laplace Equation in spherical coordinates, Solution of Laplace Equation, Brun's formula, Fundamental equation of Physical Geodesy, Stokes' Formula, Gravity, Gravitational Potential and Gravity potential, Anomalous Gravity field, Gravity Anomaly, Gravity reductions: Free Air, Bouger and Isostatic reduction, Earth Gravity Models, Potential number and different height systems.Map Projection: Introduction to Map projection, Purpose and methods of Map projection and their classification. Conformal Map projections LCC and Transverse	INTRODUCTION TO GEODESY

			Mercator Projections. Indian Grid System and UTM.Astronomy: Celestial Sphere, Definition of terms in Astronomy, Celestial coordinate systems, Variations in Celestial coordinates. Precession and Nutation. Time systems Sidereal time, Ephemeries time, Atomic time. Rotational Time systems: UT0, UT1, UT2, CIO and Polar motion, Earth Rotation parameters and Leap second.Satellite geodesy: Introduction to Satellite Geodesy, Keplerian Motion, Geometry of ellipse, Kepler ellipse in space, Perturbed satellite motion, Lagrange's and Gaussian form of perturbation equations. Introduction to GNSS satellite systems, Satellite Laser ranging, Satellite Altimetry, VLBI. **References/Text Books:**	
CE678A	3-0-0-0-9		**Course Contents:** Geometric geodesy: DatumsHorizontal & Vertical, GRS80, WGS84, ITRF. Transformation of Coordinates from one datum to another. Mean Sea level, Geoid and MSL in India. Coordinate Systems in Geodesy, Geometry of Ellipsoid, level Surface and Plumb Line, Deflection of vertical, Geoidal Separation, Natural Coordinates, Astrogeodetic deflection.Physical geodesy: Fundamentals of potential theory, Laplace Equation in spherical coordinates, Solution of Laplace Equation, Brun's formula, Fundamental equation of Physical Geodesy, Stokes' Formula, Gravity, Gravitational Potential and Gravity potential, Anomalous Gravity field, Gravity Anomaly, Gravity reductions: Free Air, Bouger and Isostatic reduction, Earth Gravity Models, Potential number and different height systems.Map Projection: Introduction to Map projection, Purpose and methods of Map projection and their classification. Conformal Map projections LCC and Transverse Mercator Projections. Indian Grid System and UTM.Astronomy: Celestial Sphere, Definition of terms in Astronomy, Celestial coordinate systems, Variations in Celestial coordinates. Precession and Nutation. Time systems Sidereal time, Ephemeries time, Atomic time. Rotational Time systems: UT0, UT1, UT2, CIO and Polar motion, Earth Rotation parameters and Leap second.Satellite geodesy: Introduction to Satellite Geodesy, Keplerian Motion, Geometry of ellipse, Kepler ellipse in space, Perturbed satellite motion, Lagrange's and Gaussian form of perturbation equations. Introduction to GNSS satellite systems, Satellite Laser ranging, Satellite Altimetry, VLBI. **References/Text Books:**	INTRODUCTION TO GEODESY
CE682	3-0-0-0-4		**Course Contents:** Introduction to supply and demand sides of transportation engineering, analysisof transportation demand (including topics such as category analysis, gravitymodel, entropy models, choice models, user equilibrium models, etc.). Introductionto public transportation. Designing efficient public transport systems (includingtopics such as route development, schedule development, pricing strategies,etc.). Concept of structural, functional and drainage design of pavementstructure. Design of flexible and rigid pavement various approaches. Cost andreliability considerations. Pavement maintenance issues. Pavement distresses,distress evaluation, maintenance measures, and network level maintenance strategy. **References/Text Books:**	ANALYSIS AND DESIGN OF TRANSPORTATION INFRASTRUCTURE
CE682A	4-0-0-0-12		**Course Contents:** Introduction to supply and demand sides of transportation engineering, analysisof transportation demand (including topics such as category analysis, gravitymodel, entropy models, choice models, user equilibrium models, etc.). Introductionto public transportation. Designing efficient public transport systems (includingtopics such as route development, schedule development, pricing strategies,etc.). Concept of structural, functional and drainage design of pavementstructure. Design of flexible and rigid pavement various approaches. Cost andreliability considerations. Pavement maintenance issues. Pavement distresses,distress evaluation, maintenance measures, and network level maintenance strategy. **References/Text Books:**	ANALYSIS AND DESIGN OF TRANSPORTATION INFRASTRUCTURE
CE682N	4-0-0--4		**Course Contents:**	ANALYSIS AND DESIGN OF

			Introduction to supply and demand sides of transportation engineering, analysisof transportation demand (including topics such as category analysis, gravitymodel, entropy models, choice models, user equilibrium models, etc.). Introductionto public transportation. Designing efficient public transport systems (includingtopics such as route development, schedule development, pricing strategies,etc.). Concept of structural, functional and drainage design of pavementstructure. Design of flexible and rigid pavement various approaches. Cost andreliability considerations. Pavement maintenance issues. Pavement distresses,distress evaluation, maintenance measures, and network level maintenance strategy. **References/Text Books:**	TRANSPORTATION INFRASTRUCTURE
CE683	3-0-0--4		**Course Contents:** Microscopic and macroscopic traffic parameters, traffic flow models, carfollowingmodels, capacity and level of service analysis, design of traffic facilitieslike unsignalized and signalized intersections, inter changes, expressways, trafficsigns, parking areas etc., simulation of traffic streams. **References/Text Books:**	TRAFFIC ENGINEERING
CE683A	3-0-0-0-9		**Course Contents:** Microscopic and macroscopic traffic parameters, traffic flow models, carfollowingmodels, capacity and level of service analysis, design of traffic facilitieslike unsignalized and signalized intersections, inter changes, expressways, trafficsigns, parking areas etc., simulation of traffic streams. **References/Text Books:**	TRAFFIC ENGINEERING
CE684	3-0-0--4		**Course Contents:** Dimensions of the widening role of urban transportation system planning; theplanning process; land use and transport system models; comparison andevaluation of various models; transportation impact study methodologies;strategies for the evaluation of alternative transportation plans and planimplementation; Regional analysis and plan implementation; Regional Analysisand development concepts; the role of transportation planning in the overallregional system; methodology and models for regional transportation systemplanning; implementation framework and case studies. **References/Text Books:**	URBAN TRANSPORTATIONS SYSTEMS
CE688	3-0-0--4		**Course Contents:** Air Transportstructure and organization, the challenges and the issues, Forecastingair travel demandtrend forecasts and analytical methods; Air freight demand,Characteristics of the aircraft as they affect airport; Airport planningrequirements:site selection, layout plan and financial plan; Air traffic control lighting andsigning; Airport capacity and configuration; Geometric design of runway, taxiwayand aprons; passenger terminal functions, passenger and baggage flow, designconcepts, analysis of flow through terminals, parking configurations and apronfacilities; Air cargo facilitiesflow through cargo terminals, unitized systems;Airport drainage and pavement design; Airport access problem; Environmentalimpact of airports. **References/Text Books:**	AIRPORT SYSTEMS PLANNING AND DESIGN
CE688A	3-0-0-0-9		**Course Contents:** Air Transport structure and organization, the challenges and the issues, Forecasting air travel demand trend forecasts and analytical methods; Air freight demand, Characteristics of the aircraft as they affect airport; Airport planning requirements: site selection, layout plan and financial plan; Air traffic control lighting and signing; Airport capacity and configuration; Geometric design of runway, taxiway and aprons; passenger terminal functions, passenger and baggage flow, design concepts, analysis of flow through terminals, parking configurations and apron facilities; Air cargo facilities flow through cargo terminals, unitized systems;	AIRPORT SYSTEMS PLANNING AND DESIGN

			Airport drainage and pavement design; Airport access problem; Environmental impact of airports. **References/Text Books:**	
CE689A	3-0-0-0-9		**Course Contents:** Components of a pavement structure. Experimental characterization of pavementmaterials bituminous mix, aggregates, subgrade, cemented material. Materialmodeling viscoelastic, viscoplastic behaviour. Load stresses in pavements,generalized multilayer solution Burmister layer, slab, foundation models. Staticand dynamic analysis. Fatigue and rutting modeling and calibration. Temperaturestresses in pavements. Estimation of cumulative damage. **References/Text Books:**	CHARACTERIZATION OF PAVEMENT MATERIALS AND ANALYSIS OF PAVEMENTS
CE689N	3-0-0--4		**Course Contents:** Components of a pavement structure. Experimental characterization of pavementmaterials bituminous mix, aggregates, subgrade, cemented material. Materialmodeling viscoelastic, viscoplastic behaviour. Load stresses in pavements,generalized multilayer solution Burmister layer, slab, foundation models. Staticand dynamic analysis. Fatigue and rutting modeling and calibration. Temperaturestresses in pavements. Estimation of cumulative damage. **References/Text Books:**	CHARACTERIZATION OF PAVEMENT MATERIALS AND ANALYSIS OF PAVEMENTS
CE690	1-0-6-0-4		**Course Contents:** Experiments to characterize pavement materials like, viscosity tests, ageing tests, skid tests, etc. Experiments to characterize bituminous mixes, like mixdesign related experiments, moisture sensitivity related experiments, etc.Experiments related to traffic data collections on speed, volume, travel time,delay, etc. Traffic studio (students will learn to use geometric design softwareand video data analysis software). Demonstrations of various equipmentsincluding possible visits to advanced labs and road systems. **References/Text Books:**	LABORATORY COURSE IN TRANSPORTATION ENGINEERING
CE690A	1-0-6-0-9		**Course Contents:** Experimental on road surface characterizationRelationship between vscosity and some of its measuresExperiments on Bituminous mixedSubgrade improvement techniques for pavementExperiments on traffic flow characterizationComputer aided analysis and design techniques in transportation engineeringEquiment demonstrator/explanation of worker principle of some equipments relevant to highway industry **References/Text Books:**	LABORATORY COURSE IN TRANSPORTATION ENGINEERING
CE690N	0-0-6--3		**Course Contents:** Experiments to characterize pavement materials like, viscosity tests, ageing tests, skid tests, etc. Experiments to characterize bituminous mixes, like mixdesign related experiments, moisture sensitivity related experiments, etc.Experiments related to traffic data collections on speed, volume, travel time,delay, etc. Traffic studio (students will learn to use geometric design softwareand video data analysis software). Demonstrations of various equipmentsincluding possible visits to advanced labs and road systems. **References/Text Books:**	LABORATORY COURSE IN TRANSPORTATION ENGINEERING
CE698	1-0-3-2-0		**Course Contents:** There will be 14 lectures in the semester on importance of good communication skills,technical writing (notes, papers, thesis, etc.), technical presentation (speed, content visa vis audience, visual and audio aids, development of a talk), ethics, expectations as a listener from a technical talk, formulating questions (as a	TECHNICAL PRESENTATION

			member ofthe audience) and answers (as the speaker), etc.Each student will be required to present two seminars on a given topic; the first seminar by a student will cover parts of the entire topic. Seminars may also be of varying durations for the same amount of material to be covered. Following each seminar there will be a discussion on the seminar led by the faculty in charge of the course. Each student will also need to submit two reports on the same topic. One will be a short report and the other will be a longer report (like a project report). The objective is for a student to lean how to deliver the same content at various levels of detail (both writing as well as in presentation mode). **References/Text Books:** Chambers, H.E. (2001), Effective Communication Skills for Scientific and TechnicalProfessionals, Perseus.Elbow, P. (1981), Writing With Power: Techniques for Mastering the Writing Process,Oxford University Press.Stevenson, S. (2002), Strategies for Engineering Communication, John Wiley and Sons. Turk. C. and Kirkman, J. (1989), Effective Writing: Improving Scientific, Technical, andBusiness Communication, Routledge.	
CE698A	0-0-0-0-3		**Course Contents:** Components of a pavement structure. Experimental characterization of pavementmaterials bituminous mix, aggregates, subgrade, cemented material. Materialmodeling viscoelastic, viscoplastic behaviour. Load stresses in pavements,generalized multilayer solution Burmister layer, slab, foundation models. Staticand dynamic analysis. Fatigue and rutting modeling and calibration. Temperaturestresses in pavements. Estimation of cumulative damage. **References/Text Books:**	CHARACTERIZATION OF PAVEMENT MATERIALS AND ANALYSIS OF PAVEMENTS
CE699	-0-0--		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M. TECH THESIS
CE699.	----9		**Course Contents:** M.TECH THESIS (FOR DUAL DEGREE ONLY) **References/Text Books:**	M.TECH THESIS (FOR DUAL DEGREE ONLY)
CE710	3-0-0-4-4		**Course Contents:** The course will consist of three components expert systems (ES), ANNs, andGAs. The contents for expert systems include history ofES, basic concepts ofES, definition and components of ES, inference engines and reasoning mechanisms e.g. forward reasoning, backward reasoning, and mixed reasoning, knowledge representation methods and development of the rule based knowledge base, dealing with uncertainty, and selected case studies of ES applications to engineering and sciences. The topics to be covered for ANNs include background and history of ANNs, definitions and basic concepts of ANNs, biological and artificial networks, feedforward and feedback networks, supervised and unsupervised learning methodsstandard backpropagation (BP), conjugate gradients BP, self organizing networks, etc., development of ANN models for specific problems and selected case studies. The course contents for the GAs include fundamentals and preliminary concepts of evolution and GA, preliminaries of optimization, genetic operatorsselection, crossover, and mutation, binary and realcoded GAs, constraint handling in GAs, and selected case studies involving GA applications to engineering.The course will have invited lectures in the form of case studies of the application of AI techniques to different areas in engineering by faculty members of liT Kanpur. The course is planned for PG students initially but can be opened as aUG elective also depending upon the interest and need. The course evaluation will include a project/term paper that will require a student or a group of students to develop an ES or ANN, or apply GA for solving certain problem in the chosen field. **References/Text Books:**	INTRODUCTION TO AI TECHNIQUES

CE717	3-0-0--4		**Course Contents:** Groundwater as a resource, general problems of chemical contamination ingroundwater; Fluid potential, hetrogenity and anisotropy; Aquifiers, aquitradsand general geology, well hydraulics, parameter estimation; Steady and transientflow equations, unsaturated flow equation; Pollutant transport in groundwater,chemical and transport processes, numerical modeling and solution, breakthrough curves; Seawater intrusion in coastal aquifiers; Modelling of pollutanttransport in the unsaturated zone; Optimization models for management ofgroundwater quantity and quality; Optimal monitoring network design; Multipleobjective management; Conjective management of surface and groundwater;Special topics. **References/Text Books:**	GROUNDWATER HYDROLOGY & POLLUTANT TRANSPORT
CE723	3-0-0-4-4		**Course Contents:** 1. Problem formulation, numerical and closed form solutions, weak form, collocation, least square, Galerkin technique, derivation of finite element equations, stiffness matrices, global assembly, coordinate transformation, enforcing boundary conditions, solution of the systems of equations. Convergence, Stability and possible sources of errors.(2. Formulation of one dimensional truss and beam elements. Application to 2D trusses and frames.3. Formulation of 2D problems involving plane stress, plane strain, and axis symmetry.Applications to pressure vessels, chimneys, dams, embankments, and pavements4. Formulation of plate bending elements. Bending of plate, Von Karman nonlinear plate theory and formulation.5. Formulation of thin shell elements. Applications to dome, water tank etc.6. Formulation of three dimensional brick elements. Applications to stress analysis in dam, earthen embankment, tunnel, etc.7. Nonlinear static and dynamic problems; geometric and material nonlinearity, Pdelta effectsin tall buildings, elastoplastic analysis as encountered in structures and geotechnical mechanics, seismic soilfoundationstructure interaction problems.8. Formulation for contact elements, infinite elements and crack tip elements.9. CE applications such as 3D elastic problems, consolidation, seepage, transpott and propagation through heterogeneous media.10. Finite element formulation of fluid flow and transp01t problems. Applications to pipe, openchannel flow, contaminant and species transport with emphasis to hydraulics and environmental flow modeling. **References/Text Books:**	FINITE ELEMENT METHODS FOR CIVIL ENGINEERING APPLICATIONS
CE723N	3-0-0-0-4		**Course Contents:** 1. Problem formulation, numerical and closed form solutions, weak form, collocation, least square, Galerkin technique, derivation of finite element equations, stiffness matrices, global assembly, coordinate transformation, enforcing boundary conditions, solution of the systems of equations. Convergence, Stability and possible sources of errors.(2. Formulation of one dimensional truss and beam elements. Application to 2D trusses and frames.3. Formulation of 2D problems involving plane stress, plane strain, and axis symmetry.Applications to pressure vessels, chimneys, dams, embankments, and pavements4. Formulation of plate bending elements. Bending of plate, Von Karman nonlinear plate theory and formulation.5. Formulation of thin shell elements. Applications to dome, water tank etc.6. Formulation of three dimensional brick elements. Applications to stress analysis in dam, earthen embankment, tunnel, etc.7. Nonlinear static and dynamic problems; geometric and material nonlinearity, Pdelta effectsin tall buildings, elastoplastic analysis as encountered in structures and geotechnical mechanics, seismic soilfoundationstructure interaction problems.8. Formulation for contact elements, infinite elements and crack tip elements.9. CE applications such as 3D elastic problems, consolidation, seepage, transpott and propagation through heterogeneous media.10. Finite element formulation of fluid flow and transp01t problems. Applications to pipe, openchannel flow, contaminant and species transport with emphasis to hydraulics and environmental flow modeling. **References/Text Books:**	FINITE ELEMENT METHODS FOR CIVIL ENGINEERING APPLICATIONS
CE731	3-0-0-0-4		**Course Contents:** Introduction: Sources and types of uncertainties associated with geotechnical analysis,importance of	RISK & RELIABILITY IN GEOTECHNICAL

			probabilistic methods and reliabilitybased analysis in geotechnicalengineering Review of probability and statistics: Discrete and continuous random variables, parameterestimation, testing of hypothesis, regression analysis Fundamentals of reliability analysis: FirstOrder Second Moment (FOSM) method, FirstOrderReliability Method (FORM), SecondOrder Reliability Method (SORM), Monte Carlosimulation Application towards geotechnical problems: Characterization of uncertainty in fieldmeasured and laboratorymeasured soilproperties, uncertainty in interpretation techniques Spatial variability of soil properties, scale of fluctuations, estimation of autocorrelationand autocovariance Probabilistic groundwater modeling, flow through earth dams Probabilistic slope stability analysis Fundamentals of LRFD design methodology, reliabilitybased design of shallow anddeep foundations, settlement analysis Reliabilitybased liquefaction analysis, lateral spreading Development of fragility curves for geotechnical problems **References/Text Books:** 1. Fenton, G. A and Griffiths, D. V. (2008). Risk Assessment in Geotechnical Engineering,Wiley, New York.2. Phoon, K. K. (Ed.) (2008). ReliabilityBased Design in Geotechnical Engineering:Computations and Applications, CRC Press.3. Griffiths, D. V. and Fenton, G. A. (Eds.) (2007) Probabilistic Methods in GeotechnicalEngineering, SpringerWienNewYork.4. Baecher, G. and Christian, J. (2003). Reliability and Statistics in GeotechnicalEngineering, Wiley, New York.	ENGINEERING
CE731A	3-0-0-0-9		**Course Contents:** Introduction: Sources and types of uncertainties associated with geotechnical analysis,importance of probabilistic methods and reliabilitybased analysis in geotechnicalengineering Review of probability and statistics: Discrete and continuous random variables, parameterestimation, testing of hypothesis, regression analysis Fundamentals of reliability analysis: FirstOrder Second Moment (FOSM) method, FirstOrderReliability Method (FORM), SecondOrder Reliability Method (SORM), Monte Carlosimulation Application towards geotechnical problems: Characterization of uncertainty in fieldmeasured and laboratorymeasured soilproperties, uncertainty in interpretation techniques Spatial variability of soil properties, scale of fluctuations, estimation of autocorrelationand autocovariance Probabilistic groundwater modeling, flow through earth dams Probabilistic slope stability analysis Fundamentals of LRFD design methodology, reliabilitybased design of shallow anddeep foundations, settlement analysis Reliabilitybased liquefaction analysis, lateral spreading Development of fragility curves for geotechnical problems **References/Text Books:** 1. Fenton, G. A and Griffiths, D. V. (2008). Risk Assessment in Geotechnical Engineering,Wiley, New York.2. Phoon, K. K. (Ed.) (2008). ReliabilityBased Design in Geotechnical Engineering:Computations and Applications, CRC Press.3. Griffiths, D. V. and Fenton, G. A. (Eds.) (2007) Probabilistic Methods in GeotechnicalEngineering, SpringerWienNewYork.4. Baecher, G. and Christian, J. (2003). Reliability and Statistics in GeotechnicalEngineering, Wiley, New York.	RISK & RELIABILITY IN GEOTECHNICAL ENGINEERING
CE733	3-0-0--4		**Course Contents:** Identification, characterization and regulatory requirements for disposal ofhazardous, nonhazardous and domestic wastes. Waste ManagementRecycling,composting, incineration and various disposal methods. Site selection and Geoenvironmentalinvestigations. Natural attenuation process and mechanism ofattenuation. Design practices of solid wastes. Tailing dams for disposal of flyash,coal, copper, iron and other metal wastes. Single and double lined landfill design,linear material clay, geosynthetics amended soils and other admixtures. Leachatecollection and detection system. Landfill construction. Construction qualitycontrol and performance monitoring. Application of geosynthetics in wastedisposal design. **References/Text Books:**	GEOENVIRONMENTAL DESIGN ASPECTS OF SOLID WASTE MANAGEMENT
CE799	----	#	**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS

EEM602	3-0-0--4		**Course Contents:** Structure and basic properties of water their significance in environmentalengineering, sources of water impurities, abiotic reactions, biological metabolism.Solidliquidgas interactions, mass transfer and transport of impurities in waterand air, diffusion, dispersion. Physical and chemical interactions due to variousforces, suspensions and dispersions. Chemical reactions, chemical equilibrium,and chemical thermodynamics, acidbase equilibria, solubility equilibria, oxidationreductionequilibria. Process kinetics, reaction rates and catalysis, surface andcolloidal chemistry, adsorption. Settling of particles in water, coagulation andflocculation, filtration mechanisms and interpretations, ion exhange andadsorption, water stabilisation, acration and gas transfer. Membrane process;reverse osmosis, electrodialysis, desalination. **References/Text Books:**	PHYSICOCHEMICAL PRINCIPLES AND PROCESS
EEM602A	3-0-0-0-9		**Course Contents:** Structure and basic properties of water their significance in environmentalengineering, sources of water impurities, abiotic reactions, biological metabolism.Solidliquidgas interactions, mass transfer and transport of impurities in waterand air, diffusion, dispersion. Physical and chemical interactions due to variousforces, suspensions and dispersions. Chemical reactions, chemical equilibrium,and chemical thermodynamics, acidbase equilibria, solubility equilibria, oxidationreductionequilibria. Process kinetics, reaction rates and catalysis, surface andcolloidal chemistry, adsorption. Settling of particles in water, coagulation andflocculation, filtration mechanisms and interpretations, ion exhange andadsorption, water stabilisation, acration and gas transfer. Membrane process;reverse osmosis, electrodialysis, desalination. **References/Text Books:**	PHYSICOCHEMICAL PRINCIPLES AND PROCESS
EEM603	3-0-0--4		**Course Contents:** Ecosystems; biotic and abiotic components, production and consumption, trophiclevels, productivity and energy flow, food webs, cycling of elements. Ecologyof population; ecological niche, mortality and survivorship, community interactions.Changes in ecosystems; succession. long range changes, long range stability.The organisation and dynamics of ecological communities. Description andstudy of typical natural and artificial ecosystems. Biochemistry; photosynthesisand respiration, important biological compounds, enzymes. Microbiologicalconcepts; cells, classification and characteristics of living organisms,characterisation techniques, reproduction, metabolism, microbial growth kinetics.Applications to environmental engineering; assimilation of wastes, engineeredsystems, concepts and principles of carbon oxidation, nitrification, denitrification,methanogenasis, etc., concepts of quantization of degradable pollutants. **References/Text Books:**	ECOLOGICAL AND BIOLOGICAL PRINCIPLES AND PROCESS
EEM603A	3-0-0-0-9		**Course Contents:** Ecosystems; biotic and abiotic components, production and consumption, trophiclevels, productivity and energy flow, food webs, cycling of elements. Ecologyof population; ecological niche, mortality and survivorship, community interactions.Changes in ecosystems; succession. long range changes, long range stability.The organisation and dynamics of ecological communities. Description andstudy of typical natural and artificial ecosystems. Biochemistry; photosynthesisand respiration, important biological compounds, enzymes. Microbiologicalconcepts; cells, classification and characteristics of living organisms,characterisation techniques, reproduction, metabolism, microbial growth kinetics.Applications to environmental engineering; assimilation of wastes, engineeredsystems, concepts and principles of carbon oxidation, nitrification, denitrification,methanogenasis, etc., concepts of quantization of degradable pollutants. **References/Text Books:**	ECOLOGICAL AND BIOLOGICAL PRINCIPLES AND PROCESS
EEM604	2-0-4-0-4		**Course Contents:**	ENVIRONMENTAL

			Genral principles of sample collection and data analysis. Gravimetric methodsfor solids analysis in water and wastewater, determination of acidity, alkalinityand turbidity, analysis of common cations and anions in water/wastewaterthrough various chemical techniques, determination of nitrogen, phosphorus andchemical oxygen demand (COD). Titrimetric methods; acidbase titrations,precipitation titrations, complexometric titrations, oxidationreduction titrations.Electrochemical methods; working principles of electrodes, different types ofelectrodes. Spectrophotometric methods; Nephelometric methods; Atomicabsorption spectroscopy; Biological methods and microbiology; biochemicaloxygen demand (BOD), MPN test for microbial pollution, plate counts; confirmatorytests. Sampling techniques for air pollution measurements; analysis of particulatesand common chemical air pollutants like oxides of nitrogen, oxides of sulphur,carbon monoxide, hydrocarbon. **References/Text Books:**	QUALITY & POLLUTION MONITORING TECHNIQUES
EEM604A	2-0-3-0-9		**Course Contents:** Genral principles of sample collection and data analysis. Gravimetric methodsfor solids analysis in water and wastewater, determination of acidity, alkalinityand turbidity, analysis of common cations and anions in water/wastewaterthrough various chemical techniques, determination of nitrogen, phosphorus andchemical oxygen demand (COD). Titrimetric methods; acidbase titrations,precipitation titrations, complexometric titrations, oxidationreduction titrations.Electrochemical methods; working principles of electrodes, different types ofelectrodes. Spectrophotometric methods; Nephelometric methods; Atomicabsorption spectroscopy; Biological methods and microbiology; biochemicaloxygen demand (BOD), MPN test for microbial pollution, plate counts; confirmatorytests. Sampling techniques for air pollution measurements; analysis of particulatesand common chemical air pollutants like oxides of nitrogen, oxides of sulphur,carbon monoxide, hydrocarbon. **References/Text Books:**	ENVIRONMENTAL QUALITY & POLLUTION MONITORING TECHNIQUES
EEM606	3-0-0--4		**Course Contents:** Air pollutants, their sources and harmful effects on the environment; Meteorologyas applied to air pollution and dispersion of air pollutants; Air quality and emissionstandards; Air pollution legislation; Methods for monitoring and control, selectionof control equipment. Engineering control concepts; process change, fuel change;Pollutant removal and disposal of pollutants; Control devices and systems,removal of dry particulate matter, liquid droplets and mist removal, gaseouspollutants and odour removal. Control of stationary and mobile sources.Economics and trends in air pollution control. **References/Text Books:**	AIR POLLUTION AND ITS CONTROL
EEM606A	3-0-0-0-9		**Course Contents:** Air pollutants, their sources and harmful effects on the environment; Meteorologyas applied to air pollution and dispersion of air pollutants; Air quality and emissionstandards; Air pollution legislation; Methods for monitoring and control, selectionof control equipment. Engineering control concepts; process change, fuel change;Pollutant removal and disposal of pollutants; Control devices and systems,removal of dry particulate matter, liquid droplets and mist removal, gaseouspollutants and odour removal. Control of stationary and mobile sources.Economics and trends in air pollution control. **References/Text Books:**	AIR POLLUTION AND ITS CONTROL
EEM609	3-0-0-0-4		**Course Contents:** Introduction: concepts of scale in natural systems, brief review of the fate processes in the environment, examples of natural systems, principles of model formulation,calibration, validation, error estimation and sensitivity analysis. Derivation of generalized mass balance equation for contaminants in incompressible fluid (water) in the noninertial frame of reference. River Modeling: one dimensional advectiondispersionreaction model, river properties and estimation of parameters, different forcing situations	MODELING OF NATURAL SYSTEMS

			(point, nonpoint, aerial sources and sinks), sediment water interaction. Estuary Modeling: types and properties, flow characterization, advectiondispersion models, salt gradient box models. Lake Modeling: box models, generalized models, special considerations for large lakes, sediment mixing and interaction with water column. Wetlands : box models for flow, equilibrium and kinetic geochemical models for redox reactions, transport of heavy metals. **References/Text Books:** Schwarzenbach, R. P., Gschwend, P.M., Imboden, D. M. Environmental Organic Chemistry,2003, John Wiley & Sons. Fischer, H. B., List, E. J., Koh, R. C. Y, Imberger, J., Brooks, N. H. Mixing in Inland and Coastal Waters, Academic Press, Inc. Stumm, W., Morgan, J. J. Aquatic Chemistry, John Wiley & Sons, Inc., 1996. Alexander, M. Biodegradation and Bioremediation, Academic Press, 2"d Ed, 1999. Vallis, Geoffrey K. Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large Scale Circulations, 2006, Cambridge University Press. Marshall, John and Plumb, Alan R. Atmosphere, Ocean and Climate Dynamics: An Introductory Text, 2007, Academic Press. FinlaysonPitts, Barbara J. and Pitts, James N. Jr. Chemistry of the Upper and Lower Atmospthere: The01y, Experiments and Applications, 1999, Academic Press.	
EEM609A	3-0-0-0-9	MTH102A CE211A	**Course Contents:** Introduction: concepts of scale in natural systems, brief review of the fate processes in the environment, examples of natural systems, principles of model formulation,calibration, validation, error estimation and sensitivity analysis. Derivation of generalized mass balance equation for contaminants in incompressible fluid (water) in the noninertial frame of reference. River Modeling: one dimensional advectiondispersionreaction model, river properties and estimation of parameters, different forcing situations (point, nonpoint, aerial sources and sinks), sediment water interaction. Estuary Modeling: types and properties, flow characterization, advectiondispersion models, salt gradient box models. Lake Modeling: box models, generalized models, special considerations for large lakes, sediment mixing and interaction with water column. Wetlands : box models for flow, equilibrium and kinetic geochemical models for redox reactions, transport of heavy metals. **References/Text Books:** Schwarzenbach, R. P., Gschwend, P.M., Imboden, D. M. Environmental Organic Chemistry,2003, John Wiley & Sons. Fischer, H. B., List, E. J., Koh, R. C. Y, Imberger, J., Brooks, N. H. Mixing in Inland and Coastal Waters, Academic Press, Inc. Stumm, W., Morgan, J. J. Aquatic Chemistry, John Wiley & Sons, Inc., 1996. Alexander, M. Biodegradation and Bioremediation, Academic Press, 2"d Ed, 1999. Vallis, Geoffrey K. Atmospheric and Oceanic Fluid Dynamics: Fundamentals and Large Scale Circulations, 2006, Cambridge University Press. Marshall, John and Plumb, Alan R. Atmosphere, Ocean and Climate Dynamics: An Introductory Text, 2007, Academic Press. FinlaysonPitts, Barbara J. and Pitts, James N. Jr. Chemistry of the Upper and Lower Atmospthere: The01y, Experiments and Applications, 1999, Academic Press.	MODELING OF NATURAL SYSTEMS
EEM613A	3-0-0-0-9		**Course Contents:** Atmosphere as a Physical system, Introduction to Atmospheric Models: Simple Radiative model, Greenhouse Effect, Global Warming, Atmospheric Observations: The mean Temperature and Wind Fields, Gravity Waves, Rossby Waves, Ozone. Potential Temperature, Parcel Concepts, The Available Potential Energy, Moisture in the Atmosphere, The Saturated Adiabatic Lapse Rate, The Tephigram, Cloud Formation.Thermodynamics of Chemical Reactions, Chemical Kinetics, Bimolecular Reactions Photodissociation, Stratospheric Ozone, Chapman Chemistry, Catalytic Cycles, Transport of Chemicals, The Antarctic Ozone Hole.Aerosol Dynamics: Discrete and continuous aerosol size distributions; Thermodynamics o atmospheric aerosols; Homogeneous and heterogeneous nucleation; Coagulation and coagulation kernels; Condensation/evaporation, saturation vapour pressure corrections; Fluxes to a particle population; Sedimentation and dry deposition; Chemical equilibria; Heterogeneous reactions in aerosol aqueous phase; Aerosolcloud interactions. Aerosol and Global Climate: Trends in anthropogenic emissions and troposphere composition Solar and terrestrial radiation; Effect of pollutants on Earth's radiation budget; Radiatio cattering by aerosols and clouds; Models for global warming and cooling.	ATMOSPHERIC PHYSICS AND CHEMISTRY

			References/Text Books: Andrews, D. G. An Introduction to Atmospheric Physics, Cambridge UniversityPress, Cambridge, 2000.Friedlander, S.K. Smoke, Dust and Haze: Fundamentals of Aerosol Dynamics, Oxford University Press, New York, 2000.Jacobson, M.Z. Fundamentals of Atmospheric Modelling, Cambridge UniversityPress, New York, 1999.Seinfeld, J.H. and Pandis, S. N. Atmospheric Chemistry and Physics: From AirPollution to climate Change, WileyInterscience, New York, 1998.Proposer: Dr. S. N. Tripathi, __ Environmental Engineering and ManagementProgramme	
EEM614	3-0-0-4-4		**Course Contents:** . Introduction2. Microstructure of Atmospheric Clouds and Precipitation3. Molecular Structure of Water Substance4. Thermodynamic Equilibrium Between Vapor, Solutions, and Ice5. Surface Properties of Water Substance6. Equilibrium Behavior of Cloud Drops and Ice Crystals7. Homogeneous Nucleation8. Heterogeneous Nucleation9. Hydrodynamics of Single Cloud and Precipitation Particles0. Diffusional Growth ofHydrometers1. Collisional Growth of Hydrometers2. Dynamics of Cloud Growth3. Cloud Electrification4. Wet deposition of pollutants **References/Text Books:** 1. H.R. Pruppacher & J.D. Klett, (1997):"Microphysics of Cloud and Precipitation". 2"d Edition. Kluwer Academic Publishers.2. R.R. Rogers & M.K. Yau, (1989): "A Short Course in CloudPhysics", (3rd ed.), Pergamon Press, paperback.3. Jacobson, M.Z. Fundamentals of Atmospheric Modelling, Cambridge(University Press, New York, 1999.4. Seinfeld, J.H. and Pandis, S.N. Atmospheric Chemistry and Physics: From AiPollution to Climate Change, WileyInterscience, New York, 1998.ollution to Climate Change, WileyInterscience, New York, 1998	PRINCIPLES OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT
EEM614A	3-0-0-0-9		**Course Contents:** . Introduction2. Microstructure of Atmospheric Clouds and Precipitation3. Molecular Structure of Water Substance4. Thermodynamic Equilibrium Between Vapor, Solutions, and Ice5. Surface Properties of Water Substance6. Equilibrium Behavior of Cloud Drops and Ice Crystals7. Homogeneous Nucleation8. Heterogeneous Nucleation9. Hydrodynamics of Single Cloud and Precipitation Particles0. Diffusional Growth ofHydrometers1. Collisional Growth of Hydrometers2. Dynamics of Cloud Growth3. Cloud Electrification4. Wet deposition of pollutants **References/Text Books:** 1. H.R. Pruppacher & J.D. Klett, (1997):"Microphysics of Cloud and Precipitation". 2"d Edition. Kluwer Academic Publishers.2. R.R. Rogers & M.K. Yau, (1989): "A Short Course in CloudPhysics", (3rd ed.), Pergamon Press, paperback.3. Jacobson, M.Z. Fundamentals of Atmospheric Modelling, Cambridge(University Press, New York, 1999.4. Seinfeld, J.H. and Pandis, S.N. Atmospheric Chemistry and Physics: From AiPollution to Climate Change, WileyInterscience, New York, 1998.ollution to Climate Change, WileyInterscience, New York, 1998	PRINCIPLES OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT
ESO202A	3-1-0-0-11		**Course Contents:** Free body diagram with examples on modelling of typical supports and joints,Conditions for equilibrium in 3D and 2D, Friction: limiting and nonlimiting cases; Forcedisplacementrelationship and geometric compatibility (for small deformations) with illustrations through simpleproblems on axially loaded members and thinwalled pressure vessels; Concept of stress at a point,Plane stress case: transformation of stresses at a point, principal stresses and Mohr's circle,Displacement field, Concept of strain at a point, Plane strain case: transformation of strain at a point,principal strains and Mohr's circle, Strain Rosette; Discussion of experimental results on 1D materialbehaviour, Concepts of elasticity, plasticity, strainhardening, failure (fracture/yielding), Idealization of1D stressstrain curve, Generalized Hooke's law (without and with thermal strains) for isotropicmaterials, Complete equations of elasticity; Force analysis (axial force, shear force, bending moment,and twisting moment diagrams) of slender members (singularity functions nat to be used); Torsion ofcircular shafts and thinwalled tubes (plastic analysis and rectangular shafts not to be discussed);Moment curvature relationship for pure bending of beams with symmetric crosssection, bending	MECHANICS OF SOLIDS

			stress,shear stress (Shear centre and plastic analysis not to be discussed); Cases of combined stresses, Conceptof strain energy, Yield criteria; Deflection due to bending, Integration of the momentcurvaturerelationship for simple boundary conditions, Method of superposition (singularity functions not to beused); Strain energy and complementary strain energy for simple structural elements (those under axialload, shear force, bending moment, and torsion), Castigliano's theorems for deflection analysis andindeterminate problems; Concept of elastic instability, Introduction to column buckling, Euler's formula(postbuckling behaviour not to be covered) **References/Text Books:** * Crandall, S.H., Dahl, N.C., and Lardner, T. J., An Introduction to the Mechanics of Solids, McGrawHill,Second Ed. with 51 Units, 1978.* Beer, F.P, Johnston, E.R. and DeWolf, J.T., Mechanics of Materials, Tata McGrawHill Edition2004 * Meriam, J.L. and Kraige, L.G., Engineering Mechanics, Vol. 1: Statics, John Wiley,Second Ed. with 51 Units, 1980. * Popov, E.P., Engineering Mechanics of Solids, PrenticeHall, First Ed., 1990	
ESO208A	3-1-0-0-11		**Course Contents:** Introduction, Engineering Systems, Physical and Mathematical Modeling, Error Analysis Approximations and round off and Truncation errors, Roots of Equations single variable Method of Bisection, Method of Interpolation, Secant Method, One point Methods, Newton Raphson method, Secant Method, Multiple roots, Solution of Linear Simultaneous EquationsDirect MethodsGauss Elimination, GaussJordan, LU decomposition; lterative MethodsGaussSeidel, Conjugate Gradient, Banded and Sparse systems Solution of Nonlinear Simultaneous Equations, Curve FittingLeast Square regression, Interpolation including splines, Fast Fourier Transforms, Regression Analysis for Multivariable, Eigen Valuesand Eigen Vectors Power method, Relaxation Method, Diagonalization method. Numerical Differentiation and IntegrationHighAccuracy Differentiation Formulas, Derivatives of Unequal Spaced Data. The trapezoidal Rule, Simpsons rule, Integration with unequal segments, Open Integration Formulas, Ordinary Differential Equations Finite Difference method, Method of Weighted Residuals, Analytical versus Numerical Methods, Initial Value and Boundary Value ProblemsEulers method, Improvement of Eulers method, RungeKutta Method, Multiple Steps Method, Partial Differential EquationsElliptic and parabolic Equations, Explicit and Implicit Methods, Crank Nicholson Method, ADI method; Introduction to Finite Element Method, Applications. **References/Text Books:**	COMPUTATIONAL METHODS IN ENGINEERING
ESO218	3-1-0-0-4		**Course Contents:** Introduction, Engineering Systems, Physical and Mathematical Modeling, ErrorAnalysis Approximations and round off and Truncation errors, Roots ofEquations single variable Method of Bisection, Method of Interpolation, SecantMethod, One point Methods, Newton Raphson method, Secant Method, Multipleroots, Solution of Linear Simultaneous EquationsDirect MethodsGauss Elimination,GaussJordan, LU decomposition; lterative MethodsGaussSeidel, ConjugateGradient, Banded and Sparse systems, Solution of Nonlinear SimultaneousEquations, Curve FittingLeast Square regression, Interpolation including splines,Fast Fourier Transforms, Regression Analysis for Multivariable, Eigen Valuesand Eigen Vectors Power method, Relaxation Method, Diagonalization method.Numerical Differentiation and IntegrationHighAccuracy Differentiation Formulas,Derivatives of Unequal Spaced Data. The trapezoidal Rule, Simpsons rule,Integration with unequal segments, Open Integration Formulas, OrdinaryDifferential Equations Finite Difference method, Method of Weighted Residuals,Analytical versus Numerical Methods, Initial Value and Boundary Value ProblemsEulers method, Improvement of Eulers method, RungeKutta Method, MultipleSteps Method, Partial Differential EquationsElliptic and parabolic Equations,Explicit and Implicit Methods, Crank Nicholson Method, ADI method; Introductionto Finite Element Method, Applications. **References/Text Books:**	COMPUTATIONAL METHODS IN ENGINEERING
TA101N	2-0-3-1-4		**Course Contents:**	ENGINEERING GRAPHICS

			Introduction to sketching; Principal views, principles ofdimensioning Introduction to computeraidedgraphics Missing view, sectional view and assembly drawings Overview of pictorial representation, and isometricdrawing in detail Perspective drawing Lines, planes, auxiliary view Relationship between lines and planes intersection oflines and planes Intersections of solids and development of lateral surfaces **References/Text Books:**	
***** Department of CHE *****				
CHE100	1-0-2-0-0		**Course Contents:** What is engineering visvis basic Science? What is Chemical Engineering? Whatdo Chemical Engineers do? Diversity of employment opportunities; Intimateconnections with other physicochemical sciences, biological and biomedicalsciences, and other engineerings: case studies and examples; Historical perspectivesand needs, e.g., petrochemical industries, pulp and paper, textiles; Concernsof chemical engineering: traditional areas, environment, energy, new materials,bioengineering and biotechnology, food, health; Safety, IPR, Professional ethics;Frontiers: role and future of Chemical Engineering in the computer/informationrevolution; biomolecular revolution (e.g., nanodevices); Basic tools of ChemicalEngineering: physicochemical, mathematical and biological sciences, transportphenomena, thermodynamics, kinetics and reactors, design; Concept of unitoperations and descriptions of important unit operations; Concepts of scaleup,modeling and simulation: from molecular to terrestrial (e.g., ecology) scales;Visit to research laboratories of the department and other specially chosenlaboratories in the Institute to introduce chemical engineering concerns; Simplelaboratory demonstrations; Screening of educational videos from AIChE and IChem E, as well as from Indian industries; Plant visits. **References/Text Books:**	INTRODUCTION TO PROFESSION
CHE211	3-1-0-1-4		**Course Contents:** Review of NavierStokes (NS) equations; nondimensionalization of NS equations;introduction to turbulence; analogies; correlations for fluid flow Short introductionto nonNewtonian flows, Engineering Bernoulli Equation; f vs. NRe charts; K factorsand equivalent lengths for various fittings; hydraulic diameter; Head vs. Q plotsof centrifugal pumps; NPSH, cavitation and priming; pipeline system designincluding pseudosteady state approximation; flow measurements; compressorsand blowers. Compressible flows in conduits, Mixing and Agitation: Powerconsumption; mixing times; scaleup, Characterization of solids; fundamentalsof twophase flow; flow through packed beds and in fluidized beds (pressuredrops, loading and flooding); pneumatic and hydraulic transportation. Filtration,Centrifuges and cyclones (including some recent models). **References/Text Books:**	FLUID MECHANICS
CHE211A	3-0-0-0-9		**Course Contents:** Introduction: Fluid, fluid types (Newtonian/NonNewtonian, compressible/incompressible), physical properties, introductionto viscosity, continuum hypothesisFluid statics :Pressure distribution in a static fluid, hydrostatic forces on submerged plane surfaces (no. curved surfaces).Kinematics: Substantial derivative, streamline, path lines, streakline, timeline, flow visualization videos.Integral/macroscoQic balances: Control volume, Reynolds transport theorem (introduction and interpretation only. Noderivation), conservation of mass, energy and linearmomentum.Agglication ofmacroscogic balances: Losses in expansion, I force on a reducing bend, iet ejector.Differential balances: Differential equation of mass conservation, differential equation of linear momentum,constitutive equations, NavierStokes equations.Applications to couette flow between a fixed and a movingplate, flow due to pressure gradient between two fixed plates,fully developed laminar pipe flowHagenPoiseuille flow, pipeflow with a power law fluidDimensional analysis and similari)X Buckingham Pi theorem,nondimensionalization of continuity and N avierStokesequations, introduction of dimensionless numbers. **References/Text Books:**	FLUID MECHANICS AND ITS APPLICATION

			Vijay Gupta and Santosh K. Gupta. Fluid Mechanics and its applications. 2"d Edition,20 ll, New Age International (P) Limited, New Delhi W.L. McCabe, J.C. Smith and P. Harriot, Unit Operations of Chemical Engineering,6'" edition , 200 I, McGrawHill Co, Singapore Robert W. Fox, Philip J. Pritchard, and Alan T. Mcdonald, Introduction To FluidMechanics, 7th Edition, 2009, Wiley India Pvt Ltd F. M. White, Fluid Mechanics, 6th edition, 2008, Tata McGrawHill PublishingCompany Limited, New Delhi	
CHE221	3-1-0-1-4		**Course Contents:** Review of I and II Laws of Thermodynamics, PVT Relations of Pure FluidsGraphical,Tabular and Mathematical representaion; Generalized compressibilitychart; Generalized EOS; Thermodynamic Potentials; Maxwell Relations,Thermodynamic Property Relations, Thermodynamic properties of real gases,Multicomponent mixtures, Properties of solutions, Phase Equilibrium (VLE, LLE,VLLE), Review of Thermochemistry; Chemical reaction equilibria. **References/Text Books:**	CHEMICAL ENGINEERING THERMODYNAMICS
CHE221A	3-0-0-0-9	ESO201A	**Course Contents:** Laws of Thermodynamics: Introduction, Work, Heat, Energy , Review Iof first Law for closed and open systems, properties of ideal gas andreal fluidsReversibility and Entropy: Reversibility, the second law of Ithermodynamics, Carnot engine, entropy change for closed and opensystemFundamental Equations: Thermodynamics calculus, thermodynamics 3derivatives, Euler's theorem for homogeneous functions, Legendre'stransformations, Derivative in terms of measurable propertiesMicroscopic origin of entropy and elementary statistical mechanics 3Equilibria and stability: Equilibrium critera, stability criteria, Maxwell 4construction, binodals , spinodals, Gibbs Phase Rule, Clapeyronequation and vapor pressure. correlationsPure component properties: Equation of state, Ideal gas heat capacities, 5ti.mdamental equations fiom experimental data, fugacity andcorresponding statesMixture Properties: Mixing function, partial molar quantities, Gibbs 9Duhem relation for mixtures, partial Molar quantities from experimentaldata, Ideal gas mixtures and fugacities, ideal mixtures and activities,excess functions, excess Gibbs free energy models, infinite dilutionproperties and Henry's Law **References/Text Books:** *Chemical, Biochemical and Engineering Thermodynamics, S.!. Sandler, Wiley(2006)(Text Book)* Essential Thermodynamics by A. Z. Panagiotopoulos,, Drios Press, Princeton (20 II)* Chemical Engineering Thermodynamics, by Smith, van Ness and Abbott, 7'" Ed.,McGrawHill (2005)* Introduction to Chemical Engineering Thermodynamics, J. E. Elliot, C. T. Lira, PrenticeHall (1999)* Chemical Engineering Thermodynamics, Y. V. Rao, Universities Press, India (1997)	CHEMICAL ENGINEERING THERMODYNAMICS
CHE251	3-1-0-1-4		**Course Contents:** Guidelines for Problem Solving; Review of Basic concepts Process variables& properties, Degree of Freedom, Steady State Material Balances in nonreactingsystems and reacting system, Recycle & purge, elemental vs. speciesbalance, combustion of fossil fuels, Steady State Material balances in Multiphasesystems, Steady State Energy Balances in nonreacting & reacting systems,DeCoupled & coupled mass & energy balances, Calculations for network of unitswith recycle & bypass, Process Flow sheeting with sequential modular calculations,Unsteady State Balances. **References/Text Books:**	CHEMICAL PROCESS CALCULATION
CHE251A	3-0-0-0-9		**Course Contents:** Objectives and Overview, Historical Perspective of Chemical 2Engineering, Role of a Chemical Engineer, Role of BalanceCalculations, Review of Basic Concepts.Steadystate Material Balances in Nonreacting Systems: on Single 4Units, Basis of calculation; number of independent equations,Development of Degrees of Freedom; specification of variables.Balances on MultipleUnit Processes: Recycle and bypass. Balances in Reacting Systems: Stoichiometry, multiple reactions, Recycle and Purge.Element (atomic) versus Species (molecular balances): Combustion of Fossil Fuels, ultimate (elemental) and proximate analyses,combustion	INTRODUCTION TO CHE AND PROCESS CALCULATION

			chemistryincomplete combustion, theoretical and excessa1r.Material Balances in Multipbase Systems: Phase Rule, GasLiquid Systems, vaporliquid equilibrium (VLE) calculations, isothermal flashvaporization, Immiscible and Partially Miscible Liquid Systems, SolidLiquid Systems; saturation solubility and crystallization. **References/Text Books:** "Basic Principles and Calculations in Chemical Engineering', D. M. Himmelblau, 7th ed.,PrenticeHall ofindia Pvt. Ltd., New Delhi 'Elementary Principles of Chemical Processes', R. M. Felder and R. W. Rousseau, 2nd ed.,Wiley, New York, 1986.	
CHE261A	2-0-0-0-6		**Course Contents:** Unit operations and processes, flowchart IInorganic Industry: Ammonia production, steam reforming, Nitric acid production, Ammonium nitrate production, Ureaproduction, Ammonium phosphate/sulphate production, Methanolproduction, Caustic soda and chlorine productionNatural products: Overview of production of soap and oils, transesterification process, glycerol production, hydrogenationand saponificationOrganic chemicals: Steam cracking of hydrocarbons, chemicals from C2, C3, aromatics (suggested chemicals vinyl chlorides,ethylene oxide, ethylene glycol, styrene, phenol, maleicanhydride, pthalic anhydride, isopropanol, cumene)Petroleum & Petrochemicals: Refining/crude distillation, FCC, **References/Text Books:** J.H. Gary, G.E. Handwerk and M.J. Kaiser, "Petroleum refining: Technology andeconomics", 51h ed. (2007), CRC PressKirkOthmer Encyclopedia oflndustrial Chemistry, 2003Ullmann's Encyclopedia oflndustrial Chemistry, 2003Riegel's Handbook of Industrial Chemical and Biotechnology, Editor: James A. Kent,II th edition"Survey oflndia" Annual Hindu Publication.R.N. Shreve and G.T. Austin, "Chemical Process Industries" 51h Edn., McGraw Hill, NewYork, 1995.	CHEMICAL PROCESS INDUSTRIES
CHE300A	0-0-2-0-2		**Course Contents:** CHEMICAL ENGINEERING COMMUNICATION SKILLS **References/Text Books:**	CHEMICAL ENGINEERING COMMUNICATION SKILLS
CHE312	3-1-0-1-4		**Course Contents:** Heat conduction, Molecular diffusion, Convective heat transfer (laminar &turbulent), convective mass transfer (laminar & Turbulent), simultaneous heatand mass transfer, wetbulb and adiabatic saturation, Interface mass transfer;Boiling: pool and convective boiling, correlations, Condensation: filmwise anddropwise condensation, correlations, Radiation: thermal radiation, radiationproperties, view factors, heat exchange between surfaces, Heat exchangerdesign: Shellandtube, compact exchangers, reboiler, and condenser, Evaporators:type of equipment, single and multiple effect evaporators, Crystallization: phaseequilibria, crystal growth, types of equipment, design, Aspen/Matlab should beused wherever possible. **References/Text Books:**	HEAT AND MASS TRANSFER
CHE312A	3-0-0-0-9	CHE211A	**Course Contents:** Introduction to heat transfer, scope, variables and general applications Modes of heat transfer (conduction, radiation, convection); Heat conduction: Fourier law, thermal conductivity in gases, liquidsand solids and their estimationsRadiation: thermal radiation, radiation properties, view factors, Heat exchange between surfaces: General differential energy balance equation, dimensionless form, simplified forms, boundary conditions,similarity and scaling analysesSteady state conduction in stagnant fluids and solids, fins, definition of heat transfer coefficientsUnsteady heat conduction in stagnant fluids and solids. Heisler charts, 2numerical solutions and Matlab, etc.Convective heat transfer (laminar): heat transfer in ducts, flat plate, 3falling film, natural convection, correlationsConvective heat transfer (turbulent): heat **References/Text Books:**	HEAT TRANSFER & ITS APPLICATIONS

			* Frank P. Incropera and David P. Dewitt, Fundamentals of Heat and Mass Transfer,Sixth ed. Wiley India* J.P. Holman, Heat Transfer, McGraw Hill; latest International or Indian edition.* D. Q. Kern, Process Heat Transfer, McGraw Hill, New York, 1950.	
CHE313	3-0-0-1-4		**Course Contents:** Mass transfer equipment: continuous contact and staged contact units forabsorption, extraction, distillation, adsorption, humidification, drying, Phaseequilibria: phase diagrams, VLE, GLE, SLE; estimation of binary andmulticomponent phase equilibria, Single stage (steady state): binary andmulticomponent, Single stage unsteady state: (distillation, drying, adsorption[blow down]), Separations without reflux: isothermal cases: stage contactor:McCabe Thiele method, stage efficiency, matrix method, Thomas method forsolution, continuous contact (HTU, NTU), Separations without reflux: nonisothermalcases (absorption, adsorption, drying, humidification): McCabeThiele method, numerical solutions, Separations with reflux: distillation, extractionand adsorption, McCabeThiele and matrix method; continuous contact, Membraneseparation processes: fundamentals, introduction, different types of processes,Design of gasliquid, liquidliquid contactor; staged and continuous contact,Estimation of stage efficiencies, Shortcut methods for distillation. Aspen shouldbe used as much as possible **References/Text Books:**	SEPARATION PROCESSES
CHE313A	3-0-0-0-9		**Course Contents:** Introduction: Definition of rate of reaction, types of reactors, industrial Ireactions and reactorsBasic Concepts in Chemical Kinetics: reaction rate constant, reaction order, elementary reactions and molecularity, reversible reactions,nonelementary reactions.Collection and Analysis of Rate Data: simple constant volume arid variable volume reaction systems, differential and integral methods ofkinetic analysis, halflives, leastsquares analysis.Nouelementary Homogeneous Reactions: reaction mechanisms, pseudosteady state hypothesis, chain reactions, enzyme reactionsIsothermal Reactor Design: batch reactor, mixed flow reactor, plug flow reactor; multiple reactor systemsDesign for Multiple Reactions in Isothermal **References/Text Books:** H. Scott Fogler, 'Elements of Chemical Reaction Engineering', 4th edition, 2006,PrenticeHall oflndia, New Delhi.	MASS TRANSFER & ITS APPLICATIONS
CHE331	3-1-0-1-4		**Course Contents:** Introduction, Basic Concepts in Chemical Kinetics, Collection and Analysis ofRate Data, Nonelementary Homogeneous Reactions, Isothermal Reactor Design,Design for Multiple Reactions in Isothermal Reactors, Nonisothermal Reactors,Nonideal flow, Catalysis, Kinetics of Catalytic Reactions , Diffusion and Reactionin Porous Catalysts. **References/Text Books:**	CHEMICAL REACTION ENGINEERING
CHE331A	3-0-0-0-9	ESO201A	**Course Contents:** Introduction: Definition of rate of reaction, types of reactors, industrial Ireactions and reactorsBasic Concepts in Chemical Kinetics: reaction rate constant, reaction order, elementary reactions and molecularity, reversible reactions,nonelementary reactions.Collection and Analysis of Rate Data: simple constant volume arid variable volume reaction systems, differential and integral methods ofkinetic analysis, halflives, leastsquares analysis.Nouelementary Homogeneous Reactions: reaction mechanisms, pseudosteady state hypothesis, chain reactions, enzyme reactionsIsothermal Reactor Design: batch reactor, mixed flow reactor, plug flow reactor; multiple reactor systemsDesign for Multiple Reactions in Isothermal Reactors: mass balances, selectivity and yield, parallel reactions, series reactions, complexreactions, best operating conditions for multiple reactions.Nonisothermal Reactors: energy balances for batch, mixed flow and plug flow reactors; adiabatic reactors, nonadiabatic reactors, multiplereactors with interstage cooling, multiple steady states.Nonideal flow: residence time distribution, tankinseries model, dispersion model, applications to design	CHEMICAL REACTION ENGINEERING

			References/Text Books: H. Scott Fogler, 'Elements of Chemical Reaction Engineering', 4th edition, 2006,PrenticeHall oflndia, New Delhi.	
CHE349A	0-0-0-4-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UG PROJECT (UGP-I)
CHE352A	1-0-2-0-5	CHE221A	**Course Contents:** Ideal and nonideal VLE (TxyPxy plots, Azeotrope): Computation of 2+2VLE data (Temperaturecomposition, Pressurecomposition plots) using (i)ideal mixture assumption and (ii) using various activity coefficient modelssuch as VanLaar model, UNIFAC etc. Special emphasis on VLE ofazeotropic mixtures. Examples: Benzeneethanol, Furfuralwater, benzenecyclohexanemixtures.Twofilm model for mass transfer between gas and Iiguid (e.g. C02 1+1absorption using K2C03 solution, NH3 absorption in dilute acid solution) :Study of the absorption, reaction and diffusion processes in a contactreactor/bubble absorber/packed tower/plate column through the twofilmmodel. Formulation of the steadystate problem in terms of differentialequations for gas and liquid phase species using Fick's law, the gasliquidequilibrium relations, and reaction rate expressions. Effect of limitingdiffusion and reaction steps. Numerical solution methods, such as CrankNicholson with Dirichlet and Neumann boundary conditions. Steadystateconcentration profiles with different combinations of rate parameters. **References/Text Books:** *Introduction to chemical engineering computing by B. A. Finlayson; Indian edition by JohnWiley* Chemical Process Modelling and Computer Simulation by A. K. Jana; PHI learning, 2008	CHEMICAL PROCESS SIMULATION LAB
CHE361	3-1-0-1-4		**Course Contents:** Role of Chemical Engineer, Elementary Process Flowsheeting P & I diagrams,Inorganic IndustryFertilizers, Chlor alkalies, Natural Products Pulp & Paper, Oils,Soaps, Herbs, Petroleum & Petrochemicals: Refining/Crude Distillation; FCC,Catalytic Reforming; Alkylation, Amination, Hydrocracking, Aromatic Extraction,Plastics, Intermediates, dyes & paints, Pharmaceuticals, Environmental Pollution& Waste Treatment. **References/Text Books:**	CHEMICAL PROCESS INDUSTRIES
CHE362	3-0-0-1-4		**Course Contents:** Cell Structure and Cell Types, Chemicals of Life (RNA, DNA, enzymes etc.),Kinetics of Enzyme Reactions, Applied Enzyme Catalysis, Metabolic Stoichiometricand Energetics, Molecular Genetics and Control, Biomass Production, TransportPhenomena in Biosystems, Design and Analysis of Biological Reactors, Fermentors,Downstream Product Recovery and Purification, Interaction of Mixed MicrobialPopulations, Biological Wastewater Treatment. **References/Text Books:**	BIOCHEMICAL ENGINEERING
CHE362A	3-0-0-0-9		**Course Contents:** Cell Structure and Cell Types, Chemicals of Life (RNA, DNA, enzymes etc.),Kinetics of Enzyme Reactions, Applied Enzyme Catalysis, Metabolic Stoichiometricand Energetics, Molecular Genetics and Control, Biomass Production, TransportPhenomena in Biosystems, Design and Analysis of Biological Reactors, Fermentors,Downstream Product Recovery and Purification, Interaction of Mixed MicrobialPopulations, Biological Wastewater Treatment. **References/Text Books:**	BIOCHEMICAL ENGINEERING
CHE381	3-0-0-1-4		**Course Contents:**	PROCESS DYNAMICS AND

			Introduction, Process models, Linearization, Laplace transforms. Process dynamics,Time delay, Feedback control, Instrumentation, Stability (Routh array & rootlocus), Frequency response analysis (Bode and Nyquist plots), Design of feedbackcontrollers, High level control (Cascade, Smith predictor, feedforward, adaptive,inferential, ratio, override etc.), MIMO systems, Digital control. **References/Text Books:**	CONTROL
CHE381A	3-0-2-0-11		**Course Contents:** Introduction: to analog and digital feedback control; measurement devicesLaplace transforms: of simple functions, derivatives, integrals, zero order holdZ transforms: of simple functions, improper sampling ANALOG: Modeling (time and Laplace domains) of simple and MIMO systems, linearization, deviations from steady state, systemswith time delaysDynamic behavior of first order systems: and their responses to Isimple, nonsinusoidal inputsDynamic behavior of second order systems: and their responses, Ioverdamped and underdamped responsesDynamic behavior of multicapacity: (interactive and non interactive) systems, systems with time delays, inverse responses; PadeapproximationsFrequency responses: Bode and Nyquist diagrams: first, second order systems, time delays, pure P, I and D controllers **References/Text Books:** D.R. Coughanowr, Process Systems Analysis and Control, 2"d ed.,McGraw Hill, New York, 1991.	PROCESS CONTROL
CHE391	0-0-6-1-4		**Course Contents:** Fluid flow, Fluid particle systems, Thermodynamics, Heat transfer, Mass transfer. **References/Text Books:**	UNIT OPERATION LABORATORY-I
CHE391A	1-0-3-2-8	CHE221A,CHE211A,CHE312A	**Course Contents:** Safety, ethical guideline, error analysis, data presentation Brief introduction to topics of experiments, relevance in industry Fluid flow, fluid pru1icle system Thermodynamics Heat and mass transfer Demonstration lab Solid size reduction e.g. crushing and Igrinding, ball milling;Solid conveying e.g. pneumatic conveying, hydraulic conveying, Ibelt conveyingAnalysis and testing of crude oil and petroleum products: 1Determination of octane number, cetane number, pour point,cloud point, smoke point **References/Text Books:** * Unit Operation Laboratory Manual.* "Unit Operations of Chemical Engineering" (7th Edition), by W.L. McCabe, J.C. Smith,and P. Harriott, McGraw Hill Publishing, 2005 (ISBN 0072848235).* Coulson and Richardson's Chemical Engineering: Chemical Engineering Design	UNIT OPERATION LABORATORY -I
CHE398A	0-0-9-0-9		**Course Contents:** UG PROJECT (UGP II) **References/Text Books:**	UG PROJECT II
CHE399A	0-0-0-2-2		**Course Contents:** CHEMICAL ENGINEERING COMMUNICATION SKILLS **References/Text Books:**	CHEMICAL ENGINEERING COMMUNICATION SKILLS
CHE452	2-0-2-0-4		**Course Contents:** Artificial Intelligence and Networks in Chemical Engineering, Expert Systems(CONPHYDE, KBS) and Tools (KEE, ART), Artificial Neural Network, Learning andTraining, Process Plant Diagnosis, Safety Analysis, Process Modelling, Interfacialproperties, Fault Diagnosis and Trouble Shooting, Data Base Management andQualitative Interpretation of Process Data, Simulation Packages, ASPEN PLUS,Batch	COMPUTER APPLICATIONS IN CHEMICAL ENGG.

			Processing Packages (SUPERPRO), FLUENT **References/Text Books:**	
CHE453	3-1-0-1-4		**Course Contents:** Introduction to Design Process Development, process alternatives, ProcessFlowsheeting and simulation using ASPEN PLUS, Conceptual Process Synthesis,Conceptual design of reactors, pressure vessels, distillation/adsorption columns,storage vessels, Synthesis of Separation Trains, Cost Estimation & profitabilityanalysis, Heat Exchange Network Analysis, Scaleup & pilot plant studies, HAZOPand Safety in design, Batch process Design for sequential processing usingSUPERPRO, Continuous plant design (group term projects). **References/Text Books:**	CHEMICAL ENGINEERING DESIGN
CHE453A	3-0-2-0-11		**Course Contents:** Introduction to Design Process Development, process alternatives, ProcessFlowsheeting and simulation using ASPEN PLUS, Conceptual Process Synthesis,Conceptual design of reactors, pressure vessels, distillation/adsorption columns,storage vessels, Synthesis of Separation Trains, Cost Estimation & profitabilityanalysis, Heat Exchange Network Analysis, Scaleup & pilot plant studies, HAZOPand Safety in design, Batch process Design for sequential processing usingSUPERPRO, Continuous plant design (group term projects). **References/Text Books:**	CHEMICAL ENGINEERING DESIGN
CHE463	3-0-0-1-4		**Course Contents:** Atomic structure, semiconductor materials, solar cells, Transistors and ProcessSequence of Fabrication, Control of Microcontamination, Microlithography,Doping, Etching, Oxidation, Chemical Vapour Deposition and Reactor Design,Classification and Electrical, Mechanical Properties of Polymer, Polymer Catalysisand Molecular Chemistry, Flow Behaviour and Polymer Processing, Polymer Blendsand Composites, Applications of Polymers (Exchange Resin etc.), Ceramic RawMaterials and Characterization, Ceramic Processing Additives, CeramicBeneficiation Process, Ceramic Forming Processes (Solgel, Casting etc.),Zeolites, Ceramic Drying, Surface Processing and Shaping. **References/Text Books:**	ELECTRONIC POLYMERIC & CERAMIC MATERIALS & PROCESSING
CHE463A	3-0-0-0-9		**Course Contents:** Atomic structure, semiconductor materials, solar cells, Transistors and ProcessSequence of Fabrication, Control of Microcontamination, Microlithography,Doping, Etching, Oxidation, Chemical Vapour Deposition and Reactor Design,Classification and Electrical, Mechanical Properties of Polymer, Polymer Catalysisand Molecular Chemistry, Flow Behaviour and Polymer Processing, Polymer Blendsand Composites, Applications of Polymers (Exchange Resin etc.), Ceramic RawMaterials and Characterization, Ceramic Processing Additives, CeramicBeneficiation Process, Ceramic Forming Processes (Solgel, Casting etc.),Zeolites, Ceramic Drying, Surface Processing and Shaping. **References/Text Books:**	ELECTRONIC POLYMERIC & CERAMIC MATERIALS & PROCESSING
CHE492	0-0-6--4	CHE312,CHE313,CHE331,CHE381	**Course Contents:** Mass Transfer, Heat transfer, chemical reactors, Computer aided data acquisitionand online analysis, Process dynamics and control. **References/Text Books:**	UNIT OPERATION LAB II
CHE492A	1-0-3-2-8	CHE312A,CHE313A,CHE331A	**Course Contents:**	UNIT OPERATIONS AND

			Mass Transfer, Heat transfer, chemical reactors, Computer aided data acquisitionand online analysis, Process dynamics and control. **References/Text Books:**	PROCESS CONTROL LABORATORY
CHE494	0-0-4--2		**Course Contents:** A written report and an oral presentation/interview after successful completionof an 8week industrial inplant training with a chemical industry. **References/Text Books:**	SUMMER IN-PLANT TRAINING
CHE494A	0-0-5-0-5		**Course Contents:** A written report and an oral presentation/interview after successful completionof an 8week industrial inplant training with a chemical industry. **References/Text Books:**	SUMMER IN-PLANT TRAINING
CHE495	0-0-8-0-4		**Course Contents:** Student will work on design/research projects to carry out theoretical/experimentalwork on problems in chemical engineering as assigned by the project advisor. **References/Text Books:**	PROJECT-I
CHE496	-0-8--4	CHE495	**Course Contents:** PROJECT II **References/Text Books:**	PROJECT II
CHE497A	0-0-0-0-9		**Course Contents:** UG PROJECT (UGPII) **References/Text Books:**	UNDER GRADUATE PROJECT-III
CHE600	3-0-0--4		**Course Contents:** Definition and nature of research, Motivation for research, different types andstyles of research in sciences, role of serendipity, scientific temperament, Isscience necessary? Working of some of the great minds from all walks of lifescientists,artists, writers,etc.Tools for thinking, critical and positive thinking,creativity and innovation, mind mapping; Development of problem solving skills,scaling and orders of magnitude analysis, role of simple models in thinking andin developing an understanding. Scientific and critical reasoning skills, art ofreading and understanding scientific papers and critical evaluation of theunderlying premises and assumptions, literature reviews. Professional attitudesand goals, concept of excellence, ethics in science and engineering, some famousfrauds in science. Scientific communication, Organisation of ideas, writingscientific papers, reports and thesis; Making scientific presentations at conferences;Presenting popular lectures to semitechnical and or/nontechnical audience/participating in public debates on scientific issues. **References/Text Books:**	RESEARCH METHODS & SKILLS
CHE601	3-0-0-0-4		**Course Contents:** Mathematics modulue:1. Linear algebra: Basics (2lectures; Chap. 3 ofMLB)2. Linear algebra: Numerical methods (3 lectures; Chap. 1 of SKG)3. Nonlinear algebraic equations: Numerical solution, including multivariable Newton Raphson method (4 lectures, Chap. 3 of SKG)4. Ordinary differential equations: Basics (2lectures; Chap. 8 ofMLB)5. Numerical solution of ODEs Initial value problems (2 lectures, Chap. 5 of SKG)6. Numerical solution of ODEs Boundary value problems (2 lectures, ChaP.. 6 of SKG)7. Probability	FUNDAMENTALS OF CHEMICAL ENGINEERING - I

			and statistics (5 lectures; Chap. 16 of MLB)Transport Phenomena module:8. Introduction to momentum transport (!lecture; Chap. 1 ofBSL)9. Shell balances for 1D momentum transport (2lectures; Chap. 2 ofBSL)10. NavierStokes equations (2lectures; Chap. 3 ofBSL)11. Unsteady and 2D momentum transfer (3 lectures ofBSL).12. Introduction to heat transfer (1 lecture; Chap. 9 ofBSL)13. Shell balances for 1D heat transfer (2lectures; Chap. 10 ofBSL)14. Temperature distributions with more than one independent variable (3 lectures; Chap. 12 ofBSL)15. Introduction to mass transfer (!lecture; Chap. 17 ofBSL).16. Diffusion and mass transfer in laminar flow (3 lectures; Chap. 18 ofBSL)17. Mass transfer with more than one independent variable (2 lectures; Chap. 20 of BSL) **References/Text Books:** 1. M. L. Boas (MLB), Mathematical Methods in the Physical Sciences (Second Edition),John Wiley & Sons (Indian edition).2. S. K. Gupta (SKG) Numerical Methods for Engineers, New Age International.3. R. B. Bird, W. E. Stewart, E. L. Lightfoot (BSL), Transport Phenomena (Second Edition)John Wiley & Sons (Indian Edition).	
CHE601A	3-0-0-0-9		**Course Contents:** Mathematics modulue:1. Linear algebra: Basics (2lectures; Chap. 3 ofMLB)2. Linear algebra: Numerical methods (3 lectures; Chap. 1 of SKG)3. Nonlinear algebraic equations: Numerical solution, including multivariable Newton Raphson method (4 lectures, Chap. 3 of SKG)4. Ordinary differential equations: Basics (2lectures; Chap. 8 ofMLB)5. Numerical solution of ODEs Initial value problems (2 lectures, Chap. 5 of SKG)6. Numerical solution of ODEs Boundary value problems (2 lectures, ChaP.. 6 of SKG)7. Probability and statistics (5 lectures; Chap. 16 of MLB)Transport Phenomena module:8. Introduction to momentum transport (!lecture; Chap. 1 ofBSL)9. Shell balances for 1D momentum transport (2lectures; Chap. 2 ofBSL)10. NavierStokes equations (2lectures; Chap. 3 ofBSL)11. Unsteady and 2D momentum transfer (3 lectures ofBSL).12. Introduction to heat transfer (1 lecture; Chap. 9 ofBSL)13. Shell balances for 1D heat transfer (2lectures; Chap. 10 ofBSL)14. Temperature distributions with more than one independent variable (3 lectures; Chap. 12 ofBSL)15. Introduction to mass transfer (!lecture; Chap. 17 ofBSL).16. Diffusion and mass transfer in laminar flow (3 lectures; Chap. 18 ofBSL)17. Mass transfer with more than one independent variable (2 lectures; Chap. 20 of BSL) **References/Text Books:** 1. M. L. Boas (MLB), Mathematical Methods in the Physical Sciences (Second Edition),John Wiley & Sons (Indian edition).2. S. K. Gupta (SKG) Numerical Methods for Engineers, New Age International.3. R. B. Bird, W. E. Stewart, E. L. Lightfoot (BSL), Transport Phenomena (Second Edition)John Wiley & Sons (Indian Edition).	FUNDAMENTALS OF CHEMICAL ENGINEERING - I
CHE602	3-0-0-0-4		**Course Contents:** Module on Thermodynamics:1. Review of 1st and 2nd Law of Thermodynamics (including applications) (2lectures)2. PVT relations of pure fluids (cubic EOS, generalized correlations, compressibility factor) (2 lectures)3. Thermodynamic properties of pure fluids (Single phase systems: Thermodynamic potentials, Maxwell's relations, residual properties. Two phase systems: Clapeyron equation, Phasediagrams. Generalized property correlations for gases) (3 lectures)4. Multicomponent Mixtures: Partial molar properties, Gibbs Duhem equation, Chemical potential for phase equilibria, Fugacity and fugacity coefficient. The ideal solution andexcess molar properties. Activity coefficients and models (Margules, NRTL, Wilson, UNIQUAC) (3 lectures)5. Vapor Liquid Equilibrium: multicomponent phase envelopes, gammaphi formulation, dewpoint, bubble point and flash calculations, modified Raoult's law, Henry's law (4lectures)6. Thermodynamic properties and VLE from cubic EOS (2 lectures)7. Other types of phase equilibria: LLE, VLLE, SLE (1 lecture)8. Heat of adsorption, multicomponent adsorption equilibrium (1 lectures)9. Chemical reaction equilibrium (2 lectures)Module on Reaction Engineering:10. Idealization in chemical reaction engineering (1 lecture; Chap. 1 ofHSF)11. Steady and unsteady state operation in idealized reactors (3 lectures; Chap. 4 of HSF)12. Multiple reactions (2 lectures; Chap. 6 ofHSF)13. Nonelementary reaction kinetics (3 lectures; Chap. 7 ofHSF)14. Modeling of Catalytic reaction kinetics (3 lectures)15. External diffusion effects on heterogeneous reactions (2lectures; Chap. 11 ofHSF)16. Diffusion and reaction in porous	FUNDAMENTALS OF CHEMICAL ENGINEERING - II

			catalysts (4lectures; Chap. 12 ofHSF)17. Design of fixed bed reactors (2 lectures) **References/Text Books:** 1. H. Scott Fogler (HSF) Elements of Chemical Reaction Engineering, Prentice Hall (India)2. S. I. Sandler (SIS) Chemical and Biological Engineering Thermodynamics, John Wiley(Indian Edition).	
CHE602A	3-0-0-0-9		**Course Contents:** Module on Thermodynamics:1. Review of 1st and 2nd Law of Thermodynamics (including applications) (2lectures)2. PVT relations of pure fluids (cubic EOS, generalized correlations, compressibility factor) (2 lectures)3. Thermodynamic properties of pure fluids (Single phase systems: Thermodynamic potentials, Maxwell's relations, residual properties. Two phase systems: Clapeyron equation, Phasediagrams. Generalized property correlations for gases) (3 lectures)4. Multicomponent Mixtures: Partial molar properties, Gibbs Duhem equation, Chemical potential for phase equilibria, Fugacity and fugacity coefficient. The ideal solution andexcess molar properties. Activity coefficients and models (Margules, NRTL, Wilson, UNIQUAC) (3 lectures)5. Vapor Liquid Equilibrium: multicomponent phase envelopes, gammaphi formulation, dewpoint, bubble point and flash calculations, modified Raoult's law, Henry's law (4lectures)6. Thermodynamic properties and VLE from cubic EOS (2 lectures)7. Other types of phase equilibria: LLE, VLLE, SLE (1 lecture)8. Heat of adsorption, multicomponent adsorption equilibrium (1 lectures)9. Chemical reaction equilibrium (2 lectures)Module on Reaction Engineering:10. Idealization in chemical reaction engineering (1 lecture; Chap. 1 ofHSF)11. Steady and unsteady state operation in idealized reactors (3 lectures; Chap. 4 of HSF)12. Multiple reactions (2 lectures; Chap. 6 ofHSF)13. Nonelementary reaction kinetics (3 lectures; Chap. 7 ofHSF)14. Modeling of Catalytic reaction kinetics (3 lectures)15. External diffusion effects on heterogeneous reactions (2lectures; Chap. 11 ofHSF)16. Diffusion and reaction in porous catalysts (4lectures; Chap. 12 ofHSF)17. Design of fixed bed reactors (2 lectures) **References/Text Books:** 1. H. Scott Fogler (HSF) Elements of Chemical Reaction Engineering, Prentice Hall (India)2. S. I. Sandler (SIS) Chemical and Biological Engineering Thermodynamics, John Wiley(Indian Edition).	FUNDAMENTALS OF CHEMICAL ENGINEERING - II
CHE603A	3-0-0-0-9		**Course Contents:** Continuous Population Models for single species : Continuous growth models, Insect outbreak model, Delay models, Linear analysis of Delay population models, Delay models in Physiology, Harvesting a single natural population, Population model with Age distribution. Models for Interacting Populations : predator prey models: LotkaVolterra systems, Complexity and stability, Realistic predatorprey models, Analysis of a predatorPrey model with limit cycle periodic behaviour: Parameter domains of stability, Competition models: Competitive exclusion principle, Mutualism or Symbiosis, General models and cautionary remarks, Threshold Phenomena. Reaction Kinetics : Enzyme kinetics: Basic enzyme reaction, Transient time estimates and nondimensionalisation, MichaelisMenten quasisteady state analysis, Suicide substrate kinetics, Cooperative phenomena, Autocatalysis, Activations and Inhibition, Multiple steady state, Mushrooms and Isolas. Biological Oscillators and Switches : Motivation, brief history and background, Feedback control mechanisms, Oscillators and switches with two or more species: General qualitative results, Simple two species oscillators: Parameter domain determination for oscillations, HodgkinHuxley theory of nerve membranes: FitzHughNagumo model. **References/Text Books:** 1. Mathematical Biology I : An Introduction, Author: J.D. Murray, Publisher Springer. 2. Mathematical Models in Biology: AuthorLeah Edelstein, Keshet, Publisher : SIAM	MATHEMATICAL MODEL IN BIOLOGY
CHE611	3-0-0--4		**Course Contents:** Kinematics, Transport theorem, constitutive relations, Equations of motion andtheir solutions, Boundary layer theory, Turbulence; Energy equation and its exactsolutions, Continuity equation for multicomponent systems, constitutive relations,Interphase transport of momentum, energy and mass and macroscopic	TRANSPORT PHENOMENA

			balances. **References/Text Books:**	
CHE611A	3-0-0-0-9		**Course Contents:** Kinematics, Transport theorem, constitutive relations, Equations of motion andtheir solutions, Boundary layer theory, Turbulence; Energy equation and its exactsolutions, Continuity equation for multicomponent systems, constitutive relations,Interphase transport of momentum, energy and mass and macroscopic balances. Course Reference : **References/Text Books:**	TRANSPORT PHENOMENA
CHE612	3-0-0-0-4		**Course Contents:** 1. Physical Chemical properties and biological activity2. .Molecular orbifal theory in drug design3. Structural features and pharmacological activity4. Drug metabolism and procedure of tailoring drugs5. Receptor site theory and substitution therapy6. CNS depressants, sedativehypnotic d1ugs and their synthesis7. CNS stimulants and their synthesis8. Chemotherapy and oncology. Synthesis of drugs, mechanism of action and procedure treatment.9. Drugs affecting sugar and diabetes mellitus. Synthesis of drugs and procedure treatment.10. Sex hormones and oral contraceptives1!."Immunity and al ergies. HIV and AIDS and procedure treatment12. Psychotic and related drugs **References/Text Books:** 1. Harrison's Principles of Internal Medicine, 15th Ed, McGraw Hill, N.Y., 2001.2. Goodman and Gillman's The Pharmacological Basis of Therapeutics, gth Ed, McGraw Hill, N.Y., 1992.3.W.O. Foye, Principles of Medicinal Chemistry, Lea and Febiger, Philadelphia,1974.	SCIENCE & TECHNOLOGY OF DRUGS
CHE613	3-0-0-0-4		**Course Contents:** Introduction to Complex Fluids (CF) and Soft Condensed Matter (SCM) (2 hours)Basic Forces, Energies and Timescales in CF and SCM. (5 hours)Excluded volume interactions, Van Der Waals interactions, Electrostatic interactions, Hydmgen bonding. Relaxation phenomena in CS and SCM.Fundamentals of Rheology (6 hours)Different types of flow fields, linear and nonlinear Viscoelasticity, Kinematics and stress, Boltzmann Superposition Principle.Various Characterization Techniques (6 hours)Microscopy, Light scattering techniques, Dielectric spectroscopy, RheaopticsPolymers (8 hours)Rheology of dilute polymer solutions: Elementary molecular theories, linear and nonlinear rheology. Rheology of entangled polymers: Reptation theories, Transient network formulations Colloidal dispersions: (6 hours)Rheological behavior of dilute and concentrated suspensions of isotropic particles, nonspherical particles, particles in viscoelastic media Glassy Systems: (6 hours)Introduction to glass transition. Rheology of amorphous polymers, very concentrated suspensions, emulsions, foams, colloidal gels. Relaxation behavior, yield stres ,thixotropic behavior, ageing and rejuvenation. **References/Text Books:** Ronald G. Larson, The Structure and Rheology of Complex Fluids, Oxford University Press(1998).Richard A.L. Jones, Soft Condensed Matter, Oxford University Press (2002).Ch. W. Macosko, Rheology: Principles, Measurements, and Applications, WileyVCH (1994). H. A. Barnes, J. F. Hutton, K. Walters, An introduction to rheology, Elsevier (1989). Montgomery T. Shaw and William J. MacKnight, Introduction to Polymer Viscoelasticity,WileyInterscience; (2005)	THE STRUCTURE & RHEOLOGY OF COMPLEX FLUIDS
CHE613A	3-0-0-0-9		**Course Contents:** Introduction to Complex Fluids (CF) and Soft Condensed Matter (SCM) (2 hours)Basic Forces, Energies and Timescales in CF and SCM. (5 hours)Excluded volume interactions, Van Der Waals interactions, Electrostatic interactions, Hydmgen bonding. Relaxation phenomena in CS and SCM.Fundamentals of Rheology (6 hours)Different types of flow fields, linear and nonlinear Viscoelasticity, Kinematics and stress, Boltzmann Superposition Principle.Various Characterization Techniques (6 hours)Microscopy, Light	THE STRUCTURE & RHEOLOGY OF COMPLEX FLUIDS

			scattering techniques, Dielectric spectroscopy, RheaopticsPolymers (8 hours)Rheology of dilute polymer solutions: Elementary molecular theories, linear and nonlinear rheology. Rheology of entangled polymers: Reptation theories, Transient network formulations Colloidal dispersions: (6 hours)Rheological behavior of dilute and concentrated suspensions of isotropic particles, nonspherical particles, particles in viscoelastic media Glassy Systems: (6 hours)Introduction to glass transition. Rheology of amorphous polymers, very concentrated suspensions, emulsions, foams, colloidal gels. Relaxation behavior, yield stres ,thixotropic behavior, ageing and rejuvenation. **References/Text Books:** Ronald G. Larson, The Structure and Rheology of Complex Fluids, Oxford University Press(1998).Richard A.L. Jones, Soft Condensed Matter, Oxford University Press (2002).Ch. W. Macosko, Rheology: Principles, Measurements, and Applications, WileyVCH (1994). H. A. Barnes, J. F. Hutton, K. Walters, An introduction to rheology, Elsevier (1989). Montgomery T. Shaw and William J. MacKnight, Introduction to Polymer Viscoelasticity,WileyInterscience; (2005)	
CHE617	3-0-0-0-4		**Course Contents:** LecturesChemical Engineering Aspects ofNuclear Power 1Uranium, Zirconium & Thorium: Concentration, Purification and Production 4Extraction ofNuclear Metals: Principles, Theory & Equipment; Solvent Extraction, IonicLiquid & Membrane Processes 5Separation ofNuclear Reactor Products: Redox, Urex I Purex, Thorex ,TTA chelation,Precipitation, IonExchange & Fluoride Distillation with simulation a 10Separation of Light Isotopes: Principles; Distillation & Electrolysis of Water, Electrolysis& Steam Hydrogen/Deuterium Exchange Processes 6Separation of Heavy Isotopes : Principles; Mass, Gas & Thermal Diffusion Processes 6Nuclear Hydrogen Production : SulfurIodine Cycle, Hybrid Sulfur Route, High 5Temperature Electrolysis; with simulation bNuclear heat for coal liquefaction & gasification; with simulation c **References/Text Books:** Books Recommended:Text: "Nuclear Chemical Engineering" by Benedict, Pigford & Han , 2nd edition,McGrawHill 1981 .General Reading: "Solvent Extraction Principles and Practice" ed by Rydberg, Cox,Musikas & Choppin ,211d ed., Marcel Dekker 2004International Atomic Energy Agency Publications +Relevant research papersfrom AIChE J, Ind.Eng.Chem.Res., Nuc.Eng.& Des.SIMULATOR: ASPEN PLUS based simulations for a) Separation Flowsheets b) SICycle, Hybrid Sulfur Route c) Coal Liquefaction/gasification	NUCLEAR CHEMICAL ENGINEERING
CHE618	3-0-0--4	CHE313	**Course Contents:** Separation Factors for Rate Governed Separation Processes, MembraneCharacterization; Reverse Osmosis: Models of Solvent and Solute Transport,Concentration Polarization; Ultrafiltration: Types of Transport through UFMembranes, Fouling and Concentration Polarization in UF, Osmaotic PressureModel utization; Diafiltration: Process Design; Dialysis: Solute Transport analysisof dialyzer operation, Mode of Dialysis; Electrodialysis: Types of Electro dialysis Ion Transport Fundamentals, Concept of Limiting Current Density, ConcentrationPolarization; Liquid Membrane; Permeation of Gases through Membranes andPervaporation. **References/Text Books:**	NEW SEPARATION PROCESSES
CHE618A	3-0-0-0-9	CHE313A	**Course Contents:** Separation Factors for Rate Governed Separation Processes, MembraneCharacterization; Reverse Osmosis: Models of Solvent and Solute Transport,Concentration Polarization; Ultrafiltration: Types of Transport through UFMembranes, Fouling and Concentration Polarization in UF, Osmaotic PressureModel utization; Diafiltration: Process Design; Dialysis: Solute Transport analysisof dialyzer operation, Mode of Dialysis; Electrodialysis: Types of Electro dialysis Ion Transport Fundamentals, Concept of Limiting Current Density, ConcentrationPolarization; Liquid Membrane; Permeation of Gases through Membranes andPervaporation. **References/Text Books:**	NEW SEPARATION PROCESSES

CHE621	3-0-0-0-4		**Course Contents:** Postulational Thermodynamics: Postulates; Equilibrium criteria; Gibbs Duhemrelation; Energy minimum principle; Thermodynamic potentials; Stability andphase Transition. Statistical Thermodynamics: Statistical mechanics of ensemblesEstimation of Thermodynamic properties in Ideal gases, Estimation of equilibriumconstant in reacting systems. **References/Text Books:**	THERMODYNAMICS
CHE621A	3-0-0-0-9		**Course Contents:** Postulational Thermodynamics: Postulates; Equilibrium criteria; Gibbs Duhemrelation; Energy minimum principle; Thermodynamic potentials; Stability andphase Transition. Statistical Thermodynamics: Statistical mechanics of ensemblesEstimation of Thermodynamic properties in Ideal gases, Estimation of equilibriumconstant in reacting systems. **References/Text Books:**	THERMODYNAMICS
CHE622	3-0-0--4	#	**Course Contents:** Theory methods, and application of molecular simulation. Elementary satisticalmechanics. Molecular modeling. Basic Monte Carlo and molecular dynamicstechniques and ensemble averaging. Evaluation of free energies, phase equilibria,interfacial properties, and transport and rate coefficients. Applications to simpleand complex fluids and solids. Commercial simulation software. **References/Text Books:**	INTRODUCTION TO MOLECULAR SIMULATIONS
CHE622A	3-0-0-0-9		**Course Contents:** Theory methods, and application of molecular simulation. Elementary satisticalmechanics. Molecular modeling. Basic Monte Carlo and molecular dynamicstechniques and ensemble averaging. Evaluation of free energies, phase equilibria,interfacial properties, and transport and rate coefficients. Applications to simpleand complex fluids and solids. Commercial simulation software. **References/Text Books:**	INTRODUCTION TO MOLECULAR SIMULATIONS
CHE623	3-0-0--4	#	**Course Contents:** Classical thermodynamics of phase equilibria: Thermodynamic properties fromvolumetric data: Nature of intermolecular forces, Theory of corresponding states;Fugacities in gas mixtures and liquid solutions; gas solubilities; High pressureequilibria. **References/Text Books:**	THERMODYNAMICS OF FLUIDS AND FLUID MIXTURES
CHE623A	3-0-0-0-9		**Course Contents:** Classical thermodynamics of phase equilibria: Thermodynamic properties from volumetric data: Nature of intermolecular forces, Theory of corresponding states; Fugacities in gas mixtures and liquid solutions; gas solubilities; High pressure equilibria. **References/Text Books:**	THERMODYNAMICS OF FLUIDS AND FLUID MIXTURES
CHE631	3-0-0--4		**Course Contents:** Behaviour of chemical reactions; Behaviour of chemical reactors: ideal and nonidealflow, nonisothermal reactor performance, reactor stability; Heterogeneousreactions: interphase and intraphase heat and mass transfer effects; FluidSolidnoncatalytic reactions; Heterogeneous catalytic reactions. **References/Text Books:**	CHEMICAL REACTION ENGINEERING

CHE631A	3-0-0-0-9		**Course Contents:** Behaviour of chemical reactions; Behaviour of chemical reactors: ideal and nonidealflow, nonisothermal reactor performance, reactor stability; Heterogeneousreactions: interphase and intraphase heat and mass transfer effects; FluidSolidnoncatalytic reactions; Heterogeneous catalytic reactions. **References/Text Books:**	CHEMICAL REACTION ENGINEERING
CHE632	3-0-0--4	#	**Course Contents:** Noncatalytic two phase reactionsIntroduction; review of physical mass transfer; different regimes of mass transfer with chemical reaction 2General theory of mass transfer with chemical reaction; global rates ofreaction for different regimes 3Design of different types of gasliquid reactors 5Penetration model for mass transfer, population balance models and particulate systems 5Solidcatalysed gasliquid reactionsTypes of multiphase reactors and their applications 1 Determination of global rates for multiphase reactions 2 Experimental methods for evaluation of parameters 3 Mechanicallyagitated slurry reactors: hydrodynamics, mass transfer, heat transfer and modelling 5Bubble column reactors: hydrodynamics, heat transfer,mass transfer and modelling 5Trickle bed reactors: hydrodynamics, heat transfer, mass transfer, effectiveness factor, and modelling 6Monolith reactors: preparation, hydrodynamics mass transfer and modelling 5 **References/Text Books:** 1) Cybulski,A. and Moulijn,J.A.,2006,Structured Catalysts and Reactors, 2nd edition,2) Froment, G.F. and Bischoff, K.B., 1990, Chemical Reactor Analysis and Design,Wiley, New York3) Gianetto, A. and Sylveston,P.L.(editors) 1986, Multiphase Chemical Reactors. Theory,Design, Scaleup, Hemisphere Publishing Co., New York.4) Ramachandran, P.A. and Chaudhari, R.V.l983, ThreePhase Catalytic Reactors, Gordonand Breach, New York, USA5) Sharma, M.M. and Doraiswamy, L.K, 1984, Heterogeneous Reactions: Volume II, Wiley, New York.6) Trambouze, P. and Euzen, J.P., 2004, Chemical Reactors. From design to operation, Technip,Paris.In addition, reading assignments will be given from recent journal publications	ANALYSIS AND DESIGN OF MULTIPHASE REACTORS
CHE633	3-0-0--4	CHE331	**Course Contents:** Adsorption; Energetics; Isotherms and Rates: Experimental aspects of adsorptionand allied phenomena on catalyst surfaces; Pore structure and surface areaestimation and their significance; Important catalysts, Promoters and Carriers;Mechanisms of some typical heterogeneous catalytic reactions, e.g., Oxidation. **References/Text Books:**	PRINCIPLES OF HETEROGENEOUS CATALYSIS
CHE633A	3-0-0-0-9	CHE331A	**Course Contents:** Adsorption; Energetics; Isotherms and Rates: Experimental aspects of adsorptionand allied phenomena on catalyst surfaces; Pore structure and surface areaestimation and their significance; Important catalysts, Promoters and Carriers;Mechanisms of some typical heterogeneous catalytic reactions, e.g., Oxidation. **References/Text Books:**	PRINCIPLES OF HETEROGENEOUS CATALYSIS
CHE641	3-0-0--4	#	**Course Contents:** Modelling, Vector Spaces, Matrices, Linear Operators, Initial Value Problem,Partial Differential Equation, Sturm Louiville Theory, Separation of Variables,Greens Functions, Transform Techniques, Nonlinear Equations, ContinuationMethods, Bifurcation and Chaos. **References/Text Books:**	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING
CHE641A	3-0-0-0-9		**Course Contents:** Modelling, Vector Spaces, Matrices, Linear Operators, Initial Value Problem,Partial Differential Equation, Sturm Louiville Theory, Separation of Variables,Greens Functions, Transform Techniques, Nonlinear	MATHEMATICAL METHODS IN CHEMICAL ENGINEERING

			Equations, ContinuationMethods, Bifurcation and Chaos. **References/Text Books:**	
CHE642	3-0-0--4	#	**Course Contents:** Systems of Linear and NonLinear Algebraic Equations: Successive Substitution,NewtonRaphson, Eigenvalues and Eigenvectors of Matrices, Interpolation,Solutions of ODEs (IVP): Runge Kutta, Multistep Methods, Gears algorithmStiffness and Stability of algorithms, ODE (BVPs) and PDEs: Finite Difference,Finite Elements, Shooting Methods. **References/Text Books:**	NUMERICAL METHODS IN CHEMICAL ENGINEERING
CHE642A	3-0-0-0-9		**Course Contents:** Systems of Linear and NonLinear Algebraic Equations: Successive Substitution,NewtonRaphson, Eigenvalues and Eigenvectors of Matrices, Interpolation,Solutions of ODEs (IVP): Runge Kutta, Multistep Methods, Gears algorithm,Stiffness and Stability of algorithms, ODE (BVPs) and PDEs: Finite Difference,Finite Elements, Shooting Methods. **References/Text Books:**	NUMERICAL METHODS IN CHEMICAL ENGINEERING
CHE644	3-0-0--4	#	**Course Contents:** Mathematical Modeling: conservation equations; dimensionlessLecturesnumbers; boundary conditions; 3Numerical solution of model equations: Finite volume method discretization schemes; Colocated and staggered grid; Boundary conditions, also for symmetric and periodic flows; pressure velocity coupling; pressurecorrection equation based solution method; under relaxation factors; Algorithms SIMPLE/R, QUICK/Superbee; convergence and error analysis; 5Turbulent flow:Reynolds Averaged Navier Stokes (RANS) equationseddy viscosity models; kE models; 3Multiphase Flow:Approaches: EulerianEulerian & Volume of fluid (VOF); dispersed multiphase flows ;flow through porous media; dense and dilute suspensions; solids pressure; granular temperature;.drag coefficientsfor single and multiphase systems; interphase heat & mass transfer correlationsfor GL,GS, LS, GLS flows. 5Reactive flow processes:reactive mixing micro, macro & turbulent; RANS based models: species transport; homogeneous and heterogeneous reactions: volumetric , wall surface & particle surface reactions. 5Reactor Flow modeling: Reactor types: stirred tank, bubble column,fixed bed, fluidized bed.;Reactor Internals: impellers, baffles, spargers,heating & cooling coils, distributors & mixing grids.; population balance models:coalescence & breakage models for bubble/drop size distributions.Sol id phase characterization based on solid pressure, granular temperature,particle size distribution, dense & dilute suspensions. 5 **References/Text Books:**	CFD OF MULTIPHASE REACTORS
CHE645	3-0-0--4		**Course Contents:** Mathematical Model and its Necessity: Model Development principles: Synthesisof submodels, Experimental facts, Hypothesis, Dimensional Analysis, Scaling,Reduction of equations.Classification of Models: Deterministic and stochastic Example from thermaldiffusion, Lumped and Distributed parameter Example from stirred tank andplug flow, Additional examples from transport processes and chemical kinetics.Modelling and Simulation Techniques: Length and time scale analysis in multiscalesystems, Population balance models Fundamentals, Examples from Crystallization,coagulation, Microbial population, Monte Carlo methods Basicsof Random No. and Probabbility distribution, Time and event driven methods,Stochastic models Poisson Process, Markov process, Birthdeath process, Nonlineardynamics and Chaos Principles, Application in mixing, reaction, stirredtank, fludized bed, Fractal models Diffusion and reaction limited growth,Aggregate structure.Solution and analysis of results: Parameter estimation, Asymptotes, Moments,Phase plane, Time series. **References/Text Books:**	MODELLING AND SIMULATION IN CHEMICAL ENGINEERING

CHE652	3-0-0--4	#	**Course Contents:** Mathematical formulation of optimization problems; single variable problems:search techniques; Multivariable problems without constraints: direct methods,first and second order methods; Multivariable problems with constraints: Calculusof variations; Pontryagins maximum principle; Dynamic Programming. **References/Text Books:**	OPTIMIZATION
CHE652A	3-0-0-0-9		**Course Contents:** Mathematical formulation of optimization problems; single variable problems:search techniques; Multivariable problems without constraints: direct methods,first and second order methods; Multivariable problems with constraints: Calculusof variations; Pontryagins maximum principle; Dynamic Programming. **References/Text Books:**	OPTIMIZATION
CHE654	3-0-0--4	#	**Course Contents:** Introduction to the elements of process design, process development, processevaluation ; flow sheeting; Pilot plant; Optimization and economic considerations,process design engineering, project engineering, practical considerations; safetyconsiderations and successful plant operations, case studies **References/Text Books:**	PROCESS ENGINEERING
CHE659	3-0-0-0-4		**Course Contents:** This course provides an insight into the process engineering principles inmicroelectronic fabrication. The transport processes, reaction kinetics and reactor designaspects of the following topics will be covered silicon crystal growth, oxidation, ionimplantation, chemical and physical vapor deposition, rapid thermal processing, epitaxy,lithography, plasma processing (deposition and etch), electrochemical deposition andchemical mechanical planarization. Also, the cleanliness and purity in processenvironment (e.g. filtration, mechanisms of particulate deposition and removal onsurfaces) will be covered. **References/Text Books:** 1. Stanley Middleman, Arthur Hochberg, "Process Engineering Analysis inSemiconductor Device Fabrication", McGraw Hill, 1st Ed, 1993. 2. Stephen A. Campbell, "The Science and Engineering of MicroelectronicFabrication", Oxford University Press, 2"d Ed, 2001. 3. Peter VanZant, "Microchip Fabrication", McGraw Hill, 5th Ed, 2004.(Students likely to take the course: Chemical Engineering, Electrical Engineering,Metallurgical and Materials Engineering, Materials Science Program.	PROCESS ENGG. PRINCIPLES IN MICRO. FABRICATION
CHE659A	3-0-0-0-9		**Course Contents:** This course provides an insight into the process engineering principles inmicroelectronic fabrication. The transport processes, reaction kinetics and reactor designaspects of the following topics will be covered silicon crystal growth, oxidation, ionimplantation, chemical and physical vapor deposition, rapid thermal processing, epitaxy,lithography, plasma processing (deposition and etch), electrochemical deposition andchemical mechanical planarization. Also, the cleanliness and purity in processenvironment (e.g. filtration, mechanisms of particulate deposition and removal onsurfaces) will be covered. **References/Text Books:** 1. Stanley Middleman, Arthur Hochberg, "Process Engineering Analysis inSemiconductor Device Fabrication", McGraw Hill, 1st Ed, 1993. 2. Stephen A. Campbell, "The Science and Engineering of MicroelectronicFabrication", Oxford University Press, 2"d Ed, 2001. 3. Peter VanZant, "Microchip Fabrication", McGraw Hill, 5th Ed, 2004.(Students likely to take the course: Chemical Engineering, Electrical Engineering,Metallurgical and Materials Engineering, Materials Science Program.	PROCESS ENGG. PRINCIPLES IN MICRO. FABRICATION
CHE661	3-0-0-0-4		**Course Contents:** 1. Introduction: Various terms in measurement. Accuracy, precision, selectivity, limit of detection,	ANALYTICAL & MATERIAL

			sensitivity, response time, reliability, signal/noise and sources of noise/errors (2 lectures).2. Chemical analysis of materials: Techniques for the analysis of structure, chemical composition and trace impurities in materials. Xray photoelectron spectroscopy (XPS), mass spectrometry (MS) and other spectroscopy techniques at atomic and molecular levels (12lectures).3. Microscopy and diffraction: Optical microscopy, Scanning probe microscopy, Electron microscopy (both SEM and TEM), Xray Diffraction. Theoretical and practical aspects of the microscopy and diffraction techniques will be introduced. Imaging using scanning tunneling microscope (STM) will also be considered (12 lectures).4. Thermal analysis: Applications of thermal analysis. Various techniques such as TGA, DSC, DTA, and TMA will be covered (6 lectures). **References/Text Books:**	CHARACTERIZATION TECHNIQUES OF ENGINEERS
CHE661A	3-0-0-0-9		**Course Contents:** 1. Introduction: Various terms in measurement. Accuracy, precision, selectivity, limit of detection, sensitivity, response time, reliability, signal/noise and sources of noise/errors (2 lectures).2. Chemical analysis of materials: Techniques for the analysis of structure, chemical composition and trace impurities in materials. Xray photoelectron spectroscopy (XPS), mass spectrometry (MS) and other spectroscopy techniques at atomic and molecular levels (12lectures).3. Microscopy and diffraction: Optical microscopy, Scanning probe microscopy, Electron microscopy (both SEM and TEM), Xray Diffraction. Theoretical and practical aspects of the microscopy and diffraction techniques will be introduced. Imaging using scanning tunneling microscope (STM) will also be considered (12 lectures).4. Thermal analysis: Applications of thermal analysis. Various techniques such as TGA, DSC, DTA, and TMA will be covered (6 lectures). **References/Text Books:**	ANALYTICAL & MATERIAL CHARACTERIZATION TECHNIQUES OF ENGINEERS
CHE662	3-0-0-0-4	#	**Course Contents:** Petroleum refining in India; refinery tests and crude oil evaluation ; crudedistillation column design; Delayed Coking; Catalytic cracking; Catalytic reforming;Catalytic isomerization; Alkylation; Polymerization; Hydrocracking; Hydrotreating. **References/Text Books:**	PETROLEUM REFINERY ENGINEERING
CHE662A	3-0-0-0-9		**Course Contents:** Petroleum refining in India; refinery tests and crude oil evaluation ; crudedistillation column design; Delayed Coking; Catalytic cracking; Catalytic reforming;Catalytic isomerization; Alkylation; Polymerization; Hydrocracking; Hydrotreating. **References/Text Books:**	PETROLEUM REFINERY ENGINEERING
CHE664	3-0-0-0-4		**Course Contents:** I.Introduction to electrochemical energy conversion and storage devices(2weeks)a. Contemporary energy challenges and opportunitiesb. Advantages and disadvantages in electrochemical approach to energy conversion and storagec. Qualitative introduction to fuel cells; Photoelectrochemical cells, batteries, supercapacitors and thermoelectric devices2. Thermodynamics of electrochemical systems(2 weeks)a. Electrochemical potential b. Activity coefficientsc. Reference electrodesd. Junction potential3. Electrodics (3 weeks)a. Electrochemical double layer b. Electrode kineticsb. Electrode kinetics4. Transport processes in electrochemical systems (3 weeks)a. Transport in diiure soiutionsb. Transport in concentrated solutionsc. Transport phenomena in electrochemically reactive systems5. Electrochemical measurements (I week)a. Cyclic voltametryb. Impedance spectroscopyc. Scanning probe techniques6. Design issues in electrochemical energy devices (3 weeks)a. Current distribution in Fuel cells and Batteriesb. Material design strategies for electrodes/electrolytes c. Economics of Electrochemical devicesDURATION: ONE SEMESTER **References/Text Books:** I. Newman, J. and ThomasAiyea, K., Electrochemical systems, WileyInterscience (2004)2. Larminie, J. and	ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE

			Dicks, A., Fuel cells systems explained, JohnWiley & Sons (2003)3. Linden, D. ed., Handbook of Batteries, McGrawHill (2001)4. Bard, A. and Faulkner, L.R, Electrochemical methods, JohnWiley & Sons(2001)5. Bockris, J.O.M. and Reddy, A.K.N., Modern Electrochemistry (Volume 1, Volume 2A and 2B),Springer (2001)6. Course materials will be supplemented with research and revieltapys f o journals	
CHE670	3-0-0--4	#	**Course Contents:** Polymer Fundamentals: Chemistry of Polymer synthesis, Polymer Reaction Kinetics:Stepgrowth polymerization, freeradical chain growth polymerization, EmulsionPolymerization, Ionic and cationic polymerization. Chain statistics and rubberelasticity. Physical properties and characterization of polymers. **References/Text Books:**	INTRODUCTION TO POLYMER SCIENCE AND TECHNOLOGY
CHE670A	3-0-0-0-9		**Course Contents:** Polymer Fundamentals: Chemistry of Polymer synthesis, Polymer Reaction Kinetics:Stepgrowth polymerization, freeradical chain growth polymerization, EmulsionPolymerization, Ionic and cationic polymerization. Chain statistics and rubberelasticity. Physical properties and characterization of polymers. **References/Text Books:**	INTRODUCTION TO POLIMER SCIENCE & TECHNOLOGY
CHE672	3-0-0--4	ESO212	**Course Contents:** Review of equations of motion, constitutive equations; Calendaring, extrusion;molding; mixing; fibre spinning. **References/Text Books:**	PRINCIPLES OF POLYMER PROCESSING
CHE672A	3-0-0-0-9		**Course Contents:** Review of equations of motion, constitutive equations; Calendaring, extrusion;molding; mixing; fibre spinning. **References/Text Books:**	PRINCIPLES OF POLYMER PROCESSING
CHE673A	3-0-0-0-9		**Course Contents:** 1. Air Pollution: a. Introduction: Atmospheric pollutants: definition, sources, concentration levels, units. b.Gaseous phase chemistry: photochemical smog in troposphere; O3 depletion in stratosphere; NOx formation in urban atmosphere, PAN/PAH formation. c. Aqueous phase chemistry: acid rain (SO2, CO2, NO2), Chemical equilibria.d. Aerosols: size, distribution, deposition, visibility degradation, nucleation. f. Mass transfer aspects: diffusion, mass transfer coefficient, characteristics times. g. Troposphere energy balance: pressuretemperature relationship, stability criteria, rising parcel of air pollutants, stack plume rise. h.Atmospheric dispersion: puff and plume dispersion, Gaussian models. i. Control of Pollutants: (1) Absorption: design of an absorber (SO2, CO2, NO2)(2)Adsorption: design of an adsorber (SO2, VOC), breakthrough analysis(3)Particles: mechanism of particles capture, fabric filters, cyclones, precipitator2. Water Pollutiona. Introduction: organic/inorganic/biological pollutants, water quality and parameters. b. Waste water treatment: primary and secondary treatments, sludge disposal (aerobic and anaerobic digesters. c. Biological organic wastes: BOD/COD, dissolved O2 model, Monods kinetics, biomass growth & food utilization. d. Biological wastewater treatment equipment design: (1) Activated sludge process reactor(2)Trickling filter (3)Biotower reactor. e. Advanced waste water reactors: (1) Continuous counter current multi stage fluidized bed. (2) Moving bed adsorption systems. **References/Text Books:** 1. Atmospheric Chemistry and Physics by Seinfeld and Pandis (Wiley.) 2. Environmental Engineering by Peavy, Rowe, and Tchobanoglous (McGraw Hill.)	ENVIROMENTAL POLLUTION CONTROL, DESIGN AND MODELLING
CHE674	3-0-0-0-4		**Course Contents:** 1. Overview nanoscience: Important concepts such as size, quantum effect, andMoores law. Characteristic	INTRODUCTION TO NANOSCIENCE AND

			length scales determining the behavior of physical andbiological systems; fundamental phenomena as a function of size and reduceddimensionality; different types of nanomaterials (metal, magnetic, quantum dots,lanthanidebased nanoparticles, polymer nanoparticles, carbon nanotubes and theirproperties (11 lectures).2. Synthesis and organization of nanomaterials: Chemical Routes for Synthesis ofNanomaterials: Chemical precipitation and coprecipitation; Metal nanocrystals byreduction, Solgel synthesis; Microemulsions or reverse micelles, Solvothermal synthesis;Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; selfassembly;lithography; microfluidics; and chemical vapor deposition; surfacemodification of nanoparticles (8 lectures).3. Characterization techniques: Beam probe methods (TEM, EDX, SEM, EDX, andXray scattering), Scanning probe methods (STM and AFM) and other techniques(Optical Spectroscopy, Chromatography, Surface Plasmon Resonance and LightScattering) (1 0 lectures).4. Application of nanoscience and technology: Drug delivery, Tissue engineering,biosensors, catalysis, and electronics (5 lectures).5. Discussion on research papers based on the above syllabus. This will be done inbetween the above topics (8 lectures). **References/Text Books:** 1. Christof M. Niemeyer, Chad A. Mirkin , Nanobiotechnology: Concepts, applicationsand perpectives, WileyInterscience (2004)2. Geoffery A. Ozin, Andre C. Arsenault, Nanochemistry: A chemical approach tonanomaterials, RSC publishing (2005)3. M. Gross, Travels to the nanoworld, Plenum Publishing Corporation (2001)	TECHNOLOGY
CHE674A	3-0-0-0-9		**Course Contents:** 1. Overview nanoscience: Important concepts such as size, quantum effect, andMoores law. Characteristic length scales determining the behavior of physical andbiological systems; fundamental phenomena as a function of size and reduceddimensionality; different types of nanomaterials (metal, magnetic, quantum dots,lanthanidebased nanoparticles, polymer nanoparticles, carbon nanotubes and theirproperties (11 lectures).2. Synthesis and organization of nanomaterials: Chemical Routes for Synthesis ofNanomaterials: Chemical precipitation and coprecipitation; Metal nanocrystals byreduction, Solgel synthesis; Microemulsions or reverse micelles, Solvothermal synthesis;Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; selfassembly;lithography; microfluidics; and chemical vapor deposition; surfacemodification of nanoparticles (8 lectures).3. Characterization techniques: Beam probe methods (TEM, EDX, SEM, EDX, andXray scattering), Scanning probe methods (STM and AFM) and other techniques(Optical Spectroscopy, Chromatography, Surface Plasmon Resonance and LightScattering) (1 0 lectures).4. Application of nanoscience and technology: Drug delivery, Tissue engineering,biosensors, catalysis, and electronics (5 lectures).5. Discussion on research papers based on the above syllabus. This will be done inbetween the above topics (8 lectures). **References/Text Books:** 1. Christof M. Niemeyer, Chad A. Mirkin , Nanobiotechnology: Concepts, applicationsand perpectives, WileyInterscience (2004)2. Geoffery A. Ozin, Andre C. Arsenault, Nanochemistry: A chemical approach tonanomaterials, RSC publishing (2005)3. M. Gross, Travels to the nanoworld, Plenum Publishing Corporation (2001)	INTRODUCTION TO NANOSCIENCE AND TECHNOLOGY
CHE676	3-0-0--4	ESO212/CHE211 CHE611	**Course Contents:** Classification of fluid behaviour: Constitutive relations; Rheometry: Flow ofnonNewtonian fluids in closed conduits: Flow in complex geometries: Fixed andfluidized beds; two phase flows, Mixing and agitation: requirements; Dimensionalanalysis; heat and mass transfer processes in nonNewtonian systems. **References/Text Books:**	ENGINEERING APPLICATIONS OF RHEOLOGY
CHE676A	3-0-0-0-9		**Course Contents:** Classification of fluid behaviour: Constitutive relations; Rheometry: Flow ofnonNewtonian fluids in closed conduits: Flow in complex geometries: Fixed andfluidized beds; two phase flows, Mixing and agitation:	ENGINEERING APPLICATIONS OF RHEOLOGY

			requirements; Dimensionalanalysis; heat and mass transfer processes in nonNewtonian systems. **References/Text Books:**	
CHE678	3-0-0--4	#	**Course Contents:** 1. Fundamental Equations: The strain tensor; The stress tensor; Thermodynamics ofdeformation; Hooke's law; Homogeneous deformations; Equilibrium of an elasticmedium bounded by a plane; Solid bodies in contact with and without interactions. (10 hours)2. Equilibrium of rods and plates: Equations of equilibrium of rods; Bending and torsion of rods. Equation of equilibrium for a bent plate; The energy of a bent plate; Application of bending plate geometry for solving problems related to Adhesion. (10 hours)3. Nonlinear elasticity: Molecular approach to rubber; strain energy theory; specific forms of strain energy; NeoHookean elasticity. Solutions for incompressible materials. Cavitation in crosslinked networks. (10 hours)4. Mechanics of cell wall: Elasticity of cellular filaments; soft networks in cell;biomembranes, membrane undulations. (10 hours) **References/Text Books:** 1. "Theory of Elasticity, 3rd edition" by Landau and Lifshitz. Course of theoreticalphysics, vol7.2. "A treatise on the mathematical theory of elasticity" by A. E. H. Love.3. "Contact Mechanics" by K. L. Johnson.4. "Mechanics of the cell" by David Boal.	MECHANICS OF SOFT MATERIALS
CHE678A	3-0-0-0-9		**Course Contents:** 1. Fundamental Equations: The strain tensor; The stress tensor; Thermodynamics ofdeformation; Hooke's law; Homogeneous deformations; Equilibrium of an elasticmedium bounded by a plane; Solid bodies in contact with and without interactions. (10 hours)2. Equilibrium of rods and plates: Equations of equilibrium of rods; Bending and torsion of rods. Equation of equilibrium for a bent plate; The energy of a bent plate; Application of bending plate geometry for solving problems related to Adhesion. (10 hours)3. Nonlinear elasticity: Molecular approach to rubber; strain energy theory; specific forms of strain energy; NeoHookean elasticity. Solutions for incompressible materials. Cavitation in crosslinked networks. (10 hours)4. Mechanics of cell wall: Elasticity of cellular filaments; soft networks in cell;biomembranes, membrane undulations. (10 hours) **References/Text Books:** 1. "Theory of Elasticity, 3rd edition" by Landau and Lifshitz. Course of theoreticalphysics, vol7.2. "A treatise on the mathematical theory of elasticity" by A. E. H. Love.3. "Contact Mechanics" by K. L. Johnson.4. "Mechanics of the cell" by David Boal.	MECHANICS OF SOFT MATERIALS
CHE679	3-0-0--4	#	**Course Contents:** Course contents vary from time to time **References/Text Books:**	SPECIAL TOPICS
CHE679A	3-0-0-0-9		**Course Contents:** Part 1: Introduction to granular materials, Issues and challenges inexperimental studies; Discrete element method for granular simulations;Hard and soft particle models; Contact force modelling, Algorithm for softand hard particle methods; Calculation of various properties of interestfrom the data; Some fundamental insights obtained from DEM.Part 2: Continuum models (Balance laws for mass, momentum and energy);Static properties of granular piles (Role of friction, Reynolds dilatancy,Pressure distribution in cylindrical container); Theory of slow flows; Flowthrough hoppers and wedge shaped bunkers; Rapid flow of smooth, inelasticgrains in simple geometries, Hydrodynamic description of rapid granularflows, Heuristic theory and introduction to Kinetic theory of inelasticgases.Part 3: Dense granular flow rheology, inertialnumber rheology in denseflow regime, 3D viscoplastic rheological model, extension to the rheologyof granular mixtures; Surface flows of granular materials, Flow overinclined plane and in rotating cylinders and heaps, depth average equationsfor surface flows; Mixing and segregation of granular mixtures,	SPECIAL TOPICS

			Savageskinetic sieving model, Khakhars single particle based segregation model,kinetic theory based segregation models. **References/Text Books:**	
CHE681	3-0-0--4		**Course Contents:** Process Identification Techniques for SISO & MIMO systems off line & on line;Generalized Predictive Control (GPC); Model Predictive Control (MPC): DynamicMatrix Control (DMC), Internal Model Control for SISO & MIMO systems; OptimalControl; Multivariable Control; Control Design for Complete Plants; Case Studiesusing MATLAB & SIMULINK software. **References/Text Books:**	ADVANCED PROCESS DYNAMICS & CONTROL
CHE681A	3-0-0-0-9		**Course Contents:** Process Identification Techniques for SISO & MIMO systems off line & on line;Generalized Predictive Control (GPC); Model Predictive Control (MPC): DynamicMatrix Control (DMC), Internal Model Control for SISO & MIMO systems; OptimalControl; Multivariable Control; Control Design for Complete Plants; Case Studiesusing MATLAB & SIMULINK software. **References/Text Books:**	ADVANCED PROCESS DYNAMICS & CONTROL
CHE684	3-0-0-0-4		**Course Contents:** Introduction to transcription Networks; The Concept ofNetwork Motif; Autoregulation loops:Positive and Negative autoregulation; FeedForward loops; Global structure of Transcription Neh:vorks and Temporal responses; Network motifs in Development, Signal Transduction, and Neuronal Networks; Robustness of Protein Circuits; Kinetic Proofreading; Optimal gene circuit design; Demand rule for gene regulation; Input function of a Gene: MichaelisMenten and Hillequations, Multidimensional input functions .Duration: One Semester **References/Text Books:** 1. An Introduction to Systems Biology by Uri A ton. (Chapman & 1Iaii/CRC, UK, 2007)2. Mathematical Models in Biology by EdelsteinKeshet, L. (Cambridge University Press,2005)3. Systems Biology Properties of restructured Networks by Bernhard 0. Palsson(Cambridge University Press, 2006)4. Virus dynamics: Mathematical principles of immunology and virology by Martin A .Nowak And Robert may (Oxford University press,USA,2001)	AN INTRODUCTION TO SYSTEMS BIOLOGY
CHE684A	3-0-0-0-9		**Course Contents:** Introduction to transcription Networks; The Concept ofNetwork Motif; Autoregulation loops:Positive and Negative autoregulation; FeedForward loops; Global structure of Transcription Neh:vorks and Temporal responses; Network motifs in Development, Signal Transduction, and Neuronal Networks; Robustness of Protein Circuits; Kinetic Proofreading; Optimal gene circuit design; Demand rule for gene regulation; Input function of a Gene: MichaelisMenten and Hillequations, Multidimensional input functions .Duration: One Semester **References/Text Books:** 1. An Introduction to Systems Biology by Uri A ton. (Chapman & 1Iaii/CRC, UK, 2007)2. Mathematical Models in Biology by EdelsteinKeshet, L. (Cambridge University Press,2005)3. Systems Biology Properties of restructured Networks by Bernhard 0. Palsson(Cambridge University Press, 2006)4. Virus dynamics: Mathematical principles of immunology and virology by Martin A .Nowak And Robert may (Oxford University press,USA,2001)	AN INTRODUCTION TO SYSTEMS BIOLOGY
CHE688	3-0-0--4	#	**Course Contents:** Capillarity, interfacial thermodynamics, surflactants, stability of muliphasesystems, foam, emulsion,	FUNDM. OF COLLOID & INTERFACE SCI. & TECH.

			multiphase reactors, wetting and adhesion, catalystsintering/redispersion; Stability and coagulation of colloids, nucleation andgrowth: Colloids in chemical engineering, in separation processes, bioscience. **References/Text Books:**	
CHE688A	3-0-0-0-9		**Course Contents:** Capillarity, interfacial thermodynamics, surflactants, stability of muliphasesystems, foam, emulsion, multiphase reactors, wetting and adhesion, catalystsintering/redispersion; Stability and coagulation of colloids, nucleation andgrowth: Colloids in chemical engineering, in separation processes, bioscience. **References/Text Books:**	FUNDM. OF COLLOID & INTERFACE SCI. & TECH.
CHE699	----		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
CHE699.	0-0-0--9		**Course Contents:** M TECH THESIS (FOR DUAL DEGREE ONLY) **References/Text Books:**	M TECH THESIS (FOR DUAL DEGREE ONLY)
CHE701	----0	#	**Course Contents:** M. Tech. Seminar **References/Text Books:**	M. TECH. SEMINAR
CHE701A	0-0-0-0-0		**Course Contents:** M. Tech. Seminar **References/Text Books:**	M. TECH. SEMINAR
CHE702	0-0-0--0	#	**Course Contents:** M. Tech. Seminar **References/Text Books:**	M TECH SEMINAR
CHE799	----	#	**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
CHE801	----0	#	**Course Contents:** Ph. D. Seminar **References/Text Books:**	PHD SEMINAR
CHE802	----0	#	**Course Contents:** Ph. D. Seminar **References/Text Books:**	PHD SEMINAR
ESO201A	3-1-0-0-11		**Course Contents:** Definitions & concepts: SI Units; System; Property; Energy; ThermodynamicEquilibrium; Work, State	THERMODYNAMICS

			Postulate; Zeroth Law of Thermodynamics; TemperatureScale, Thermodynamic Properties of Fluids: Mathematical, Tabular and Graphicalrepresentation of data; Ideal gas Van der Waals Equation of state; Compressibilitychart; Thermodynamic Diagrams including Mollier diagram; Steam Tables, Firstlaw of Thermodynamics & its applications to Non flow processes, Applicationsof First Law of Thermodynamics of Flow Processes; Steady state Steady flowand Transient flow processes, Applications of First Law of Thermodynamics toChemically Reacting Systems Second Law of Thermodynamics & its Applications,Thermodynamic Potentials, Maxwells Relations; Thermodynamic Relations andAvailability, Power Cycles, Refrigeration Cycles; SI Units, Definitions & Concepts:System, Property, Energy, Thermodynamic Equilibrium, Work interaction &various modes of work, Heat, State Postulate, Zeroeth Law of Thermodynamics,Temperature Scale, IPTS.Thermodynamic Properties of Fluids: Pure substance. Phase, Simple compressiblesubstance, Ideal gas Equation of state, van der Waals Equation of State; Lawof corresponding states, Compressibility chart, Pressurevolume; Temperaturevolumeand Phase diagrams; Mollier diagram and Steam tables. **References/Text Books:**	
ESO212	3-1-0-1-4		**Course Contents:** I. FLUID MECHANICS (34 lectures)1. Introduction to transport phenomena 2. Fluid statics; pressure as a scalar, manometry, forces on submerged surfaces by integration of pressure forces3. Description of flows; Lagrangian and Eulerian approaches; Euler acceleration formula; streamlines; control volume4. Conservation of mass; integral and differential approaches 5. Linear momentum balance: stress; deformation; Newtons law of viscosity; NavierStokes equation;6. Applications of NavierStokes equation for simple 1D problems; Poiseuille flow, Couette flow7. Total energy equation; Bernoulli equation; applications including flow measurement (Pitot tube, orifice meters)8. Pipe flows; friction factor; Reynolds experiment; losses in fittings 9. Similitude and modeling using nondimensionalization of Navier Stokes equations and boundary conditions, simplifications for caseswithout free surfaces and without cavitation (scale factor approachshould NOT be done)10. Low Re flows: flow past circular cylinders; stream functions; Stokes flow; drag coefficient correlations11. High Re flow: Prandtls approximation; basic inviscid flow; need for boundary layer; MagnusRobin effect12. Boundary layer flow; flow on flat plates; separation; flow past immersed bodies (bluff, streamlined); physics of ballgames(qualitative)II. HEAT TRANSFER1. Introduction: Fouriers law; unsteady conduction equation; boundary conditions2. Convection: heat transfer coefficient and correlations III. MASS TRANSFER1. Introduction; Ficks law; unsteady species conservation equations mass transfer coefficent and correlations **References/Text Books:** (a) V. Gupta and S.K. Gupta, Fluid Mechanics and its Applications, New Age Intl., NewDelhi, 1984.(b) V. Gupta, Elements of Heat and Mass Transfer, New Age Intl., New Delhi, 1995.(c) R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7th Ed.,Wiley, 2008.(d) J. Lighthill, Physiological Fluid Mechanics, Springer, 1972.(e) J. P.Holman, Heat Transfer, 10th Ed., McGraw Hill, 2009.	FLUID MECHANICS AND RATE PROCESSES
***** Department of CHM *****				
CHM101A	0-0-3-0-3		**Course Contents:** Chemical analysis with relevance to everyday lifeI. Determination of amount of Ca2+ in milk by complexometric titration2. Estimation of iodine in common iodized salt by iodometry3. Estimation of phosphoric acid in cola drinks by molybdenum bluemethod4. Analysis of kidney stone model chemical compounds by permanganometric titratton5. Extraction of DNA from green peas or onions and its identification6. Extraction of caffeine, an alkaloid from tea leaves7. How many pigments are there in the green portion of spinach? A paper chromatographyexperiment to separate the various pigments including chlorophyllSynthesis of Chemical CompoundsI. Preparation and characterization of aspirin, a common medicine2. DielsAlder reaction a versatile organic reaction to form CC bonds: a reaction betweenanthracene and maleic anhydride3. Preparation and characterization of an inorganic coordination complex compound:[Ni[NH3]6f+ 2cr4. Organometallic compounds: bridges between inorganic and organic	CHEMISTRY LABORATORY

			compounds. AcetylationofF errocene5. An environmentrelated synthesis: Preparation of potash alum fromscrap aluminumPhotochemistry: Light as a reagent in chemistryI. Photochemical reduction of ferric oxalate and its use in blueprintingExperiments on Physical Chemistry Conceptsl. Partition of solutes in mixture of solvents: Acetic acid inwater/nbutanol2. Kinetics of reactions: An example using the iodidehydrogen peroxide clock reaction3. Determining the pi of amino acids by using potentiometry4. Weak and strong acids and bases: conductometry **References/Text Books:** A. J. Elias:" A Collection oflnteresting General Chemistry Experiments". UniversitiesPress, Hyderabad, 2009	
CHM101N	0-1-3-0-2		**Course Contents:** Experiments related to general, organic, physical and inorganic chemistry. **References/Text Books:**	CHEMISTRY LAB
CHM102A	2-1-0-0-8		**Course Contents:** Atomic Structure (4 Lectures). Chemical Bonding (5 Lectures). Molecular Spcctmscopy (5 Lectures). Coordination complexes of transition metal ions (3 Lectures). Organometallic Chemistry (3 Lectures). Molecular Structure of organic Compounds (3 Lectures). Organic Reactions of Industrial Relevance (4 Lectures). Chemistry of New Materials: For example, Fullerenes, nanotubes and graphene (1 Lecture) **References/Text Books:** 1. Atkins & Julio de Paula: Physical Chemist1y, 8th Edition, Freeman & Co.2. Atkins & Shriver: Inorganic Chemistry, 4th Edition (2008).3. Clayden, Greaves, Warren &Wothers: Organic Chemistry, Oxtbrd Univeisity Press.	GENERAL CHEMISTRY
CHM201N	3-1-0-1-4		**Course Contents:** Chemistry, man and matter, Experimental methods of structure determination,System at finite temperature, Molecular reaction of Transition Metal ionchemistry, Organometallic chemistry, 18electron rule, simple ligands such asCO, ethylene, triphenyl phosphine etc., Homogeneous catalysis, Green chemistry,Structures of organic molecules. Conformations of ethane, butane, cyclohexaneand monosaccharides such as glucose and fructose. Anomeric effect. E and Zconfigurations (inter conversions between E and Z). Optical activity, R and S(in brief), importance of optical activity in drug synthesis and biological activity,Synthesis of organic molecules, Photochemistry of organic and biomolecules,Chemistry of life processes, Biotechnology and Biomedical applications. **References/Text Books:**	CHEMISTRY
CHM202A	3-0-0-0-9	CHM203A	**Course Contents:** Oxidation: (5)With Cr and Mn compounds; with peracids and other peroxides; with periodic acid, Pb(OAc)4,Hg(OAc)2 and SeO2.Reduction: (6)Catalytic hydrogenation; metal hydride, dissolving metal and hydrazine based reductions. CramFelkinAnh model.CC Bond Formation : (10)Acyloin, Aldol, Stobbe, Claisen, Knovenagel and Benzoin condensations, Darzens glycidic estersynthesis; Dieckmann reactions, Wittig reaction, DielsAlder and ene reactions, Reformatsky reaction.Acetoacetic ester and malonic ester synthesis. Acylation reactions. Enamine reactions. Gattermannaldehyde synthesis. Michael and Mannich reactions.Synthesis o f Polynuclear Hydrocarbons: (2)Carbohydrate Chemistry: Introduction, Structural elucidation and some typical eactions of mono anddischharides (5)Heterocyclic Chemistry: Furan, Pyrrole, Thiophene, Pyridine, Indole, quinolines etc. (5)Problems: (9)Based on multistep reactions involving CC bond formation, oxidation and Reduction (to be solved inthe class and supplemented by home assignments). **References/Text Books:** 1. Carruthers, W., Coldham, I. Some Modern Methods of Organic Synthesis, 2008.2. House, H. O., Modern Synthetic Reactions.3. March, J., Advanced Organic Chemistry, 4th ed, 1999.4. Clayden, Greeves, Warren,	BASIC ORGANIC CHEMISTRY -II

			and Wothers, Organic Chemistry, 1st ed, 2001.5. R. Bruckner, Advanced Organic Chemistry, 20026. R. Bruckner, Organic Mechanisms, 20107. M. B. Smith, Organic Synthesis, 3rd Ed. 2010	
CHM203A	3-0-0-0-9		**Course Contents:** Nomenclature o f Organic molecules : (1)Brief revision, Nomenclature of polycyclic compounds including bridged, spiro and other special structures.Structure and Bonding : (2)Nature of bonding in aliphatic, alicyclic, aromatic and heterocyclic compounds; Aromaticity in benzenoid and nonbenzenoid compounds. Alternant and nonalternant hydrocarbons; Dipole moment; Resonance; Inductive and Field effects, hyperconjugation, Steric inhibition of resonance, structural effects on acidity and basicity.Stereochemistry: (10) Conformational analysis of acyclic systems (Pitzer strain, A strain, etc.) and cyclohexane systems (brief review as studied in Chm 201). Introduction of terminologies such as erythro, threo, , , exo, endo, epimers, etc. Conformational analysis of decalins and other polycyclic compounds related to steroids. A brief introduction to asymmetric synthesis; Induction of chirality on a prochiral carbon atom; R and S nomenclature in (i) cyclic systems (ii) in compounds with more than one chiral centre and (iii) in biphenyls, allenes and spiro compounds. Optical isomerism in compounds without an asymmetric atom, Racemic modifications. Conformation of acyclic molecules, topicity and prostereoisomerism (topicity of ligands and faces),chemical and biochemical transformations of heterotopic ligands and faces. Conformations of cyclic, fused and bridged ring compounds. Allylic strain (A1,2 and A1,3) and other strains. **References/Text Books:** 1. March, J., Advanced Organic Chemistry, 4th ed, 1999.2. Nasipuri, D., Stereochemistry of Organic Compounds, 2nd ed., 1995.3. Solomons, T. W. G., Organic Chemistry 6th ed, 1996.4. Sykes, Peter, A guide book to Mechanism in Organic Chemistry.5. R. Bruckner, Advanced Organic Chemistry, 20026. R. Bruckner, Organic Mechanisms, 20107. M. B. Smith, Organic Synthesis, 3rd Ed. 2010	BASIC ORGANIC CHEMISTRY-I
CHM205	3-1-0--4		**Course Contents:** Various aspects of the energy and raw material supply: Coal, oil, natural gas,nuclear, and biomass as energy sources; Basic products of industrial synthesis:synthesis gas, methanol, formaldehyde, halogen derivatives of methane,chlorofluorohydrocarbons; Olefins:Historical perspective, cracking of hydrocarbons,ethylene, butanes, higher olefins, unbranched higher olefins and their use inmetathesis reactions,Acetylene: Significance and manufacturing process for acetylene, manufacturethrough calcium carbide, thermal process, applications of acetylene, 1,3Dioolefins:1,3Butadiene, industrial manufacture from cracking, dehydrogenation,applications of butadiene,Synthesis using carbon monoxide: Hydroformylation, industrial operations,utilization of oxo products, carbonylation of olefins;Oxidation products of ethylene: Ethylene oxide, process operation, ethyleneglycol, ethylene glycol ethers, acetaldehyde, acetic acid, acetic anhydride,Alcohols: Ethanol, propanol, butanols, amyl alcohols, aldol synthesis, polyhydricalcohols, neopentyl glycol.Vinylhalogen and oxygen compounds: Vinyl chloride, vinylidene chloridevinylacetate, binyl ethers;Polyamides: Adipic acid, hexamethylenediamine, adiponitrile, lactams;Propene conversion products; Propylene oxide, acetone, acrolein, allylchloride,acrylonitrile.;Aromatics: Source of feedstocks, coking of hard coal, isolation, specialseparation techniques, condensed aromatics, naphthalene, anthracene,hydrodealkylation.Benzene derivatives; Styrene, cumene, cyclohexane, phenol, maleic anhydride,nitrobenzene, aniline, diisocyanates. Oxidation products of xylene and naphthalene;Phthalic anhydride, esters of phthalic acid and derivatives, terephthalic acid. **References/Text Books:**	INDUSTRIAL ORGANIC CHEMISTRY
CHM222	3-1-0-0-4		**Course Contents:** 1. Zeroth Law of Thermodynamics: Equilibrium, State Functions, Temperature, Equations ofState2. First Law of Thermodynamics: Work, Heat, Internal Energy, Heat Capacity, Concept ofEnthalpy3. Second Law of Thermodynamics: Reversible and Irreversible Process, Heat Engines,Carnot Cycle, Different statements of the Second Law, Spontaneous Change, Entropy4. Third Law of Thermodynamics: Concept of the absolute zero temperature5. Free Energy and Standard States: Free energies and Thermodynamic potentials, LegendreTransforms, Equilibrium and NonEquilibrium, Chemical Potentials, Free Energy, StandardStates,	BASIC PHYSICAL CHEMISTRY

			Reaction Thermodynamics, Equilibrium Constant6. Equilibrium Thermodynamics: Chemical Potential of Mixtures, Phase Equilibrium, PhaseRule, Clapeyron Equation, Phase Diagram7. Real Gases: Equations of State, Phase Transitions8. Solutions: Molarity, Partial Molar Quantities, Mixing, Ideal Solutions, NonIdeal Solutions,Electrolytes, Ionic activity and the DebyeHueckel Theory, the Nernst Equation, Colligativeproperties, Multicomponentphase diagrams9. Kinetic Theory of Gases and Transport Processes10. Reaction Kinetics: Reaction Rates, Rate Laws, Reaction Mechanisms, Applications **References/Text Books:** 1. P. W. Atkins and Julio de Paula, Physical Chemistry2. I. N. Levine, Physical Chemistry3. R. J. Silbey, R. A. Alberty, and M. G. Bawendi, Physical Chemistry	
CHM222A	3-0-0-0-9		**Course Contents:** 1. Zeroth Law of Thermodynamics: Equilibrium, State Functions, Temperature, Equations ofState2. First Law of Thermodynamics: Work, Heat, Internal Energy, Heat Capacity, Concept ofEnthalpy3. Second Law of Thermodynamics: Reversible and Irreversible Process, Heat Engines,Carnot Cycle, Different statements of the Second Law, Spontaneous Change, Entropy4. Third Law of Thermodynamics: Concept of the absolute zero temperature5. Free Energy and Standard States: Free energies and Thermodynamic potentials, LegendreTransforms, Equilibrium and NonEquilibrium, Chemical Potentials, Free Energy, StandardStates, Reaction Thermodynamics, Equilibrium Constant6. Equilibrium Thermodynamics: Chemical Potential of Mixtures, Phase Equilibrium, PhaseRule, Clapeyron Equation, Phase Diagram7. Real Gases: Equations of State, Phase Transitions8. Solutions: Molarity, Partial Molar Quantities, Mixing, Ideal Solutions, NonIdeal Solutions,Electrolytes, Ionic activity and the DebyeHueckel Theory, the Nernst Equation, Colligativeproperties, Multicomponentphase diagrams9. Kinetic Theory of Gases and Transport Processes10. Reaction Kinetics: Reaction Rates, Rate Laws, Reaction Mechanisms, Applications **References/Text Books:** 1. P. W. Atkins and Julio de Paula, Physical Chemistry2. I. N. Levine, Physical Chemistry3. R. J. Silbey, R. A. Alberty, and M. G. Bawendi, Physical Chemistry	BASIC PHYSICAL CHEMISTRY
CHM242A	3-0-0-0-9	CHM102A	**Course Contents:** Basic Concepts (10)1. Molecular symmetry, point groups and character tables2. Bonding models3. Chemical forces4. Acids and BasesMainGroup Chemistry (12)5. Chemistry of selective maingroup elements and their compoundsTransition Metal Chemistry (15)6. Types of ligands, Structure and isomerism of transition metal complexes, Bonding intransition metal complexes Valence Bond, Crystal Field and Molecular Orbital theories,effects of dorbital splitting7. Organometallic compounds: EAN rule, metalcarbonyls, metalolefins, reactions oforganometallic compounds8. Homogeneous and Heterogeneous CatalysisLanthanide Chemistry (5)9. Chemistry of fblock elements: special features, lanthanide contraction, coordinationnumber, structure and reactions **References/Text Books:** 1. Shriver, D. F.; Atkins, P. W. and Langford, C. G. Inorganic Chemistry, 3rd Edn., Oxford University, Oxford, 1999.2. Jolly, W. L.: Modern Inorganic Chemistry, 2nd Edn., 1991.3. Cotton, F. A. Chemical Applications of Group Theory, 3rd Edn., John Wiley and Sons,2003.4. Cotton, F. A.; Wilkinson, G., Basic Inorganic Chemistry, 3rd Edn., John Wiley and Sons1998.5. Cotton, F.A.; Carlos, A. M,; and Bochmann, M. Advanced Inorganic Chemistry, 6th Edn .Wiley Interscience Publication, 2001.	BASIC INORGANIC CHEMISTRY
CHM301	3-1-0-0-4		**Course Contents:** Nomenclature of organic molecules Structure and bonding, Stereochemistry,Reactive Intermediates, Substitution and Elimination Reactions, MolecularRearrangements, Photochemistry. **References/Text Books:**	BASIC ORGANIC CHEMISTRY-I
CHM302	3-1-0-0-4		**Course Contents:**	BASIC ORGANIC

			Oxidation, Reduction, CC Bond Formations, Syhthesis of Polynuclear Hydrocarbons,Carbohydrates, Nucleotides, Amino Acids and Peptides. **References/Text Books:**	CHEMISTRY II
CHM303A	3-0-0-0-9	CHM203A/CHM202A	**Course Contents:** Stereochemistry (8)Dynamic stereochemistry: Conformation and Reactivity. Various chemo, regio and stereoselectivereactions.Reactive Intermediates : (8) Carbenes and carbenoids Radicals: Structure, reactivity, selectivity and mechanisms of radicals and radical basedreactions, involving various functional groups. Radical cations and radical anions. Carbocations: Nonclassical carbocation. Sigma and piparticipation.Mechanistic and Stereochemica l Aspects of : (10)BaeyerVilliger, Claisen (including JohnsonClaisen, IrelandClaisen, Eschenomser, Overmanmodifications) Cope, and oxyCope, Wittig rearrangements (both 1,2 and 2,3 Wittig rearrangements);ene and metalloene reactions; (2+2), (3+2) and (4+2) cycloadditions; Barton reaction.Organometallic Chemistry : (5)Mechanism and stereochemistry of various reactions. Palladium based reactions such as Heck, Stille,Suzuki, Sonogashira, BuchwaldHartwig couplings; TsujiTrost CC bond formations; Ni and Sncatlysed reactions.Enzymatic Reactions : (3)Mecahnistic and stereochemical aspects of hydrolases (including esterases and lipases), oxidoreductases.Green Chemistry : Concepts and applications (3)Classification and Structures o f some natura l products such as terpenoids, steroids, alkaloids andprostaglandins (5) **References/Text Books:** 1. March, J., Advanced Organic Chemistry, 4th ed, 1999.2. Nasipuri, D., Stereochemistry of Organic Compounds, 2nd ed., 1995.3. Solomons, T. W. G., Organic Chemistry 6th ed, 1996.4. Sykes, Peter, A guide book to Mechanism in Organic Chemistry.5. R. Bruckner, Advanced Organic Chemistry, 20026. R. Bruckner, Organic Mechanisms, 20107. M. B. Smith, Organic Synthesis, 3rd Ed. 20108. Clayden, Greeves, Warren, and Wothers, Organic Chemistry, 1st ed, 2001	ORGANIC CHEMISTRY I
CHM305A	0-0-6-0-6		**Course Contents:** 1. Experimental Techniques(A) Purification of Organic Compoundsa. Recrystallisationb. Sublimation at atmospheric pressure and under reduced pressurec. Separation or organic compounds by Steam distillationd. Distillation of organic compounds under reduced pressuree. Bulbtobulb distillation under reduced pressure(B) Chromatographya. Thin layer chromatography (TLC) and calculation of Rf valuesb. Column Chromatography: separation of organic mixture.c. Preparative TLC: preparation of plates and separation of organic mixtures(C) Physical Constantsa. Melting Points and Boiling Pointsb. Optical rotation and calculation of specific rotation and molecular rotation(D) Spectroscopic Methodsa. Preparation of an ester and its confirmation by IR and NMRb. Structure illucidation of unknown compounds based on the given spectral data2. Investigation and Characterization of Organic Compoundsa. Detection of elements present in a given organic compound.b. Identification of functional groups in a given organic compound.c. Identification of unknown organic compounds.d. Separation of organic mixture by chemical methods, preparation of derivatives, andidentification of the material. **References/Text Books:**	ORGANIC QUALITATIVE & QUANTITATIVE ANALYSIS
CHM321A	3-0-0-0-9		**Course Contents:** 1. Introduction: importance, historic background, quantum mechanics vs classical mechanics,waveparticle duality, uncertainty principle2. Schroedinger equation: wavefunction and interpretation, timedependent and timeindependent Schroedinger equation, eigenvalue problem3. Quantum mechanics of some simple systems: free particle, particle in a box , harmonicoscillator, one dimensional potential step and barrier4. Angular Momentum: rigid rotor, orbital and spin angular momentum5. Hydrogen and hydrogen like atoms6. Approximate methods: perturbation theory, variational method, some simple examples.7. Many electron atom: Pauli antisymmetry principle, Slater determinant, He atom, Li atom. **References/Text Books:**	PHYSICAL CHEMISTRY I

			1. I. N. Levine, Quantum Chemistry2. J. P. Lowe and K. A. Peterson, Quantum Chemistry3. D. A. McQuarrie, Quantum Chemistry4. D. A. McQuarrie, J. D. Simon, Physical Chemistry: A molecular approach5. P. W. Atkins, Molecular Quantum Mechanics	
CHM322A	3-0-0-0-9		**Course Contents:** Equilibrium Thermodynamics: Laws of thermodynamics,the equilibrium state, thermodynamic variables, conjugate quantities,thermodynamic potentialsStatistical Mechanics: Kinetic Theory of gases, Boltzmann distribution,the ensemble postulate, partition function, canonical ensemble, otherensembles, fluctuations, ideal monatomic, diatomic and polyatomicgases, chemical equilibrium, quantum statisticsTransport Phenomena: Transport coefficients, thermal conductivity,diffusivity, viscosity, ionic conductivity, Limiting law of DebyeHckelOnsager, NernstEinstein relation, StokesEinstein relationMolecular Reaction Dynamics: Collision theory, activation energy,transitionstate theory, reactions as trajectories, molecular beam experiments,reactions in liquid phase, Kramers theory, Diffusion limited reactions **References/Text Books:** 1. P.W. Atkins and Julio de Paula : Physical Chemistry2. I.N. Levine: Physical Chemistry3. D.A. McQuarrie and J. D. Simon : Physical Chemistry A Molecular Approach4. D. A. McQuarrie, Statistical Mechanics5. H. B. Callen: Thermodynamics and an introduction to Thermostatistics6. David Chandler : Introduction to Modern Statistical Mechanics7. R.S. Berry, S.A. Rice and John Ross : Physical Chemistry	PHYSICAL CHEMISTRY -II
CHM341	3-0-0-0-4		**Course Contents:** Vector model of the atom (RussellSaunders Coupling), the molecule and molecularions, periodicity of the elements, shielding, the size of the atoms, ionizationenergy, electron affinity, inorganic solid state, Covalent bonding, Heteronuclearbonds, Types of chemical forces, Effects of chemical forces, Hard and soft acidsand bases: Classification, acids and bases, Optical activity, Experimentalevidence for metalligand orbital overlap. **References/Text Books:**	BASIC INORGANIC CHEMISTRY
CHM342A	3-0-0-0-9	CHM345A	**Course Contents:** 1. Symmetry, point groups, character tables, concepts of orbital symmetries for dorbitalsplitting diagrams in different stereochemistry 2. Synthesis and structure of mononuclear and multinuclear transition metal complexes 3. Theories of bonding. Crystalfield and Molecular orbital, effects of ligandfield(spectrochemical series, consequences of dorbital splitting) 4. Spectroscopy of transitionmetal complexes: RussellSaunders coupling scheme, TermSymbols 5. Magnetism of transitionmetal complexes: Curie law, para, ferro, antiferro and ferrimagneticsystems. 6. Reaction mechanism of transition metal complexes and electrontransfer reactions 7. Introduction of bioinorganic chemistry: heme, nonheme, FeS proteins 8. New trends of research: supramolecular chemistry, metalorganic frameworks, gasstorage,nanochemistry, the renaissance of carbon9. Transition metalbased inorganic materials (magnetic, optical and biomaterials) **References/Text Books:** 1) Huheey, J. E.; Keiter, K. E.; Keiter, R. L., Inorganic ChemistryPrinciples of Structure andReactivity: 4th Edn, Pearson Education, 2008.2) Shriver. D. F.; Atkins. P. W.; Langford, C. G., Inorganic Chemistry. 3rd Edn., OxfordUniversity, Oxford, 1999.3) Cotton, F. A.; Murillo, C. A.; and Bochmann, M., Advanced Inorganic Chemistry , 6th Edn. ,Wiley Interscience, 2001.4) Cotton, F. A., Chemical Applications of Group Theory 3rd ed., John Wiley and Sons, 20035) Carter, R. L., Molecular Symmetry and Group Theory, John Wiley and Sons, 3rdEdn.,19986) Kahn, O., Molecular Magnetism, VCH, Weinheim, 19937) Lehn, J. M., Supramolecular Chemistry: Concepts and Perspectives, VCH, Weinheim,19958) Berg, J. M.; Lippard, S. J., Principles of Bioinorganic Chemistry, University Science Books,CA, 1995.	INORGANIC CHEMISTRY -II
CHM344A	0-0-6-0-6		**Course Contents:** Estimation of iron in minute quantities by UVvis spectrophotometryPrinciples of colorimetric analysis: determination of iron content of an unknown sample.Preparation of hexamminenickel(II)chloride: estimation of ammonia and nickel bytitrimetric and gravimetric methodsDetermination of complex composition using	INORGANIC CHEMISTRY LABORATORY EXPERIMENTS

			simple techniquesPreparation of diamagnetic and paramagnetic maingroup and transitionmetalacetylacetonatesSynthesis, isolation and spectroscopic characterization of the complexesSynthesis and characterization of ferrocene and acetylferroceneSynthesis of the complex and their purification using chromatographyAcidbase and redox titration of tablets containing VitaminCEstimation of ascorbic acid in VitaminC tabletsPaper chromatographic separation of Cu^{2+}, Fe^{3+} and Ni^{2+}Utilization of paper chromatographic techniques to separate the metal saltsSpectrophotometric determination of phosphate: estimation of phosphate in coladrinksDetermination of concentration of phosphates applying BeerLambert law8. Potassium trisoxalatoferrate(III): synthesis, analysis and photochemistrySynthesis of the complex and its utilization in blueprinting experiment **References/Text Books:** Elias, A. J., A Collection of Interesting General Chemistry Experiments, Universities Press(India) Pvt. Ltd., 2002.Roesky, H. W.; Mckel, K., Chemical Curiosities: spectacular experiments and inspiredquotes, VCH, 1996.Handouts prepared for the laboratory experiments: collections from various literature sources	
CHM345A	3-0-0-0-9	CHM242A	**Course Contents:** 1. Representative Chemistry of MainGroup Elements (15)(a) Organometallic Chemistry of Lithium and Magnesium: synthesis, structure and reactivity(b) Chemistry of Boron: boranes, bonding in boranes, topology of boranes, synthesis andreactivity, carboranes and metallacarboranes. New Lewis acids based on boron; polymersupported Lewis acids(c) Chemistry of Aluminum: Aluminum alkyls, use of aluminum alkyls in polymerization ofolefins(d) C60 and carbon nanotubes: discovery, preparation and selected reactions(e) Chemistry of Silicon: organosilicon compounds, silicates and aluminosilicates2. Unusual Compounds of MainGroup Elements (10)(a) Multiple bonding in heavier maingroup elements, unusual compounds of maingroupelements: (i) SiSi double bond, SiSi triple bond, PP double bond, BiBi double bond,synthesis, structure and reactivity(b) Chemistry of lowvalent compounds: Synthesis, structure and bonding models andreactivity of Al(I), Si(II) lowvalent compounds(c) Chemistry of stable Nheterocyclic carbenes, use of carbenes in catalysis(d) Inorganic rings and polymers: cyclo and heterocyclophosphazenes, polysilanes, borazine and boron nitride3. Chemistry of halogens and noble gases: recent trends, CFCs and ozone layer (2)4. Organometallic Chemistry (15)(a) bonded systems: metalalkyls, aryls and hydrides, stability, preparation and reactivity, metalcarbonyls, metalphosphines, metalnitrosyls, metalisocyanides: structures, reactivity and bonding Metalcarbenes, metalcarbynes, Fischer carbenes, Schrock carbenes, complexes with Nheterocyclic carbenes, olefin metathesis(b) bonded systems: metalolefins, alkyls, alkynes, dienes, Cp and Cp*, structure,bonding and reactivity(c) Applications of organometallics in organic synthesis: CC bond coupling reactions (Heck, Sonogashira, Suzuki), reduction using transition metal hydrides, asymmetrichydrogenation **References/Text Books:** 1) Elschenbroich, C.; and Salzer, A., Organometallics: A Concise Introduction, 3rd Edn. 1999.2) Greenwood, N. N.; Earnshaw, A., Chemistry of the Elements, Pergamon Press, 2nd Edn.,2002.3) Douglas, B.; McDaniel, D.; and Alexander, J., Concepts and Models of InorganicChemsitry. 3rd Edn., John Wiley, New York. 19934) Crabtree, R. H. The Organometallic Chemistry of the Transition Metals, 5th Edn., JohnWiley and Sons, 2009	INORGANIC CHEMISTRY I
CHM391A	0-0-4-0-4		**Course Contents:** 5TH SEMESTER UNDERGRADUATE PROJECT **References/Text Books:**	UNDER GRADUATE PROJECT-I
CHM392A	0-0-0-0-9		**Course Contents:** UG PROJECT II **References/Text Books:**	UG PROJECT II

CHM399A	0-0-0-2-2		**Course Contents:** CHEMISTRY COMMUNICATION SKILLS **References/Text Books:**	CHEMISTRY COMMUNICATION SKILLS
CHM401	3-0-0-0-4		**Course Contents:** Stereochemistry, Dynamic stereochemistry, Mechanistic and Stereochemicalaspects, Reactive Intermediates: Carbenes, Nitrenes, Radicals, Carbocations. **References/Text Books:**	ORGANIC CHEMISTRY I
CHM401A	3-0-0-0-9		**Course Contents:** Stereochemistry, Dynamic stereochemistry, Mechanistic and Stereochemicalaspects, Reactive Intermediates: Carbenes, Nitrenes, Radicals, Carbocations. **References/Text Books:**	ORGANIC CHEMISTRY I
CHM402	3-0-0-0-4		**Course Contents:** Oxidation: (6)Oxidation involving organosulfur (such as Swern) and organoselenium compounds; DessMartin, IBXand related hypervalent iodine based oxidations, Ag2CO3/celite Prevost, photosensitised oxidation,dimethyldioxirane, RuO4, 2sulfonyl oxaziridne, transition metal catalysed oxidation, oxidation atunfunctionalised carbons, FlemingTamao oxidation, and microbial oxidations.Reduction: (6)Using silanes, Al and B based reagents (e.g. DIBAL, Lselectride, Kselectride, RedAl etc.), low valentTi species, microbial reductions (NADH model etc.)Asymmetric Synthesis : (8)Sharpless epoxidation and dihydroxylation, Jacobsens epoxidation, Coreys oxazaborolidinecatalyzed reduction, Noyoris BINAP reduction, SAMP, RAMP, Evans oxazoline and Oppolzer sultams,Aldol reaction (in brief: only principles using models).CC Bond Formation : (14) via anions to electron withdrawing groups (carbonyl group, esters, NO2, SO2Ph, CN etc.) via B and Si enolates via imines Michael additions (cuprates etc.) Via allyl boron, allyl tin, allyl and vinyl silanes Metal catalyzed Cyclopropanation reactions (including Simmons Smith reaction) Ringclosing, ringopening and cross metathesisOrganic Synthesis : (8)Application of above reactions and the ones studied in CHM 401 in synthesis of natural products. **References/Text Books:** 1. Carruthers, W., Coldham, I. Some Modern Methods of Organic Synthesis, 2008.2. Smith, M. B., Organic Synthesis, 2nd ed., 2002.3. Carreira, E. M.; Kvaerno, L. Classics in stereoselective synthesis, 20094. Nicolaou, K. C.; Sorenson, E. J., Classics in total synthesis, 19965. Nicolaou, K. C.; Snyder, S. A., Classics in total synthesis II, 20036. Tsuji, J., Transition metal reagents and catalysts, 2000	ORGANIC CHEMISTRY II
CHM402A	3-0-0-0-9	CHM303A	**Course Contents:** Oxidation: (6)Oxidation involving organosulfur (such as Swern) and organoselenium compounds; DessMartin, IBXand related hypervalent iodine based oxidations, Ag2CO3/celite Prevost, photosensitised oxidation,dimethyldioxirane, RuO4, 2sulfonyl oxaziridne, transition metal catalysed oxidation, oxidation atunfunctionalised carbons, FlemingTamao oxidation, and microbial oxidations.Reduction: (6)Using silanes, Al and B based reagents (e.g. DIBAL, Lselectride, Kselectride, RedAl etc.), low valentTi species, microbial reductions (NADH model etc.)Asymmetric Synthesis : (8)Sharpless epoxidation and dihydroxylation, Jacobsens epoxidation, Coreys oxazaborolidinecatalyzed reduction, Noyoris BINAP reduction, SAMP, RAMP, Evans oxazoline and Oppolzer sultams,Aldol reaction (in brief: only principles using models).CC Bond Formation : (14) via anions to electron withdrawing groups (carbonyl group, esters, NO2, SO2Ph, CN etc.) via B and Si enolates via imines Michael additions (cuprates etc.) Via allyl boron, allyl tin, allyl and vinyl silanes Metal catalyzed Cyclopropanation reactions (including Simmons Smith reaction) Ringclosing, ringopening and cross metathesisOrganic Synthesis : (8)Application of above reactions and the ones studied in CHM 401 in synthesis of natural products.	ORGANIC CHEMISTRY II

			References/Text Books: 1. Carruthers, W., Coldham, I. Some Modern Methods of Organic Synthesis, 2008.2. Smith, M. B., Organic Synthesis, 2nd ed., 2002.3. Carreira, E. M.; Kvaerno, L. Classics in stereoselective synthesis, 20094. Nicolaou, K. C.; Sorenson, E. J., Classics in total synthesis, 19965. Nicolaou, K. C.; Snyder, S. A., Classics in total synthesis II, 20036. Tsuji, J., Transition metal reagents and catalysts, 2000	
CHM421	3-0-0-0-4		**Course Contents:** Atomic Structure, chemical binding and molecular structure. Elements ofmolecular spectroscopy. **References/Text Books:**	PHYSICAL CHEMISTRY I
CHM421A	3-0-0-0-9		**Course Contents:** Atomic Structure, chemical binding and molecular structure. Elements ofmolecular spectroscopy. **References/Text Books:**	PHYSICAL CHEMISTRY I
CHM422	3-0-0-0-4		**Course Contents:** Thermodynamics, Statistical Thermodynamics, Chemical kinetics. **References/Text Books:**	PHYSICAL CHEMISTRY II
CHM423	0-0-6-0-2		**Course Contents:** 1. Calibration of volumetric apparatus. (One day)2. Analysis of the rotationalvibrational spectra of HCl molecules. (One day)3. Determination of partial molal volume. (One day)4. Determination of the isotherm for a three component system. (Two days)5. Kinetics of fast reactions by stoppedflow technique. (One day)6. Spectrophotometric determination of the acid dissociation constant (Two day)7. The measurement of electrical conductance for the determination of the equivalentconductance at infinite dilution (Two days)8. Rate of the hydrolysis of sucrose using polarimeter. (Two day)9. Determination of pKa of polybasic acid with the pH meter. (One day)10. Determination of critical miceller concentration. (One day)11. Determination of transport number by moving boundary method. (One day)12. Polarizability from refractive index measurements. (One day)13. Formula and stability constant of a complex by spectrophotometry. (One day)14. Fluorescence quantum yield determination of an unknown molecule. (One day)15. Fluorescence spectrum and sternvolmer quenching constant. (One day)16. IR and Raman spectroscopy of solvent mixtures. (Two days)17. Computing Potential Energy Surface of molecules using Quantum Mechanics. (Twodays) **References/Text Books:** 1. Experimental physical chemistry, F. A. Bettelheim2. Experimental physical chemistry, G. P. Matthews3. Experimental physical chemistry, F. Daniels4. Experimental physical chemistry, A. Halpern and G. McBane5. Experimental Physical Chemistry, D. P. Shoemaker, C. W. Garland, and J. W. Nibler	PHYSICAL CHEMISTRY LAB
CHM423A	0-0-6-0-6		**Course Contents:** 1. Calibration of volumetric apparatus. (One day)2. Analysis of the rotationalvibrational spectra of HCl molecules. (One day)3. Determination of partial molal volume. (One day)4. Determination of the isotherm for a three component system. (Two days)5. Kinetics of fast reactions by stoppedflow technique. (One day)6. Spectrophotometric determination of the acid dissociation constant (Two day)7. The measurement of electrical conductance for the determination of the equivalentconductance at infinite dilution (Two days)8. Rate of the hydrolysis of sucrose using polarimeter. (Two day)9. Determination of pKa of polybasic acid with the pH meter. (One day)10. Determination of critical miceller concentration. (One day)11. Determination of transport number by moving boundary method. (One day)12. Polarizability from refractive index measurements. (One day)13. Formula and stability constant of a complex by spectrophotometry. (One day)14. Fluorescence quantum yield determination of an unknown molecule. (One day)15. Fluorescence spectrum and sternvolmer quenching constant. (One day)16. IR and Raman spectroscopy of solvent mixtures.	PHYSICAL CHEMISTRY LABORATORY

			(Two days)17. Computing Potential Energy Surface of molecules using Quantum Mechanics. (Twodays) **References/Text Books:** 1. Experimental physical chemistry, F. A. Bettelheim2. Experimental physical chemistry, G. P. Matthews3. Experimental physical chemistry, F. Daniels4. Experimental physical chemistry, A. Halpern and G. McBane5. Experimental Physical Chemistry, D. P. Shoemaker, C. W. Garland, and J. W. Nibler	
CHM441	3-0-0-0-4		**Course Contents:** Principles of modern inorganic chemistry, discussion of the chemistry of nontransitionelements. **References/Text Books:**	INORGANIC CHEMISTRY I
CHM441A	3-0-0-0-9		**Course Contents:** Principles of modern inorganic chemistry, discussion of the chemistry of nontransitionelements. **References/Text Books:**	INORGANIC CHEMISTRY I
CHM442	3-0-0-0-4		**Course Contents:** Coordination Chemistry: Bonding, Spectra, Magnetism, Structure and ReactionMechanism, Supramolecular Chemistry, Molecular Magnetism, OrganometallicChemistry, Inorganic Chemistry of Biological systems. **References/Text Books:**	INORGANIC CHEMSTRY II
CHM481	3-0-0-0-4		**Course Contents:** Buffers (their use in study of biomolecules), pH, pKa of amino acids, D and L amino acidnomenclature. (1)Proteins: protein sequencing by chemical and mass & NMR spectroscopic methods, Use ofspectroscopic tools in studying biomolecules. Primary (single letter amino acid codes),Ramachandran plot, secondary , 310, helices, parallel and antiparallel sheets, turns, turns), circular dichroism of secondary structures, tertiary (motifs and domains : someimportant motifs like Rossman fold, helix turn helix, 4 helix bundles, beta barrel) andquaternary structure (Hemoglobin and Myoglobin). Protein Engineering (17).Nucleic acids: A, B and ZDNA structures, Method of replication, sequencing of nucleic acids(chemical, dideoxy and fluorescence), Transcription, Translation, genetic code, genomes,genes, over expression of recombinant proteins, mutagenesis (random and site directed).Polymerase chain reaction (PCR). Use of modified bases in PCR (9)Carbohydrates and Glycoproteins, proteoglycans, Membranes and lipids, bacteial cell wallsynthesis and mechanism of some important antibiotics like penicllin, antibiotic resistance. (4)Metabolism: Photosynthesis, Calvins cycle, Glycolysis, Krebs cycle, electron transport,cofactors. (4)Enzymes and their kinetics: MichaelisMenten kinetics, Reaction order, competitive, uncompetitive,noncompetitive and irreversible inhibition of enzymes. Effect of pH, temperatureon enzyme activity. (4)Biophysical techniques to purify and study proteins. Dialysis, salting out and precipitation byorganic solvents, Ion exchange, gel filtration, reversed phase, affinity chromatography,ultracentrifugation, gel electrophoresis. (3) **References/Text Books:** Fundamentals of Biochemistry by Voet, Voet and Pratt,Biochemistry by L. Stryer,Proteins by T.E. Creighton,Genes VII by B. Lewin,Introduction to protein structure by Branden and Tooze,Enzyme structure and Mechanism by Alan Fersht.	BIOSYSTEMS
CHM481A	3-0-0-0-9	CHM102A	**Course Contents:** Buffers (their use in study of biomolecules), pH, pKa of amino acids, D and L amino acidnomenclature. (1)Proteins: protein sequencing by chemical and mass & NMR spectroscopic methods, Use ofspectroscopic tools in studying biomolecules. Primary (single letter amino acid codes),Ramachandran plot, secondary , 310, helices, parallel and antiparallel sheets, turns, turns), circular dichroism of secondary structures, tertiary (motifs and domains : someimportant motifs like Rossman fold, helix turn helix, 4 helix bundles, beta barrel) andquaternary structure (Hemoglobin and Myoglobin). Protein Engineering (17).Nucleic acids: A, B and	BIOSYSTEMS

			ZDNA structures, Method of replication, sequencing of nucleic acids(chemical, dideoxy and fluorescence), Transcription, Translation, genetic code, genomes,genes, over expression of recombinant proteins, mutagenesis (random and site directed).Polymerase chain reaction (PCR). Use of modified bases in PCR (9)Carbohydrates and Glycoproteins, proteoglycans, Membranes and lipids, bacteial cell wallsynthesis and mechanism of some important antibiotics like penicllin, antibiotic resistance. (4)Metabolism: Photosynthesis, Calvins cycle, Glycolysis, Krebs cycle, electron transport,cofactors. (4)Enzymes and their kinetics: MichaelisMenten kinetics, Reaction order, competitive, uncompetitive,noncompetitive and irreversible inhibition of enzymes. Effect of pH, temperatureon enzyme activity. (4)Biophysical techniques to purify and study proteins. Dialysis, salting out and precipitation byorganic solvents, Ion exchange, gel filtration, reversed phase, affinity chromatography,ultracentrifugation, gel electrophoresis. (3) **References/Text Books:** Fundamentals of Biochemistry by Voet, Voet and Pratt,Biochemistry by L. Stryer,Proteins by T.E. Creighton,Genes VII by B. Lewin,Introduction to protein structure by Branden and Tooze,Enzyme structure and Mechanism by Alan Fersht.	
CHM491A	0-0-0-0-9		**Course Contents:** UG PROJECT (UGPIII) **References/Text Books:**	UNDER GRADUATE PROJECT-III
CHM503	0-0-6-0-2		**Course Contents:** Preparations of various organic compounds employing different reactions willbe carried out, with a view to give the student sufficient training in syntheticorganic chemistry. **References/Text Books:**	ORGANIC PREPARATION LAB
CHM503A	0-0-6-0-6		**Course Contents:** Preparations of various organic compounds employing different reactions willbe carried out, with a view to give the student sufficient training in syntheticorganic chemistry. **References/Text Books:**	ORGANIC PREPARATION LAB
CHM521	3-0-0--4	#	**Course Contents:** Preparations of various organic compounds employing different reactions willbe carried out, with a view to give the student sufficient training in syntheticorganic chemistry. **References/Text Books:**	MATHEMATICS FOR CHEMISTRY
CHM521A	3-0-0-0-9		**Course Contents:** Preparations of various organic compounds employing different reactions willbe carried out, with a view to give the student sufficient training in syntheticorganic chemistry. **References/Text Books:**	MATHEMATICS FOR CHEMISTRY
CHM600	3-0-0--4	#	**Course Contents:** Error Analysis, Scalars, vectors, curl, divergence and gradient, ordinary3000[4] differential equations, symmetry and group theory, matrices, etc. **References/Text Books:**	MATHEMATICS FOR CHEMISTRY
CHM600A	3-0-0-0-9		**Course Contents:** Error Analysis, Scalars, vectors, curl, divergence and gradient, ordinary3000[4] differential equations,	MATHEMATICS FOR CHEMISTRY

			symmetry and group theory, matrices, etc. **References/Text Books:**	
CHM602	3-0-0-0-4		**Course Contents:** Principles of retrosynthetic analysis: Linear and convergent synthesis, Synthesis 7under steric control, Regio and stereoselective synthesis, Basic synthetic methods.Methodolgies for the construction of 37 membered rings, medium and large rings. Application in natural product synthesis.25Methodolies for the construction of 37 membered heterocyclic rings. Application In organic synthesis.10 **References/Text Books:** Corey and Cheng, The Logic of Chemical Synthesis, Wiley, 1989.Nicolaou and Sorensen, Classics in Total Synthesis, 1996.Nicolaou and Snyder, Classics in Total Synthesis II, 2003.Carey and Sundberg, Advanced Organic Chemistry, Part I and II, 4th ed., 2000.	ADVANCED ORGANIC CHEMISTRY II
CHM602A	3-0-0-0-9	CHM402A	**Course Contents:** Principles of retrosynthetic analysis: Linear and convergent synthesis, Synthesis 7under steric control, Regio and stereoselective synthesis, Basic synthetic methods.Methodolgies for the construction of 37 membered rings, medium and large rings. Application in natural product synthesis.25Methodolies for the construction of 37 membered heterocyclic rings. Application In organic synthesis.10 **References/Text Books:** Corey and Cheng, The Logic of Chemical Synthesis, Wiley, 1989.Nicolaou and Sorensen, Classics in Total Synthesis, 1996.Nicolaou and Snyder, Classics in Total Synthesis II, 2003.Carey and Sundberg, Advanced Organic Chemistry, Part I and II, 4th ed., 2000.	ADVANCED ORGANIC CHEMISTRY II
CHM609	3-0-0-0-4		**Course Contents:** Stereochemistry, mechanisms of selected reactions, Reactive intermediates,oxidation, Reduction, CC bond formations, synthesis of some useful naturalproducts **References/Text Books:**	PRINCIPALES OF ORGANIC CHEMISTRY
CHM609A	3-0-0-0-9		**Course Contents:** Stereochemistry, mechanisms of selected reactions, Reactive intermediates,oxidation, Reduction, CC bond formations, synthesis of some useful naturalproducts **References/Text Books:**	PRINCIPALES OF ORGANIC CHEMISTRY
CHM611	3-0-0-0-4		**Course Contents:** Pericyclic Reactions: (7)Conservation of orbital symmetry, and Woodward and Hoffmann rules. Cycloadditions,Electrocyclizations, Sigmatropic rearrangements, and Chelotropic reactions. Orbital overlapeffects in chemical processes.Stereoelectronic Effects in Organic Chemistry: (10)Acetals, Esters, Amides and related functions. Reactions at sp3, sp2, and sp carbons.Examples in synthesis and biological processes. FelkinAhn model, Houk model, Cieplakmodel, EFOE model, and Cationcomplexation model as applied to Facial selectivity.Reactive Intermediates: (5)Carbonium ions, carbanions, and radicals (formation, rearrangement, and further reactions inreference to Baldwin rules for ringclosure)Chemical Equilibria and Chemical Reactivity: (4)Correlation of reactivity with structure, Hammett equation, substituent constants and reactionconstantsChemical Kinetics and Isotope Effects: (4)Various types of catalysis and isotope effects. Importance in the elucidation of organicreaction mechanisms.ElectronTransfer Reactions: (3)Theoretical basis, Examples of photoinduced and chemicallyinduced electron transferreactions (PET and CET).Organic Photochemistry: (6)Energy and electronic spin states, Spectroscopic transitions, photophysical processes,fluorescence and phosphorescence, energy transfer and electron transfer, and properties ofexcited states, Representative photochemical reactions of carbonyl compounds, olefins, andaromatic	PHYSICAL ORGANIC CHEMISTRY

			compounds.Miscellaneous: (3)A(1,2) and A(1,3) strain, Captodative effect, Hammonds postulate, CurtinHammett principle,and thermodynamic and kinetic control of reactions. **References/Text Books:** 1. Isaacs, N. S., Physical Organic Chemistry.2. Lowry and Richardson, Mechanism and Theory in Organic Chemistry.3. Deslongchamps, P., Stereoelectronic Effects in Organic Chemistry.	
CHM611A	3-0-0-0-9		**Course Contents:** Pericyclic Reactions: (7)Conservation of orbital symmetry, and Woodward and Hoffmann rules. Cycloadditions,Electrocyclizations, Sigmatropic rearrangements, and Chelotropic reactions. Orbital overlapeffects in chemical processes.Stereoelectronic Effects in Organic Chemistry: (10)Acetals, Esters, Amides and related functions. Reactions at sp3, sp2, and sp carbons.Examples in synthesis and biological processes. FelkinAhn model, Houk model, Cieplakmodel, EFOE model, and Cationcomplexation model as applied to Facial selectivity.Reactive Intermediates: (5)Carbonium ions, carbanions, and radicals (formation, rearrangement, and further reactions inreference to Baldwin rules for ringclosure)Chemical Equilibria and Chemical Reactivity: (4)Correlation of reactivity with structure, Hammett equation, substituent constants and reactionconstantsChemical Kinetics and Isotope Effects: (4)Various types of catalysis and isotope effects. Importance in the elucidation of organicreaction mechanisms.ElectronTransfer Reactions: (3)Theoretical basis, Examples of photoinduced and chemicallyinduced electron transferreactions (PET and CET).Organic Photochemistry: (6)Energy and electronic spin states, Spectroscopic transitions, photophysical processes,fluorescence and phosphorescence, energy transfer and electron transfer, and properties ofexcited states, Representative photochemical reactions of carbonyl compounds, olefins, andaromatic compounds.Miscellaneous: (3)A(1,2) and A(1,3) strain, Captodative effect, Hammonds postulate, CurtinHammett principle,and thermodynamic and kinetic control of reactions. **References/Text Books:** 1. Isaacs, N. S., Physical Organic Chemistry.2. Lowry and Richardson, Mechanism and Theory in Organic Chemistry.3. Deslongchamps, P., Stereoelectronic Effects in Organic Chemistry.	PHYSICAL ORGANIC CHEMISTRY
CHM612	3-0-0--4	CHM402	**Course Contents:** Asymmetric Synthesis : Including organo and metal based catalysis (13)Synthesis using Organometallic Chemistry : Transition and main group elements basedreactions involving region, stereo, and enantioselective reactions and application inorganic synthesis.(12)Supramolecular Chemistry , Combinatoria l Chemistry , etc.(5)Green Chemistry, Glycobiology, Synthetic aspects using Domino reactions, (12)Principles of atom economy with examples, Templated and solid supportedOrganic Synthesis. **References/Text Books:** M. B. Smith Organic Synthesis Wavefunction, Inc 2000HJ. Schmalz, T. Wirth Organic Synthesis Highlights, 2003J. Tsuji, Transition metal reagents and catalyst innovations in organic synthesis JohnWiley& Sons, Ltd, New York, 2000T. K. Lidhorst, Essentiall of carbohydrate chemistry and biochemistry, WileyVCH, 2006	FRONTIERS IN ORGANIC CHEMISTRY
CHM612A	3-0-0-0-9		**Course Contents:** Asymmetric Synthesis : Including organo and metal based catalysis (13)Synthesis using Organometallic Chemistry : Transition and main group elements basedreactions involving region, stereo, and enantioselective reactions and application inorganic synthesis.(12)Supramolecular Chemistry , Combinatoria l Chemistry , etc.(5)Green Chemistry, Glycobiology, Synthetic aspects using Domino reactions, (12)Principles of atom economy with examples, Templated and solid supportedOrganic Synthesis. **References/Text Books:** M. B. Smith Organic Synthesis Wavefunction, Inc 2000HJ. Schmalz, T. Wirth Organic Synthesis Highlights, 2003J. Tsuji, Transition metal reagents and catalyst innovations in organic synthesis JohnWiley& Sons, Ltd, New York, 2000T. K. Lidhorst, Essentiall of carbohydrate chemistry and biochemistry, WileyVCH, 2006	FRONTIERS IN ORGANIC CHEMISTRY

CHM614	3-0-0--4	#	**Course Contents:** An overview of basic concepts of photochemistryEnergy transfer; theoretical aspects of organic photochemistry; reaction mechanisms;photoreduction and photosubstitution reactions; photocycloadditions;photoisomerizations; photofragmentation and elimination reactions; photolyticdeprotection and activation of functional groups.Singlet oxygen: generation and reactions; photoinduced electron transfer{basic concepts,illustrative examples of application to organic synthesis; photochemistry in organizedmedia.Nanosecond and picoseconds studies of organic photoreactions. **References/Text Books:** Modern Molecular Photochemistry by N. J. TurroOrganic Photochemistry by J. M. Coxan and B. HaltonEssentials of Molecular Photochemistry by A. Gilbert and J. BaggotOrganic Photochemistry and Photobiology, CRC Handbook, Edited by W. M. Horspool and P.S. Song.	ORGANIC PHOTOCHEMISTRY
CHM616	3-0-0--4	#	**Course Contents:** Introduction (2)History of organometallic chemistry; Werner complexes; Coordination number and geometry;Crystal field theory and ligand field theory; Bonding and molecular orbitals.Ligands (10)Bonding Types, Charges, and Donor Electrons; Ligand: chelate effect and heptaciy; 18electron rule: Usefulness and limitationLewis Base Ligands: Halide donors, Oxygen ligands, Sulphur ligands, Nitrogen ligands: R3N,R2N, RN2; Tris(pyrazolyl)borate, A Few Biologically Important NLigands: imidazole,purine, porphyrineCarbonylsPhosphines{bound carbon ligands: hydrides, alkyls, arylsbonded carbon ligands: alkene, alkyne, allyl, diene, arenes, arenes, metalacylesMetallocene and sandwich complexes/bonded carbon ligands: carbenes, carbinesBimetallic complexes and Metal Clusters (3)Metalmetal bond in bimetallic complexes; Clusters; Isolobal analogy; Metal nanoparticlesElementary organometallic reactions (6)Ligand substitutions; Oxidative addition; Reductive elimination; Intramolecularinsertions/eliminations; Nucleophillic/Electrophillic attacks on coordinated ligands.Homogeneous catalysis and Catalysts (10)Introduction; Alkene isomerization; Hydrogenation; Hydroformylation; Monsanto acetic acidprocess; Alkene polymerization; Cross coupling reactions; Metathesis; CH activation andfunctionalization; Oxidation of olefins; Metal Clusters and catalysisPhysical methods in Organometallic chemistry (6)1H NMR spectroscopy; 13C NMR spectroscopy; 31P NMR spectroscopy; Dynamic NMR, Massspectroscopy, Isotope effect.Bioinspired Organometallic chemistry (5)Introduction, Coenzyme B12, Nitrogen fixation; Nickel enzyme; **References/Text Books:** 1. J. Tsuji, Transition metal reagents and catalyst innovations in organic synthesis JohnWiley & Sons, Ltd, New York, 20002. M. B. Smith Organic Synthesis Wavefunction, Inc 20003. HJ. Schmalz, T. Wirth Organic Synthesis Highlights, 20034. K. C. Nicolaou, Classics in Total Synthesis Vols IIII, WileyVCH, 1996; 2003; 20115. "The Organometallic Chemistry of the Transition Metals" by Robert Crabtree(3rd Edition, Wiley).6. The Principles and Applications of Transition Metal Chemistry, by Collman, Hegedus,Norton and Finke (2nd eds, University Science Books).7. Organometallics by , Christoph Elschenbroich. (3rd Edition, Wiley)	CHEMISTRY OF ORGANOMETALLIC COMPOUNDS
CHM616A	3-0-0-0-9	CHM342A	**Course Contents:** Introduction (2)History of organometallic chemistry; Werner complexes; Coordination number and geometry;Crystal field theory and ligand field theory; Bonding and molecular orbitals.Ligands (10)Bonding Types, Charges, and Donor Electrons; Ligand: chelate effect and heptaciy; 18electron rule: Usefulness and limitationLewis Base Ligands: Halide donors, Oxygen ligands, Sulphur ligands, Nitrogen ligands: R3N,R2N, RN2; Tris(pyrazolyl)borate, A Few Biologically Important NLigands: imidazole,purine, porphyrineCarbonylsPhosphines{bound carbon ligands: hydrides, alkyls, arylsbonded carbon ligands: alkene, alkyne, allyl, diene, arenes, arenes, metalacylesMetallocene and sandwich complexes/bonded carbon ligands: carbenes, carbinesBimetallic complexes and Metal Clusters (3)Metalmetal bond in bimetallic complexes; Clusters; Isolobal analogy; Metal nanoparticlesElementary organometallic reactions (6)Ligand substitutions; Oxidative addition; Reductive elimination; Intramolecularinsertions/eliminations; Nucleophillic/Electrophillic attacks on coordinated ligands.Homogeneous catalysis and Catalysts (10)Introduction; Alkene isomerization; Hydrogenation; Hydroformylation; Monsanto acetic acidprocess;	CHEMISTRY OF ORGANOMETALLIC COMPOUNDS

			Alkene polymerization; Cross coupling reactions; Metathesis; CH activation andfunctionalization; Oxidation of olefins; Metal Clusters and catalysisPhysical methods in Organometallic chemistry (6)1H NMR spectroscopy; 13C NMR spectroscopy; 31P NMR spectroscopy; Dynamic NMR, Massspectroscopy, Isotope effect.Bioinspired Organometallic chemistry (5)Introduction, Coenzyme B12, Nitrogen fixation; Nickel enzyme; **References/Text Books:** 1. J. Tsuji, Transition metal reagents and catalyst innovations in organic synthesis JohnWiley & Sons, Ltd, New York, 20002. M. B. Smith Organic Synthesis Wavefunction, Inc 20003. HJ. Schmalz, T. Wirth Organic Synthesis Highlights, 20034. K. C. Nicolaou, Classics in Total Synthesis Vols IIII, WileyVCH, 1996; 2003; 20115. "The Organometallic Chemistry of the Transition Metals" by Robert Crabtree(3rd Edition, Wiley).6. The Principles and Applications of Transition Metal Chemistry, by Collman, Hegedus,Norton and Finke (2nd eds, University Science Books).7. Organometallics by , Christoph Elschenbroich. (3rd Edition, Wiley)	
CHM621	3-0-0-0-4		**Course Contents:** Review of basic principles of quantum theory and atomic structure. Introduction to chemicalbonding and weak intermolecular forces. (4)Electronic structure of many electron atoms and variation principle. Electronic structure ofdiatomic molecules. BornOppenheimer approximation, H2+ ion, approximate molecularorbital(MO) theory of ground and excited states of H2+, homo and heteronuclear diatomicmolecules, electronic term symbols, valence bond(VB) theory of diatomic molecules,comparison of VB and MO theories. (10)HartreeFock theory of atoms and extension to molecules. Self Consistent Field (SCF) wavefunctions for diatomic molecules, configuration interaction(CI) wave functions.(6)Electronic structures of polyatomic molecules. SCFMO treatment of closed shell systems.Basis functions. SCFMO treatment of simple molecules like H2O, NH3, C2H6, C2H4 etc.Population analysis, Potential energy surface and equilibrium geometry, molecular vibrationalfrequencies. Koopmans' and Brillouin's theorems. Brief introduction to electron correlation.MllerPlesset (MP) perturbation theory and CI calculations. Virial and HellmannFeynmantheorems. Hckel theory applied to conjugated molecules.(14)Elements of Density Fuctional Theory (DFT), Semiempirical methods (extended Hckel andCNDO), Molecular mechanics, Topological characteristics of electron density.(8) **References/Text Books:** 1. I.N. Levine, Quantum Chemistry, Fifth edition, Pearson Education (2000)2. F.L. Pilar, Elementary Quantum Chemistry, Second edition, McGrawHill (1990)3. J.P. Lowe, Quantum Chemistry, Second edition, Academic Press (1993)4. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics,Third edition,OxfordUniversityPress (1997)5 A. Szabo and N. S. Ostlund, Modern Quantum Chemistry, Dover (1996).	CHEMICAL BINDING
CHM621A	3-0-0-0-9	CHM321A/CHM421	**Course Contents:** Intoroduction, The origin of quantum numbers, some constant potentialproblems, commutation relationships, the atomic selfconsistentfield (SCF),Hartree and Hartree Fock methods. Screening effects Staters rules and electroncorrelation overlaphybridisation and examples thereof. Directed valence inspace. Observable features of the chemical bond Chemical Binding. **References/Text Books:**	CHEMICAL BINDING
CHM622	3-0-0--4	#	**Course Contents:** Phenomenological kinetics: Simple and complex systems including opposing, concurrent andconsecutive reactions (8)Rate law and mechanism, relation with thermodynamics (6)Precision in rate measurement, data analysis (4)Special experimental methods including flash photolysis, shock tube, molecular beam andrelaxation techniques (6)Oscillatory reactions (4)Theories of reaction rates: bimolecular reactions, rate coefficient, activation energy, potentialenergy surfaces, trajectory methods and transition state theory. Unimolecular andtermolecular reactions (8)Applications: photochemistry, solution kinetics, homogeneous	CHEMICAL KINETICS

			and heterogeneous catalysisand enzyme kinetics (6) **References/Text Books:** 1. K. J.Laidler, Chemical Kinetics, 3rd Ed. Harper & Row, New York, 19872. R. D. Levine and R. B. Bernstein, Molecular Reaction Dynamics and ChemicalReactivity, Oxford Univ. Press, Oxford, 19873. J. I. Steinfeld, J. S. Francisco, W. L. Hase, Chemical Kinetics and Dynamics, 2nd ed.PrenticeHall, NJ 1999.	
CHM626	3-0-0--4	#	**Course Contents:** Chemical crystallography (10)Introduction, Space lattice, Crystal point groups, space group (working knowledge),Stereographic projections, Packing in solids, Crystal structures of representative systems,Silicates and Zeolites, Cements, Glasses, Quasicrystals, Nanostructures.Bonding in solids and Crystal energetics (03)Crystal classifications, Madelung constant and Lattice energy.Characterization techniques (working knowledge) for solids (07)Xray diffraction, Electron microscopy (SEM, TEM, AFM), Thermal techniques (TG, DTA,DSC), Spectroscopic techniques (Mossbauer, IR, UVVIS) and Physical propertymeasurement techniques (Magnetic momentsVSM /SQUID, Electrical resistivity V Two / Fourprobe methods and thermal conductivity, Optical band gap, XPES, XAS).Electronic properties and Band theory of solids (04)Free electron model, Metals, semiconductors and insulators, doped semiconductorsSolid state ionics.Defects, Nonstoichiometry and Diffusion (05)Point defects, Dislocations, Extended defects, Clusters and aggregates, Color centres, Nonstoichiometryof compounds, Diffusion mechanisms, Ficks law, Kirkenall effect.Phase transitions (06)Critical phenomena, variety of phase transitions (Ordered disorder, Martensiteaustenite,Spinoidal decompositions etc), Liquid crystals, Structureproperty relations (magnetic,electrical, superconductivity, optical and thermal).Preparative techniques (07)Powder synthesis by conventional and modern chemical methods, Reactivity of solids,Decomposition mechanisms, Powder processing (sintering and diffusion processes), Tailoringof solids, Special methods for single crystal growth and thin films depositions. **References/Text Books:** * A R. West, Solid state chemistry and its applications, John Wiley & Sons, 1989.* L Smart and E. Moore, Solid state chemistry, Chapman and Hall , 1992.* A K. Cheetham and P. Day, Solid state chemistry compounds, Clarendon Press,Oxford 1992.* C N. R. Rao and J. Gopalkrishanan, New directions in solid state chemistry,Cambridge Univ. Press 1997. *R E. Newnham, Structure property relations, SpringerVerlag, 1975. P. A. Cox,Electronic structure and chemistry of solids, Oxford Univ. Press 1987.	SOLID STATE CHEMISTRY
CHM626A	3-0-0-0-9		**Course Contents:** Chemical crystallography (10)Introduction, Space lattice, Crystal point groups, space group (working knowledge),Stereographic projections, Packing in solids, Crystal structures of representative systems,Silicates and Zeolites, Cements, Glasses, Quasicrystals, Nanostructures.Bonding in solids and Crystal energetics (03)Crystal classifications, Madelung constant and Lattice energy.Characterization techniques (working knowledge) for solids (07)Xray diffraction, Electron microscopy (SEM, TEM, AFM), Thermal techniques (TG, DTA,DSC), Spectroscopic techniques (Mossbauer, IR, UVVIS) and Physical propertymeasurement techniques (Magnetic momentsVSM /SQUID, Electrical resistivity V Two / Fourprobe methods and thermal conductivity, Optical band gap, XPES, XAS).Electronic properties and Band theory of solids (04)Free electron model, Metals, semiconductors and insulators, doped semiconductorsSolid state ionics.Defects, Nonstoichiometry and Diffusion (05)Point defects, Dislocations, Extended defects, Clusters and aggregates, Color centres, Nonstoichiometryof compounds, Diffusion mechanisms, Ficks law, Kirkenall effect.Phase transitions (06)Critical phenomena, variety of phase transitions (Ordered disorder, Martensiteaustenite,Spinoidal decompositions etc), Liquid crystals, Structureproperty relations (magnetic,electrical, superconductivity, optical and thermal).Preparative techniques (07)Powder synthesis by conventional and modern chemical methods, Reactivity of solids,Decomposition mechanisms, Powder processing (sintering and diffusion processes), Tailoringof solids, Special methods for single crystal growth and thin films depositions. **References/Text Books:**	SOLID STATE CHEMISTRY

			* A R. West, Solid state chemistry and its applications, John Wiley & Sons, 1989.* L Smart and E. Moore, Solid state chemistry, Chapman and Hall , 1992.* A K. Cheetham and P. Day, Solid state chemistry compounds, Clarendon Press,Oxford 1992.* C N. R. Rao and J. Gopalkrishanan, New directions in solid state chemistry,Cambridge Univ. Press 1997. *R E. Newnham, Structure property relations, SpringerVerlag, 1975. P. A. Cox,Electronic structure and chemistry of solids, Oxford Univ. Press 1987.	
CHM629	3-0-0--4		**Course Contents:** Atomic and Molecular structure, Molecular Spectroscopy, Concepts of StatisticalThermodynamics, Electrochemistry, Chemical Kinetics, Photochemistry **References/Text Books:**	PRINCIPLES OF PHYSICAL CHEMISTRY
CHM629A	3-0-0-0-9		**Course Contents:** Atomic and Molecular structure, Molecular Spectroscopy, Concepts of StatisticalThermodynamics, Electrochemistry, Chemical Kinetics, Photochemistry **References/Text Books:**	PRINCIPLES OF PHYSICAL CHEMISTRY
CHM631	3-0-0--4	CHM402,CHM442	**Course Contents:** Applications of multinuclear NMR (1H, 13C, 29Si, 31P, 19F, 11B, 119Sn etc.). ESR,ENDOR (Electron Nuclear Double Resonance), Mossbauer and photoelectronspectroscopy towards structure elucidation of inorganic, organic and biologicallyimportant compounds. **References/Text Books:**	APPLICATIONS OF MODERN INSTRUMENTAL METHODS
CHM631A	3-0-0-0-9	CHM402A CHM342A	**Course Contents:** Applications of multinuclear NMR (1H, 13C, 29Si, 31P, 19F, 11B, 119Sn etc.). ESR,ENDOR (Electron Nuclear Double Resonance), Mossbauer and photoelectronspectroscopy towards structure elucidation of inorganic, organic and biologicallyimportant compounds. **References/Text Books:**	APPLICATIONS OF MODERN INSTRUMENTAL METHODS
CHM632	3-0-0--4	#	**Course Contents:** Enzyme kinetics of single and multiple substrate systems including Enzyme assays andinhibition (15 lectures)Cooperativity and multienzyme systems (4 lectures)Enzyme structure and identification of active site residues labelin, chemical modification andmutagenesis (6 lectures)Enzyme Mechanisms Methods of study and mechanisms of some enzymes likeSerine proteases, polymerases, ribonucleases, lysozyme and ribonucleotide reductases(radical enzyme) (15 lectures)Mechanism based enzyme inhibition and drugs 5fluorouracil for thymidylate synthase (2lectures) **References/Text Books:** 1. Allan Ferhst, Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysisand Protein Folding2. N. C. Price and E. Stevens, Fundamentals of Enzymology: The Cell and Molecular Biologyof Catalytic Proteins3. I. H. Segel, Biochemical calculations, How to Solve Mathematical Problems in GeneralBiochemistry, 2nd Edition.	ENZYME REACTIONS MECHANISM AND ENZYME KINETICS
CHM636	3-0-0--4	#	**Course Contents:** 1. Theory of electronic absorption spectra, Beers law, Absorption crosssection,Solvatochromism (4)2. Radiative and nonradiative transitions, Vibrational relaxation, Internal conversion, Intersystem crossing (5)3. Fluorescence, Phosphorescence, Various photophysical processes, Solvent effect onemission, Lippert equation, Dynamic stokes shift, Dynamic and static quenching,SternVolmer equation, Forster resonance energy transfer and theory, Fluorescenceanisotropy and Perrin equation, Excited state proton/electron transfer, Excimer andexciplex (20)4. Laser fundamentals, Stimulated emission, Population inversion, Light amplification,Pulsed laser: cavity dumping, Qswithching, modelocking (4)5. Spectroscopic techniques,	PHYSICAL PHOTOCHEMISTRY

			Spectrophotometer, Spectrofluorimeter, Time correlatedsingle photon counting, Transient absorption, Streak camera, Fluorescence upconversion(6)6. Single molecule spectroscopy, Fluorescence correlation spectroscopy, Proteinfluorescence (3) **References/Text Books:** 1. Nicholas J. Turro, Modern Molecular Photochemistry2. K. K. RohatgiMukherjee, Fundamentals of Photochemistry3. J. R. Lakowicz, Principles of Fluorescence Spectroscopy4. W. T. Silvast, Laser Fundamentals	
CHM636A	3-0-0-0-9		**Course Contents:** 1. Theory of electronic absorption spectra, Beers law, Absorption crosssection,Solvatochromism (4)2. Radiative and nonradiative transitions, Vibrational relaxation, Internal conversion, Intersystem crossing (5)3. Fluorescence, Phosphorescence, Various photophysical processes, Solvent effect onemission, Lippert equation, Dynamic stokes shift, Dynamic and static quenching,SternVolmer equation, Forster resonance energy transfer and theory, Fluorescenceanisotropy and Perrin equation, Excited state proton/electron transfer, Excimer andexciplex (20)4. Laser fundamentals, Stimulated emission, Population inversion, Light amplification,Pulsed laser: cavity dumping, Qswithching, modelocking (4)5. Spectroscopic techniques, Spectrophotometer, Spectrofluorimeter, Time correlatedsingle photon counting, Transient absorption, Streak camera, Fluorescence upconversion(6)6. Single molecule spectroscopy, Fluorescence correlation spectroscopy, Proteinfluorescence (3) **References/Text Books:** 1. Nicholas J. Turro, Modern Molecular Photochemistry2. K. K. RohatgiMukherjee, Fundamentals of Photochemistry3. J. R. Lakowicz, Principles of Fluorescence Spectroscopy4. W. T. Silvast, Laser Fundamentals	PHYSICAL PHOTOCHEMISTRY
CHM637	3-0-0--4	CHM421	**Course Contents:** 1. Group theory (6)Review of point groups, permutation inversion and molecular symmetry groups.2. Interaction of radiation and matter (5)Qualitative aspects, Einstein A, B coefficients, absorptionemission and lineshapes.3. Rotational Spectroscopy (8)Rigid body, selection rules, vibrational angular momentum, tops.4. Vibrational Spectroscopy (8)Normal modes, selection rules, Fermi and Coriolis perturbations, polyatomic molecules.5. Electronic Spectroscopy (6)Introduction, symmetry aspects, vibronic effects.6. Advanced topics (9)Coupling of rotational and vibrational motions, nonrigid systems, high resolution and highlyexcited states, WilsonHowardWatson Hamiltonian, timedependent viewpoint. **References/Text Books:** 1. Bernath, Spectra of Atoms and Molecules, 1995.2. Bunker & Jensen, Molecular Symmetry & Spectroscopy, 1998.3. Papousek & Aliev, Molecular VibrationalRotational Spectra, 1982.4. Hollas, Modern Spectroscopy, 2004.5. McHale, Molecular Spectroscopy, 1998.	MOLECULAR SPECTROSCOPY
CHM637A	3-0-0-0-9		**Course Contents:** 1. Group theory (6)Review of point groups, permutation inversion and molecular symmetry groups.2. Interaction of radiation and matter (5)Qualitative aspects, Einstein A, B coefficients, absorptionemission and lineshapes.3. Rotational Spectroscopy (8)Rigid body, selection rules, vibrational angular momentum, tops.4. Vibrational Spectroscopy (8)Normal modes, selection rules, Fermi and Coriolis perturbations, polyatomic molecules.5. Electronic Spectroscopy (6)Introduction, symmetry aspects, vibronic effects.6. Advanced topics (9)Coupling of rotational and vibrational motions, nonrigid systems, high resolution and highlyexcited states, WilsonHowardWatson Hamiltonian, timedependent viewpoint. **References/Text Books:** 1. Bernath, Spectra of Atoms and Molecules, 1995.2. Bunker & Jensen, Molecular Symmetry & Spectroscopy, 1998.3. Papousek & Aliev, Molecular VibrationalRotational Spectra, 1982.4. Hollas, Modern Spectroscopy, 2004.5. McHale, Molecular Spectroscopy, 1998.	MOLECULAR SPECTROSCOPY

CHM641	3-0-0--4	CHM441	**Course Contents:** An advanced course on the physical principles of inorganic chemistry withillustrations from the chemistry of transition and nontransition elements. **References/Text Books:**	ADVANCED INORGANIC CHEMISTRY I
CHM646	3-0-0-0-4		**Course Contents:** 1. Mineral Origin of life. Archaeal, Eucarial and Bacterial domain. (3 Lectures)2. Transition metal ions in biology. Metalobiomolecules. Electron carriers, oxygencarriers, enzymes. Biogeoinorganic chemistry, environment. (10 Lectures)3. Specific examples: Hemoglobin, Myoglobin, Hemocyanin,Hemrythrincytochromes, FeS proteins, Cytochrome P450, Nitrophorin, NOsynthase,peroxidase, catalase, Ferritin, cytochromeC oxidase, cerulplasmin, bluecopper proteins, di and tricopper proteins. Other enzymes like,hydrogenase, methane monooxygenase, dioxygenases, dehydratase,nitrogenase, molybdenum containing oxidase and reductase class of enzymeslike sulfite oxidase, xanthine oxidase, nitrate reductase, DMSO reductase,tungsten containing formate dehydrogenase and tungsten bearinghyperthermophilic and thermophilic enzymes. Zn enzymes like carbonicanhydrase, carboxypeptidase, DNA and RNA polymerases, Nickel containingF430, role of manganese in water splitting. (15 Lectures)4. Active site analogue reaction models and structural models of theseenzymes. (5 Lectures)5. Environmental chemistry, auto exhaust, arsenic and other heavymetal pollutions. (2 Lectures)6. Forensic chemistry; inorganic chemistry in medicine, platinum complexes, MoScomplexes as anticancer drugs. **References/Text Books:** 1. Principles of Bioinorganic Chemistry, S. J. Lippard and J. M. Berg,University Science Books, Mill Valley, 1994.2. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, W. Kaim and B.Schwederski, John Wiley & Sons Inc., 1994.	BIO-INORGANIC CHEMISTRY
CHM646A	3-0-0-0-9		**Course Contents:** 1. Mineral Origin of life. Archaeal, Eucarial and Bacterial domain. (3 Lectures)2. Transition metal ions in biology. Metalobiomolecules. Electron carriers, oxygencarriers, enzymes. Biogeoinorganic chemistry, environment. (10 Lectures)3. Specific examples: Hemoglobin, Myoglobin, Hemocyanin,Hemrythrincytochromes, FeS proteins, Cytochrome P450, Nitrophorin, NOsynthase,peroxidase, catalase, Ferritin, cytochromeC oxidase, cerulplasmin, bluecopper proteins, di and tricopper proteins. Other enzymes like,hydrogenase, methane monooxygenase, dioxygenases, dehydratase,nitrogenase, molybdenum containing oxidase and reductase class of enzymeslike sulfite oxidase, xanthine oxidase, nitrate reductase, DMSO reductase,tungsten containing formate dehydrogenase and tungsten bearinghyperthermophilic and thermophilic enzymes. Zn enzymes like carbonicanhydrase, carboxypeptidase, DNA and RNA polymerases, Nickel containingF430, role of manganese in water splitting. (15 Lectures)4. Active site analogue reaction models and structural models of theseenzymes. (5 Lectures)5. Environmental chemistry, auto exhaust, arsenic and other heavymetal pollutions. (2 Lectures)6. Forensic chemistry; inorganic chemistry in medicine, platinum complexes, MoScomplexes as anticancer drugs. **References/Text Books:** 1. Principles of Bioinorganic Chemistry, S. J. Lippard and J. M. Berg,University Science Books, Mill Valley, 1994.2. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, W. Kaim and B.Schwederski, John Wiley & Sons Inc., 1994.	BIO-INORGANIC CHEMISTRY
CHM648	3-0-0--4		**Course Contents:** Introduction to Organometallics: Bonding, Types of Ligands, and some basics concepts likeisoelectronic and isolobal analogyCharacterization techniques of Organometallic compounds (NMR and IR spectroscopy andMass spectrometry)Representative chemistry of main group OrganometallicsOrganometallic chemistry of lithium and magnesium: synthesis, structures, fluxionality andreactivityChemistry of Aluminum: Aluminum alkyls. Use of aluminum alkyls in polymerization of olefins.Organometallic chemistry of transition metals bonded ligands:Metal alkyls, aryls and hydrides. Stability, preparation and reactivity.Metal carbonyls / Metal	THE CHEMISTRY OF METAL-CARBON BOND: STRUCTURE REACTIVITY & APPLICATIONS

			phosphines / metal nitrosyls / metal isocyanide: structures,reactivity and bonding.Metal carbenes, metalcarbynes, Fischer carbenes, Schrock, carbenes, complexes with Nheterocycliccarbenes (NHCs), bonded ligand:Metalolefins, alkyls metal alkynes, dienes, Cp and Cp*, structure, bonding and reactivity.Reactions in Organometallic Chemistry: Oxidative addition, reductive elimination, insertion,elimination, and migrationApplications of organometallics in organic synthesisCC bond coupling reactions (Heck, sangoshira, Suzuki)Reduction using transition metal hydrides, asymmetric hydrogenation.Olefin metathesis **References/Text Books:** Most of the material for this course will be accessed from primary literature viz., Journalarticles. Some text books that will be followed are as follows:Elschenbroich, C.; Salzer, A.; Organometallics: A Concise Introduction 3rd Edn. John Wileyand sons 2005B . D . Gupta and A . J . Elias , Basic Organometallic Chemistry: Concepts, Syntheses andApplications, First Edition, Universities Press, 2010Douglas, B.; McDaniel, D.; and Alexander, J. Concepts and Models of Inorganic Chemsitry 3rdEdn. John Wiley, New York. 1993.Rober t H . Crabtree , The Organometallic Chemistry of the Transition Metals, John Wiley andSons, 4th edn. John Wiley and sons 2005.	
CHM648A	3-0-0-0-9	CHM342A	**Course Contents:** Introduction to Organometallics: Bonding, Types of Ligands, and some basics concepts likeisoelectronic and isolobal analogyCharacterization techniques of Organometallic compounds (NMR and IR spectroscopy andMass spectrometry)Representative chemistry of main group OrganometallicsOrganometallic chemistry of lithium and magnesium: synthesis, structures, fluxionality andreactivityChemistry of Aluminum: Aluminum alkyls. Use of aluminum alkyls in polymerization of olefins.Organometallic chemistry of transition metals bonded ligands:Metal alkyls, aryls and hydrides. Stability, preparation and reactivity.Metal carbonyls / Metal phosphines / metal nitrosyls / metal isocyanide: structures,reactivity and bonding.Metal carbenes, metalcarbynes, Fischer carbenes, Schrock, carbenes, complexes with Nheterocycliccarbenes (NHCs), bonded ligand:Metalolefins, alkyls metal alkynes, dienes, Cp and Cp*, structure, bonding and reactivity.Reactions in Organometallic Chemistry: Oxidative addition, reductive elimination, insertion,elimination, and migrationApplications of organometallics in organic synthesisCC bond coupling reactions (Heck, sangoshira, Suzuki)Reduction using transition metal hydrides, asymmetric hydrogenation.Olefin metathesis **References/Text Books:** Most of the material for this course will be accessed from primary literature viz., Journalarticles. Some text books that will be followed are as follows:Elschenbroich, C.; Salzer, A.; Organometallics: A Concise Introduction 3rd Edn. John Wileyand sons 2005B . D . Gupta and A . J . Elias , Basic Organometallic Chemistry: Concepts, Syntheses andApplications, First Edition, Universities Press, 2010Douglas, B.; McDaniel, D.; and Alexander, J. Concepts and Models of Inorganic Chemsitry 3rdEdn. John Wiley, New York. 1993.Rober t H . Crabtree , The Organometallic Chemistry of the Transition Metals, John Wiley andSons, 4th edn. John Wiley and sons 2005.	THE CHEMISTRY OF METAL-CARBON BOND: STRUCTURE REACTIVITY & APPLICATIONS
CHM649	3-0-0--4		**Course Contents:** Principles of modern inorganic chemistry discussion of the chemistry of nontransition elements, Coordination Chemistry, organometallic chemistry, Inorganicchemistry of biological systems. **References/Text Books:**	PRINCIPALES OF INORGANIC CHEMISTRY
CHM649A	3-0-0-0-9		**Course Contents:** Principles of modern inorganic chemistry discussion of the chemistry of nontransition elements, Coordination Chemistry, organometallic chemistry, Inorganicchemistry of biological systems. **References/Text Books:**	PRINCIPALES OF INORGANIC CHEMISTRY
CHM650	3-0-0--4	#	**Course Contents:** Course description: Thermodynamics, Statistical Mechanics of noninteracting systems,interacting systems,	STATISTICAL MECHANICS & ITS APPL. TO

			and nonequilibrium systemsCourse Details1. Equilibrium Thermodynamics: Thermodynamic Equilibrium state, laws ofthermodynamics, axiomatic formulation of thermodynamics, thermodynamic potentials,stability criteria, phase equilibria (4 lectures)2. Ensembles in Statistical Mechanics: Ensemble postulate and ergodicity, microcanonical,canonical and grand canonical ensembles, quantum and classicalpartition functions, phase space, fluctuations (6 lectures)3. Noninteracting systems: Factorization of the partition function, quantum correlations,collective modes, occupation numbers, collections of fermions, bosons,photons, classical deal gas of spinless particles, molecular partition functions, idealparamagnets. (6 lectures)4. Interacting Systems 1: Classical Liquids Interparticle potentials, ConfigurationalPartition functions, distributions, pair correlation function, neutron scatteringexperiments, Virial equation, Meyer cluster diagrams (6 lectures)5. Interacting Systems 2: Computer Simulations Ensemble averages, ergodicity,random numbers, Monte Carlo methods, Molecular Dynamics, constant temperatureMD. (5 lectures)6. Interacting Systems 3: Phase Transitions in Lattice models Lattice gas,Ising Model, order parameter, Mean Field theory, Renormalization group theory(6 lectures)7. Nonequilibrium Statistical Mechanics (6 lectures) Linear Response theory,fluctuation dissipation theorem, time correlation functions, applications to transportphenomena. **References/Text Books:** 1. D.A. McQuarrie, Statistical Mechanics2. David Chandler, Introduction to Modern Statistical Mechanics3. K.L. Huang, Statistical Mechanics4. B. Widom, Statistical Mechanics: A concise introduction for chemists	CHEMISTRY
CHM650A	3-0-0-0-9		**Course Contents:** Course description: Thermodynamics, Statistical Mechanics of noninteracting systems,interacting systems, and nonequilibrium systemsCourse Details1. Equilibrium Thermodynamics: Thermodynamic Equilibrium state, laws ofthermodynamics, axiomatic formulation of thermodynamics, thermodynamic potentials,stability criteria, phase equilibria (4 lectures)2. Ensembles in Statistical Mechanics: Ensemble postulate and ergodicity, microcanonical,canonical and grand canonical ensembles, quantum and classicalpartition functions, phase space, fluctuations (6 lectures)3. Noninteracting systems: Factorization of the partition function, quantum correlations,collective modes, occupation numbers, collections of fermions, bosons,photons, classical deal gas of spinless particles, molecular partition functions, idealparamagnets. (6 lectures)4. Interacting Systems 1: Classical Liquids Interparticle potentials, ConfigurationalPartition functions, distributions, pair correlation function, neutron scatteringexperiments, Virial equation, Meyer cluster diagrams (6 lectures)5. Interacting Systems 2: Computer Simulations Ensemble averages, ergodicity,random numbers, Monte Carlo methods, Molecular Dynamics, constant temperatureMD. (5 lectures)6. Interacting Systems 3: Phase Transitions in Lattice models Lattice gas,Ising Model, order parameter, Mean Field theory, Renormalization group theory(6 lectures)7. Nonequilibrium Statistical Mechanics (6 lectures) Linear Response theory,fluctuation dissipation theorem, time correlation functions, applications to transportphenomena. **References/Text Books:** 1. D.A. McQuarrie, Statistical Mechanics2. David Chandler, Introduction to Modern Statistical Mechanics3. K.L. Huang, Statistical Mechanics4. B. Widom, Statistical Mechanics: A concise introduction for chemists	STATISTICAL MECHANICS & ITS APPL. TO CHEMISTRY
CHM651	3-0-0--4	#	**Course Contents:** Generation of Xrays, monochromators, safety (1 Lecture)Concept of direct and reciprocal lattices, Braggs law of Xray diffraction in direct andreciprocal lattice, crystal systems, point groups, Bravais lattices(5 Lectures)Rotational axes of symmetry, screw axes, glide planes, equivalent points, systematicabsences, space groups (8 Lectures)Argand diagram, intensity data collection and quantitative aspects of Xray diffraction,temperature factor and scaling of data (10 Lectures)The phase problem, direct method of solving structures (8 Lectures)Patterson method, isomorphous replacement method(8 Lectures)Structure refinement and their critical evaluation (5 Lectures) **References/Text Books:** Xray Structure Determination A Practical Guide by G. H. Stout and H. L. Jensen, MacMillan,N.Y.	CRYSTAL AND MOLECULAR STRUCTURE DETERMINATION

			1968.Contemporary Crystallography, M. J. Buerger, McGrawHill, N.Y. 1970Crystal Structure Analysis A Primer J. P. Glusker and K. N. Trueblood, OUP, N.Y. 1985Structure Determination by Xary Crystallography, M. Ladd and R. Palmer, KluwerAcademic/Plenum, N.Y. 2003	
CHM651A	3-0-0-0-9		**Course Contents:** Generation of Xrays, monochromators, safety (1 Lecture)Concept of direct and reciprocal lattices, Braggs law of Xray diffraction in direct andreciprocal lattice, crystal systems, point groups, Bravais lattices(5 Lectures)Rotational axes of symmetry, screw axes, glide planes, equivalent points, systematicabsences, space groups (8 Lectures)Argand diagram, intensity data collection and quantitative aspects of Xray diffraction,temperature factor and scaling of data (10 Lectures)The phase problem, direct method of solving structures (8 Lectures)Patterson method, isomorphous replacement method(8 Lectures)Structure refinement and their critical evaluation (5 Lectures) **References/Text Books:** Xray Structure Determination A Practical Guide by G. H. Stout and H. L. Jensen, MacMillan,N.Y. 1968.Contemporary Crystallography, M. J. Buerger, McGrawHill, N.Y. 1970Crystal Structure Analysis A Primer J. P. Glusker and K. N. Trueblood, OUP, N.Y. 1985Structure Determination by Xary Crystallography, M. Ladd and R. Palmer, KluwerAcademic/Plenum, N.Y. 2003	CRYSTAL AND MOLECULAR STRUCTURE DETERMINATION
CHM654	3-0-0-0-4		**Course Contents:** Introductionthe meaning of supramolecular chemistry, phenomenon of molecular recognitionand their quantification (2 Lectures)Building blocks of supramolecular chemistry acyclic receptors for neutral and chargedguests, macrocycles and crown ethers, macrobicycles and cryptands, macropolycycles,cucurbiturils and cyclodextrins (12 Lectures)Sensors and information processing, electrooptic phenomena, molecular machines (12Lectures)Amphiphilic molecules and their aggregation, LangmuirBlodgettry, molecular recognition atthe airwater interface. (3 Lectures)Discrete and polymeric metalorganic hybrid materials guest inclusion, catalysis and otherapplications. (12 Lectures)Future scopes (1 Lecture) **References/Text Books:** Supramolecular Chemistry: Concepts and Perspectives, J.M. Lehn, VCH, Weinheim, 1995Principles and Methods in Supramolecular Chemistry, H. J. Schneider and A. Yatsimirsky,Wiley, New York, 2000Supramolecular Chemistry, J. W. Steed and J. L. Atwood, John Wiley & Sons, Chichester,2009	SUPRAMOLECULAR CHEMISTRY
CHM654A	3-0-0-0-9		**Course Contents:** Introduction the meaning of supramolecular chemistry, phenomenon of molecular recognitionand their quantification (2 Lectures)Building blocks of supramolecular chemistry acyclic receptors for neutral and chargedguests, macrocycles and crown ethers, macrobicycles and cryptands, macropolycycles,cucurbiturils and cyclodextrins (12 Lectures)Sensors and information processing, electrooptic phenomena, molecular machines (12Lectures)Amphiphilic molecules and their aggregation, LangmuirBlodgettry, molecular recognition atthe airwater interface. (3 Lectures)Discrete and polymeric metalorganic hybrid materials guest inclusion, catalysis and otherapplications. (12 Lectures)Future scopes (1 Lecture) **References/Text Books:** Supramolecular Chemistry: Concepts and Perspectives, J.M. Lehn, VCH, Weinheim, 1995Principles and Methods in Supramolecular Chemistry, H. J. Schneider and A. Yatsimirsky,Wiley, New York, 2000Supramolecular Chemistry, J. W. Steed and J. L. Atwood, John Wiley & Sons, Chichester,2009	SUPRAMOLECULAR CHEMISTRY
CHM662	3-0-0--4	#	**Course Contents:** Biosynthetic aspects and Synthesis of selected natural products of biological and structuralimportance: Discussions on synthetic methods, strategies towards these natural productsmostly in chiral forms will be discussed in detail.The natural products include carbacycles and heterocyclic moieties containing structuresraning from 3memebered to macrocyles, and complex natural products such as Taxol,rapamycin,	CHEMISTRY OF NATURAL PRODUCTS

			lejimailde B etc. **References/Text Books:** K. C. Nicolaou, Classics in Total Synthesis Vols IIII, WileyVCH, 1996; 2003; 2011T. Hudlicky and J. W. Reed, The way of synthesis , WileyVCH, 2007E. J. Corey and XM. Cheng, The logic of chemical synthesis, JohnWiley & Sons, New York1989.D.H. R. Barton, K. Nakanishi, O. MethCohn, Comprehensive natural products chemistryVols 19, Elsevier, 1999	
CHM662A	3-0-0-0-9	CHM402A	**Course Contents:** Biosynthetic aspects and Synthesis of selected natural products of biological and structural importance: Discussions on synthetic methods, strategies towards these natural product smostly in chiral forms will be discussed in detail.The natural products include carbacycles and heterocyclic moieties containing structuresraning from 3memebered to macrocyles, and complex natural products such as Taxol,rapamycin, lejimailde B etc. **References/Text Books:** K. C. Nicolaou, Classics in Total Synthesis Vols IIII, WileyVCH, 1996; 2003; 2011T. Hudlicky and J. W. Reed, The way of synthesis , WileyVCH, 2007E. J. Corey and XM. Cheng, The logic of chemical synthesis, JohnWiley & Sons, New York1989.D.H. R. Barton, K. Nakanishi, O. MethCohn, Comprehensive natural products chemistryVols 19, Elsevier, 1999	CHEMISTRY OF NATURAL PRODUCTS
CHM664	3-0-0-0-4		**Course Contents:** 1. Symmetry and Group Theory: Group multiplication table, elements of a symmetry group,symmetry group classification, characters, group representation, The Great Orthogonalitytheorem, basis of representation, wavefunctions as bases of IR representations, symmetryadapted linear combinations, direct products, spectral transitions.(15)2. Interaction of light with matter, Einsteins coefficients, relationship of Einsteins coefficientswith transition moments (no derivation) and transition probabilities, oscillator strength. BeerLambert law, relationship between Einsteins coefficients and total absorbance. BornOppenheimer approximation, energy levels, potential energy curves, MO and term symbols,Franck Condon principle, symmetry and selection rules, spin and parity forbidden transitions,vibronic interaction.(8)3. Simple harmonic motion, anharmonicity, introduction of different coordinates (generalised,mass weighted generalized, internal and normal coordinates). Force constants, selectionrules, (F and G matrix if time permits). Applications: Organic molecules, functional groupversus frequency approach, Fermi resonance, frequency shifts because of substitutions,isotope effect., theory and application of Raman Spectroscopy(15)4. Other spectroscopic methods like Mass Spectrometry, Magnetic Resonance, PhotoelectronSpectroscopy(4) **References/Text Books:** 1. Chemical Applications of Group Theory F.A. Cotton2. Theory and applications of UV spectroscopy. H.H. Jaffe and M. Orchin.3. Quantum mechanics, CohenTannoudj, Diu and Lalo (2005)4. Molecular Spectroscopy I. N. Levine5. High Resolution NMR, theory and application, E.D. Becker6. Modern Spectroscopy J. M. Hollas	MODERN PHYSICAL METHODS IN CHEMISTRY
CHM664A	3-0-0-0-9		**Course Contents:** 1. Symmetry and Group Theory: Group multiplication table, elements of a symmetry group,symmetry group classification, characters, group representation, The Great Orthogonalitytheorem, basis of representation, wavefunctions as bases of IR representations, symmetryadapted linear combinations, direct products, spectral transitions.(15)2. Interaction of light with matter, Einsteins coefficients, relationship of Einsteins coefficientswith transition moments (no derivation) and transition probabilities, oscillator strength. BeerLambert law, relationship between Einsteins coefficients and total absorbance. BornOppenheimer approximation, energy levels, potential energy curves, MO and term symbols,Franck Condon principle, symmetry and selection rules, spin and parity forbidden transitions,vibronic interaction.(8)3. Simple harmonic motion, anharmonicity, introduction of different coordinates (generalised,mass weighted generalized, internal and normal coordinates). Force constants, selectionrules, (F and G matrix if time	MODERN PHYSICAL METHODS IN CHEMISTRY

			permits). Applications: Organic molecules, functional groupversus frequency approach, Fermi resonance, frequency shifts because of substitutions,isotope effect., theory and application of Raman Spectroscopy(15)4. Other spectroscopic methods like Mass Spectrometry, Magnetic Resonance, PhotoelectronSpectroscopy(4) **References/Text Books:** 1. Chemical Applications of Group Theory F.A. Cotton2. Theory and applications of UV spectroscopy. H.H. Jaffe and M. Orchin.3. Quantum mechanics, CohenTannoudj, Diu and Lalo (2005)4. Molecular Spectroscopy I. N. Levine5. High Resolution NMR, theory and application, E.D. Becker6. Modern Spectroscopy J. M. Hollas	
CHM668	3-0-0--4	CHM441	**Course Contents:** A. Topics for SelfStudy1. VSEPR Theory and prediction of molecular geometry2. Symmetry. Symmetry elements and symmetry operations. Point groups. Introduction tocharacter tables. Uses of character tables.B. Chemistry of Maingroup ElementsChemistry of boron: Selfstudy: boranes, bonding in boranes, topology of boranes, synthesisand reactivity, Carboranes and metalla carboranes. Lowvalent boron compounds,organoboron compounds and organic synthesis. Use of 11B NMR in structure elucidationof organoboron compounds. Boron containing polymers. Borazine and Boron NitrideOrganolithium compounds. Synthesis, bonding and reactivity. Organomagnesiusm andorganosodium compounds.Chemistry of Aluminum. Aluminum Alkyls. Unusual organometallic compounds of aluminum.Including low oxidation state Al compounds and aluminum clusters.Chemistry of Low valent compounds: NHCs and their analogous group 13, 14 and 15compounds and the recent advancesMultiple bonding in main group elements: Compounds involving silicon, phosphorus, bismuthetc.Synthesis, structure and reactivity. Recent literature on multiple bonding modelsamong low valent compoundsInorganic rings and polymers: Siloxanes, Cyclophosphazenes and cyclophosphazanes.Polysilanes and PolyphosphazenesNoble gas compounds **References/Text Books:** Most of the material for this course will be accessed from primary literature viz., Journalarticles. Some text books that will be followed are as follows:Inorganic ChemistryPrinciples of Structure and Reactivity. 4th Edn. Huheey J. E.; Keiter, E.A.; and Keiter, R. L. HarperCollins, NY, 1993Concepts and Models of Inorganic Chemsitry. 3rd Edn. Douglas, B.; McDaniel, D.; andAlexander, J. John Wiley, New York. 1993Chemistry of the Elements. 2nd Edn. Greenwood, N. N.; and Earnshaw, A. Pergamon,Oxford, 1989Elschenbroich, C.; and Salzer, A.; Organometallics: A Concise Introduction 3rd Edn. 1999Inorganic and Organometallic Polymers. Chandrasekhar, V. SpringerVerlag, Heidelberg,2005	ADVANCED MAIN GROUP CHEMISTRY
CHM668A	3-0-0-0-9	CHM345A	**Course Contents:** A. Topics for SelfStudy1. VSEPR Theory and prediction of molecular geometry2. Symmetry. Symmetry elements and symmetry operations. Point groups. Introduction tocharacter tables. Uses of character tables.B. Chemistry of Maingroup ElementsChemistry of boron: Selfstudy: boranes, bonding in boranes, topology of boranes, synthesisand reactivity, Carboranes and metalla carboranes. Lowvalent boron compounds,organoboron compounds and organic synthesis. Use of 11B NMR in structure elucidationof organoboron compounds. Boron containing polymers. Borazine and Boron NitrideOrganolithium compounds. Synthesis, bonding and reactivity. Organomagnesiusm andorganosodium compounds.Chemistry of Aluminum. Aluminum Alkyls. Unusual organometallic compounds of aluminum.Including low oxidation state Al compounds and aluminum clusters.Chemistry of Low valent compounds: NHCs and their analogous group 13, 14 and 15compounds and the recent advancesMultiple bonding in main group elements: Compounds involving silicon, phosphorus, bismuthetc.Synthesis, structure and reactivity. Recent literature on multiple bonding modelsamong low valent compoundsInorganic rings and polymers: Siloxanes, Cyclophosphazenes and cyclophosphazanes.Polysilanes and PolyphosphazenesNoble gas compounds **References/Text Books:** Most of the material for this course will be accessed from primary literature viz., Journalarticles. Some text books that will be followed are as follows:Inorganic ChemistryPrinciples of Structure and Reactivity. 4th Edn. Huheey J. E.; Keiter, E.A.; and Keiter, R. L. HarperCollins, NY, 1993Concepts and Models of	ADVANCED MAIN GROUP CHEMISTRY

			Inorganic Chemsitry. 3rd Edn. Douglas, B.; McDaniel, D.; andAlexander, J. John Wiley, New York. 1993Chemistry of the Elements. 2nd Edn. Greenwood, N. N.; and Earnshaw, A. Pergamon,Oxford, 1989Elschenbroich, C.; and Salzer, A.; Organometallics: A Concise Introduction 3rd Edn. 1999Inorganic and Organometallic Polymers. Chandrasekhar, V. SpringerVerlag, Heidelberg,2005	
CHM679	3-0-0--4	#	**Course Contents:** 1. Introduction (5)Review of kinetic theory of gases, collisions atomic and molecular.2. Rate theories (6)Transition state theory and RRKM theory, scattering classical and quantum.3. Reactive Collisions (10)Potential energy surfaces, atomdiatom reactions, polyatomic reactions, stateselective,molecular beams, reaction rates and cross sections.4. Dynamics in gas phase (8)Photodissociation, energy transfer, stereodynamics, chemistry in real time with lasers,control.5. Dynamics in condensed phase (8)Solvation, diffusion, barrier crossing, KramerGroteHynes theory, Langevin equation,correlation functions.6. Advanced topics (5)Dynamics on surfaces, spatiotemporal aspects of pattern formation, ultrafast dynamics. **References/Text Books:** 1. Levine, Molecular Reaction Dynamics, 2005.2. Henriksen & Hansen, Theories of Molecular Reaction Dynamics, 2008.3. Schinke, Photodissociation Dynamics, 1993.4. Manz & Wste, Femtosecond Chemistry, 1995.5. Nitzan, Chemical Dynamics in Condensed Phases, 2006.	MOLECULAR REACTION DYNAMICS
CHM681	3-0-0--4	#	**Course Contents:** Recombinant DNA techniques, Protein folding, design and Engineering, ChouFasman rules,Ramachandran plot and conformation of biopolymers. Mechanisms of importantenzymes. Biosynthesis of nucleic acids and proteins. confactors. (12)Immunology. Immune response, Innate immunity and adaptive immunity, Immune dysfunctionand its consequences, Immunogenicity, antigens, antibody diversity, monoclonalantibodies, autoimmunity, Hybridoma technology (15)Biosynthesis of lipids and fatty acids. Secondary metabolism, Membrane transport, Aminoacid biosynthesis and metabolism. (6)Cell differenciation, Regulation of gene expression, recombination, DNA replication, signaltransduction. (8)Suggested reading: Fundamentals of Biochemistry by Voet, Voet and Pratt,Biochemistry by L. Stryer, Proteins by T.E. Creighton, Genes VII by B. Lewin, Introduction toprotein structure by Branden and Tooze, Enzyme structure and Mechanism by AlanFersht. **References/Text Books:**	BASIC BIOLOGICAL CHEMISTRY
CHM684	3-0-0-0-4		**Course Contents:** Fortran and Computer Programming: Elements of Fortran programming, constants, variablesand operators, control statements, I/O operations, functions and subprograms, common,equivalence, arrays, strings, DATA statements, Disk I/O. New features in Fortran 90compared to Fortran 77.Programming considerations Round off and truncation errors, pitfalls and debugging (18)Numerical Methods: Roots of equations Bisection and NewtonRaphson methods, Systemof linear equations, Gaussian, GaussJordan elimination, Nonlinear system of equations.Regression analysis and Least square fit, Linear, Polynomial and NonLinear regressionanalysis, eigenvalues and eigenvectors, Numerical differentiation and integration, Differentialequations (15)Applications to chemistry : statistical thermodynamics, chemical kinetics, Curve fitting,Gaussian and Lorentzian deconvolution (5)Use of software packages such as visualization, semiempirical methods. (4) **References/Text Books:** 1) Michael Boillot, Understanding Fortran77, wesspublishing company, New York(1987).2) Fortran95/2003 for scientists and engineers, S.J.Chapman, McGrawHill (2008).3) (Ed) D.F. De Tar, Computer programs for chemistry, vol 14, Academic press, New York(1972).4) K.B. Wiberg, Computer Programming for Chemists, W.A. Benjamin Inc, New York (1965).5) S.C.Chapra and R.P.Canale, Numerical Methods for Engineers, Tata McGraw Hill, NewDelhi (2003).	COMPUTER PROGRAMMING FOR CHEMISTRY
CHM684A	3-0-0-0-9		**Course Contents:** Fortran and Computer Programming: Elements of Fortran programming, constants, variablesand operators,	COMPUTER PROGRAMMING FOR

			control statements, I/O operations, functions and subprograms, common,equivalence, arrays, strings, DATA statements, Disk I/O. New features in Fortran 90compared to Fortran 77.Programming considerations Round off and truncation errors, pitfalls and debugging (18)Numerical Methods: Roots of equations Bisection and NewtonRaphson methods, Systemof linear equations, Gaussian, GaussJordan elimination, Nonlinear system of equations.Regression analysis and Least square fit, Linear, Polynomial and NonLinear regressionanalysis, eigenvalues and eigenvectors, Numerical differentiation and integration, Differentialequations (15)Applications to chemistry : statistical thermodynamics, chemical kinetics, Curve fitting,Gaussian and Lorentzian deconvolution (5)Use of software packages such as visualization, semiempirical methods. (4) **References/Text Books:** 1) Michael Boillot, Understanding Fortran77, wesspublishing company, New York(1987).2) Fortran95/2003 for scientists and engineers, S.J.Chapman, McGrawHill (2008).3) (Ed) D.F. De Tar, Computer programs for chemistry, vol 14, Academic press, New York(1972).4) K.B. Wiberg, Computer Programming for Chemists, W.A. Benjamin Inc, New York (1965).5) S.C.Chapra and R.P.Canale, Numerical Methods for Engineers, Tata McGraw Hill, NewDelhi (2003).	CHEMISTRY
CHM685	3-0-0--4	#	**Course Contents:** 1. Classical Elecromagnetics (5)Fields, Maxwells equations, gauges and optics.2. Quantization of Electromagnetic Fields (10)Photons, polarizations, Stokes parameters, nontrivial role of the vector potential.3. Interactions (10)One and two photon processes, linewidths and lineshapes, broadening, Raman scattering.4. Spectroscopy (10)BornOppenheimer limit, timedependent viewpoints, nonadiabatic effects.5. Advanced topics (7)Beyond dipole approximation, attosecond spectroscopy. **References/Text Books:** 1. Sakurai, Advanced Quantum Mechanics, 1967.2. CohenTannoudji & DupontRoc, AtomPhoton Interactions, 2004.3. Landau & Lifshitz, Classical Theory of Fields, 1951.4. CohenTannoudji, DupontRoc & Grynberg, Photons & Atoms, 1989.5. Feynman Lectures in Physics II, 2005.	MOLECULE RADIATION INTERACTION
CHM685A	3-0-0-0-9		**Course Contents:** 1. Classical Elecromagnetics (5)Fields, Maxwells equations, gauges and optics.2. Quantization of Electromagnetic Fields (10)Photons, polarizations, Stokes parameters, nontrivial role of the vector potential.3. Interactions (10)One and two photon processes, linewidths and lineshapes, broadening, Raman scattering.4. Spectroscopy (10)BornOppenheimer limit, timedependent viewpoints, nonadiabatic effects.5. Advanced topics (7)Beyond dipole approximation, attosecond spectroscopy. **References/Text Books:** 1. Sakurai, Advanced Quantum Mechanics, 1967.2. CohenTannoudji & DupontRoc, AtomPhoton Interactions, 2004.3. Landau & Lifshitz, Classical Theory of Fields, 1951.4. CohenTannoudji, DupontRoc & Grynberg, Photons & Atoms, 1989.5. Feynman Lectures in Physics II, 2005.	MOLECULE RADIATION INTERACTION
CHM689	3-0-0--4		**Course Contents:** Introduction to NMR Spectroscopy.(1)Angular momentum, matrix representation of angular momentum operators. (6)Density matrices, pure and mixed states, density operator and calculation of expectationvalues.(6)Chemical shifts, coupling constants, rotating frame concept and qualitative description ofpulse experiments.(5)Construction of hamiltonian matrix for multispin systems and the solution of AB and ABX spinsystems.(5)Product operator formalism and vector diagrams.(5)Analysis of multipulse experiments: INEPT, DEPT, COSY, NOESY and double quantumfiltered COSY. (12)Multidimensional NMR and macromolecular structure determination. (2) **References/Text Books:** 1. M.Goldman, Quantum Description of High Resolution NMR in Liquids, Clarendon Press,New York(1988).2. J.A.Pople, W.G.Schneider and H.J.Bernstein, High Resolution NMR, McGraw Hill, NewYork(1959).3. J.Cavanagh, W.J.Fairbrother, A.G.Palmer III and N.J.Skelton, Protein NMR	NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

			Spectroscopy,Academic Press(1996).4. C.P.Slichter, Principles of Magnetic Resonance, SpringerVerlag, Berlin(1990).	
CHM689A	3-0-0-0-9		**Course Contents:** Introduction to NMR Spectroscopy.(1)Angular momentum, matrix representation of angular momentum operators. (6)Density matrices, pure and mixed states, density operator and calculation of expectationvalues.(6)Chemical shifts, coupling constants, rotating frame concept and qualitative description ofpulse experiments.(5)Construction of hamiltonian matrix for multispin systems and the solution of AB and ABX spinsystems.(5)Product operator formalism and vector diagrams.(5)Analysis of multipulse experiments: INEPT, DEPT, COSY, NOESY and double quantumfiltered COSY. (12)Multidimensional NMR and macromolecular structure determination. (2) **References/Text Books:** 1. M.Goldman, Quantum Description of High Resolution NMR in Liquids, Clarendon Press,New York(1988).2. J.A.Pople, W.G.Schneider and H.J.Bernstein, High Resolution NMR, McGraw Hill, NewYork(1959).3. J.Cavanagh, W.J.Fairbrother, A.G.Palmer III and N.J.Skelton, Protein NMR Spectroscopy,Academic Press(1996).4. C.P.Slichter, Principles of Magnetic Resonance, SpringerVerlag, Berlin(1990).	NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY
CHM691	3-0-0--4		**Course Contents:** Developing facets of Inorganic Chemistry (2 Lectures)Oxidative generation of molecular oxygen from water during photosynthesis (8 Lectures)Its importance from the standpoint of nonconventional energy research (6 Lectures)Reductive cleavage of the dioxygen bond (3 Lectures)Reductive cleavage of dioxygen bond and novel organic transformations including methane tomethanol performed by a large number of Fe containing metalloenzymes (8 Lectures)Reductive cleavage of dioxygen bond and novel organic transformations performed by alarge number of Cu containing metalloenzymes and synthetic catalysts (15 Lectures) **References/Text Books:** Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, UniversityScience Books, Mill Valley, 2006.	FRONTIERS IN INORGANIC CHEMISTRY
CHM691A	3-0-0-0-9	CHM342A	**Course Contents:** Developing facets of Inorganic Chemistry (2 Lectures)Oxidative generation of molecular oxygen from water during photosynthesis (8 Lectures)Its importance from the standpoint of nonconventional energy research (6 Lectures)Reductive cleavage of the dioxygen bond (3 Lectures)Reductive cleavage of dioxygen bond and novel organic transformations including methane tomethanol performed by a large number of Fe containing metalloenzymes (8 Lectures)Reductive cleavage of dioxygen bond and novel organic transformations performed by alarge number of Cu containing metalloenzymes and synthetic catalysts (15 Lectures) **References/Text Books:** Bioinorganic Chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, UniversityScience Books, Mill Valley, 2006.	FRONTIERS IN INORGANIC CHEMISTRY
CHM693	3-0-0--4		**Course Contents:** Chemical methods of synthesis play a crucial role in designing materials,discovering novel materials, metastable phases, nanomaterials and provide lesscumbersome routes for the known materials. Chemical ingenuity is importantfor the synthesis of solid materials with desired structure and properties. Keepingin mind the multidisciplinary nature of the subject, a rational approach to thesynthesis of materials is evolved. Indeed, soft chemistry routes/techniques arepursued with greater vigour. These include precursor technique, solgel,hydrothermal, nonaqueous liquid phase reactions, polymer pyrolysis, gas phasereactions, plasma reactions, electron beam evaporation, freeze drying, spraydrying, topochemical reactions, intercalation, electrochemical methods, CVDlaser ablation, arcmethod, molten salt method, intergrown structures.	CHEMICAL APPROACHES TO THE SYNTHESIS OF ADVANCED MATERIALS

			Solidstate reactivity, working knowledge of characterization techniques and conventionaltechniques. **References/Text Books:**	
CHM695	3-0-0--4		**Course Contents:** Brief Review of the basic Principles of quantum mechanics of atoms and molecules.Potential energy surfaces and intermolecular interactions: Quantum mechanical ab initiocalculations within BornOppenheimer approximation and modelling of calculated energies bymodel potentials for simple atoms, molecules and ions. Energy calculations using molecularmechanics. (16)Simple applications of molecular modelling: Study of an assembly of atoms or molecules(clusters and/or bulk phases). Approximation of the total potential energy as the sum of pairpotentials. Concept of large number of microstates, averages and basic principles ofsimulations. Study of cluster and bulk properties through simulations. (10)Modelling of water and small organic molecules: Nonpolarizable and polarizable rigid models.Flexible models and calculation of force constants. Structural, dielectric and dynamicalproperties of a polar medium: Continuum models versus molecular models. Calculation offree energy using molecular models. (10)Modelling of macromolecules: Study of selforganized assemblies, biomolecules like peptides,proteins, membranes and ion channels. Concept of hydrophobic and hydrophilic interactions.Use of molecular modelling in drug design, QSAR (6) **References/Text Books:** 1. A.R. Leach, Molecular Modeling : Principles and Applications, Longman (1996).2. J. H. Jensen, Molecular Modeling Basics, CRC Press (2010).3. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Ed., Wiley(2004).4. J. Israelachvili, Intermolecular and surface Forces, Academic (1991)5. M. P. Allen and D. J. Tildesley, Computer Simulation of Liquids, Clarendon Press (1987)6. D. Frenkel and B. Smit, Understanding Molecular Simulation : From algorithms toApplications, Academic Press (1996)7. P.W. Atkins, Molecular Quantum Mechanics, Oxford (1997)8. W. Koch & M. C. Holthausen, A Chemists Guide to Density Functional Theory, WileyVCH.9. A. Szabo, Modern Quantum Chemistry: Introduction to Advanced Electronic StructureTheory, Dover Publications (1996).	MOLECULAR MODELLING IN CHEMISTRY
CHM695A	3-0-0-0-9		**Course Contents:** Brief Review of the basic Principles of quantum mechanics of atoms and molecules.Potential energy surfaces and intermolecular interactions: Quantum mechanical ab initiocalculations within BornOppenheimer approximation and modelling of calculated energies bymodel potentials for simple atoms, molecules and ions. Energy calculations using molecularmechanics. (16)Simple applications of molecular modelling: Study of an assembly of atoms or molecules(clusters and/or bulk phases). Approximation of the total potential energy as the sum of pairpotentials. Concept of large number of microstates, averages and basic principles ofsimulations. Study of cluster and bulk properties through simulations. (10)Modelling of water and small organic molecules: Nonpolarizable and polarizable rigid models.Flexible models and calculation of force constants. Structural, dielectric and dynamicalproperties of a polar medium: Continuum models versus molecular models. Calculation offree energy using molecular models. (10)Modelling of macromolecules: Study of selforganized assemblies, biomolecules like peptides,proteins, membranes and ion channels. Concept of hydrophobic and hydrophilic interactions.Use of molecular modelling in drug design, QSAR (6) **References/Text Books:** 1. A.R. Leach, Molecular Modeling : Principles and Applications, Longman (1996).2. J. H. Jensen, Molecular Modeling Basics, CRC Press (2010).3. C. J. Cramer, Essentials of Computational Chemistry: Theories and Models, 2nd Ed., Wiley(2004).4. J. Israelachvili, Intermolecular and surface Forces, Academic (1991)5. M. P. Allen and D. J. Tildesley, Computer Simulation of Liquids, Clarendon Press (1987)6. D. Frenkel and B. Smit, Understanding Molecular Simulation : From algorithms toApplications, Academic Press (1996)7. P.W. Atkins, Molecular Quantum Mechanics, Oxford (1997)8. W. Koch & M. C. Holthausen, A Chemists Guide to Density Functional Theory, WileyVCH.9. A. Szabo, Modern Quantum Chemistry: Introduction to Advanced Electronic StructureTheory, Dover Publications (1996).	MOLECULAR MODELLING IN CHEMISTRY
CHM696	3-0-0--4		**Course Contents:**	QUANTUM COMPUTING

			Thermodynamics of computing, Shannon Theory, elementary information theory (2)Basics of computers, ChurchTuring hypothesis, basics of computing complexity (4)Basic of quantum mechanics, FeynmanBlock Pseudopolarization Vector Model, Time DependentSchrodinger equation, basics of approximate quantum approaches (8)Twolevel Systems, Coherence, Superposition Principle, Density Matrix, Entanglement, RelaxationProcesses.(6)Quantum gates and circuits, Theory of Quantum Information and Computation, DeutschJozsaalgorithm, Shor's algorithm for factoring, Grover's search algorithm and its applications.(8)Quantum Complexity, Quantum Turing Machine. (6)Physical implementations of Quantum Computation, Light polarization, NMR, Cavity QED, IonTraps,Lasermatter interaction, Coherent Control. (8) **References/Text Books:** a. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information,Cambridge University Press, 2000b. Jozef Gruska, Quantum Computing, McGraw Hill, 1999c. Neil Gershenfeld, Physics of Information Technology, Cambridge University Press, 2000d. CohenTannoudji, Diu, and Lalo, Quantum Mechanics I, 2005.e. Mika Hirvensalo, Quantum Computing, SpringerVerlag New York, 2000.f. G. Alber, T. Beth, M. Horodecki, P. Horodecki, R. Horodecki, M. Rotteler, H. Weinfurter, R.Werner, A. Zeilinger, Quantum Information: An Introduction to Basic Theoretical Conceptsand Experiments, Springer, 2001.	
CHM696A	3-0-0-0-9		**Course Contents:** Thermodynamics of computing, Shannon Theory, elementary information theory (2)Basics of computers, ChurchTuring hypothesis, basics of computing complexity (4)Basic of quantum mechanics, FeynmanBlock Pseudopolarization Vector Model, Time DependentSchrodinger equation, basics of approximate quantum approaches (8)Twolevel Systems, Coherence, Superposition Principle, Density Matrix, Entanglement, RelaxationProcesses.(6)Quantum gates and circuits, Theory of Quantum Information and Computation, DeutschJozsaalgorithm, Shor's algorithm for factoring, Grover's search algorithm and its applications.(8)Quantum Complexity, Quantum Turing Machine. (6)Physical implementations of Quantum Computation, Light polarization, NMR, Cavity QED, IonTraps,Lasermatter interaction, Coherent Control. (8) **References/Text Books:** a. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information,Cambridge University Press, 2000b. Jozef Gruska, Quantum Computing, McGraw Hill, 1999c. Neil Gershenfeld, Physics of Information Technology, Cambridge University Press, 2000d. CohenTannoudji, Diu, and Lalo, Quantum Mechanics I, 2005.e. Mika Hirvensalo, Quantum Computing, SpringerVerlag New York, 2000.f. G. Alber, T. Beth, M. Horodecki, P. Horodecki, R. Horodecki, M. Rotteler, H. Weinfurter, R.Werner, A. Zeilinger, Quantum Information: An Introduction to Basic Theoretical Conceptsand Experiments, Springer, 2001.	QUANTUM COMPUTING
CHM698	3-0-0--4		**Course Contents:** Physicochemical Principles of Drug Action; Partition Coefficients; ReceptorEffector Theories;Role of Second Messengers in Drug Action; Methods of Receptor Isolation,Characterization and Modeling (5)Principles of Drug Design: Random Screening, Analogue Synthesis, Rational Design,Combinatorial Libraries; Enantiopure Drugs and Regulatory Implications; TheoreticalApproaches: QSAR, Topliss Tree, MSA, CoMFA (2)Neuroactive Drugs: Neurons and Neurotransmitters; Brainrelated Disorders andChemotherapy; Drugs Interacting with Cholinergic, Adrenergic, Dopaminergic andHistaminic Receptors and Receptorsubtypes (5)Anticancer, Antimalarial, Antiviral, and Cardiovascular Drugs; Emerging Trends in DrugDesign: Inhibitors of DNA Topoisomerase and Protein Farnesylation & Prenylation; GeneBased Medicines (8)Biopharmaceuticals: Recombinant Proteins as Medicines and Vaccines (2)Drug Delivery: Passive, Assisted and VectorBased Delivery of Conventional and GeneticDrugs; TissueSpecific Delivery of Antitumor Agents (8)Drug Administration, Distribution, Metabolism and Elimination (ADME); Pathways of DrugMetabolism: Enzymology and Molecular Mechanisms; Detoxification of Diverse DrugClasses; Dose Formulation (10)Induction and Inhibition of Drug Metabolism; Toxicological Aspects of Metabolism: MetabolicActivation of Environmental Carcinogens and DNA Damage; Drug Pharmacokinetics andFinal	CHEMISTRY OF DRUG DESIGN AND METABOLISM

			Body Clearance (2) **References/Text Books:** 1. Medicinal Chemistry: A Biochemical Approach, Thomas Nogrady2. Principles of Medicinal Chemistry, William O. Foye3. The Pharmacological Basis of Therapeutics: Goodman and Gilman4. Introduction to Drug Metabolism, G. Gordon Gibson and Paul Skett	
CHM698A	3-0-0-0-9	CHM481A	**Course Contents:** Physicochemical Principles of Drug Action; Partition Coefficients; ReceptorEffector Theories;Role of Second Messengers in Drug Action; Methods of Receptor Isolation,Characterization and Modeling (5)Principles of Drug Design: Random Screening, Analogue Synthesis, Rational Design,Combinatorial Libraries; Enantiopure Drugs and Regulatory Implications; TheoreticalApproaches: QSAR, Topliss Tree, MSA, CoMFA (2)Neuroactive Drugs: Neurons and Neurotransmitters; Brainrelated Disorders andChemotherapy; Drugs Interacting with Cholinergic, Adrenergic, Dopaminergic andHistaminic Receptors and Receptorsubtypes (5)Anticancer, Antimalarial, Antiviral, and Cardiovascular Drugs; Emerging Trends in DrugDesign: Inhibitors of DNA Topoisomerase and Protein Farnesylation & Prenylation; GeneBased Medicines (8)Biopharmaceuticals: Recombinant Proteins as Medicines and Vaccines (2)Drug Delivery: Passive, Assisted and VectorBased Delivery of Conventional and GeneticDrugs; TissueSpecific Delivery of Antitumor Agents (8)Drug Administration, Distribution, Metabolism and Elimination (ADME); Pathways of DrugMetabolism: Enzymology and Molecular Mechanisms; Detoxification of Diverse DrugClasses; Dose Formulation (10)Induction and Inhibition of Drug Metabolism; Toxicological Aspects of Metabolism: MetabolicActivation of Environmental Carcinogens and DNA Damage; Drug Pharmacokinetics andFinal Body Clearance (2) **References/Text Books:** 1. Medicinal Chemistry: A Biochemical Approach, Thomas Nogrady2. Principles of Medicinal Chemistry, William O. Foye3. The Pharmacological Basis of Therapeutics: Goodman and Gilman4. Introduction to Drug Metabolism, G. Gordon Gibson and Paul Skett	CHEMISTRY OF DRUG DESIGN AND METABOLISM
CHM699	3-0-0-0-4		**Course Contents:** Fundamentals of Lasers, laserinduced fluorescence and multiphoton ionization processes of molecules, probing IVR and dynamics of chemical reactions in liquid and molecular beam, spectroscopy of single molecule, probing of proton dynamics, optical trapping and manipulations of biological macromolecules and organelles, confocal microscopy and fluorescence correlation spectroscopy, applications to diagnostics and biotechnology. **References/Text Books:**	LASERS IN CHEMISTRY AND BIOLOGY
CHM699A	3-0-0-0-9		**Course Contents:** Fundamentals of Lasers, laserinduced fluorescence and multiphoton ionization processes of molecules, probing IVR and dynamics of chemical reactions in liquid and molecular beam, spectroscopy of single molecule, probing of proton dynamics, optical trapping and manipulations of biological macromolecules and organelles, confocal microscopy and fluorescence correlation spectroscopy, applications to diagnostics and biotechnology. **References/Text Books:**	LASERS IN CHEMISTRY AND BIOLOGY
CHM700	0-0-0-0-27		**Course Contents:** PROJECT **References/Text Books:**	PROJECT
CHM700.	----0		**Course Contents:**	PROJECT

			PROJECT **References/Text Books:**	
CHM799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	RESEARCH
CHM800	----0		**Course Contents:** General Seminar **References/Text Books:**	GENERAL SEMINAR
CHM800A	----0		**Course Contents:** GENERAL SEMINAR **References/Text Books:**	GENERAL SEMINAR
CHM800B	----0		**Course Contents:** GENERAL SEMINAR **References/Text Books:**	GENERAL SEMINAR
CHM801	----0		**Course Contents:** Graduate Seminar **References/Text Books:**	GRADUATE SEMINAR
CHM801A	----0		**Course Contents:** GENERAL SEMINAR **References/Text Books:**	GRADUATE SEMINAR
CHM801B	----0		**Course Contents:** GENERAL SEMINAR **References/Text Books:**	GRADUATE SEMINAR
CSO201A	3-1-0-0-11		**Course Contents:** Basic Organic Chemistry Concepts: introduction to organic molecules and functional groups,understanding organic reactions, stereochemistry and carboncarbon bond forming reactions in organic synthesis. (8 Lectures)Drugs some examples including love drugs and molecules of death. (2 Lectures)Chemistry of odours, dyes and flavors (3 Lectures)Green Chemistry introduction, principles, sustainability, atom economy, some green initiatives, management of resources and its effect on health and environment. Catalysis and biocatalysts in organic chemistry. enantioselectivity and chiralsynthesis, organocatalysis.(6 Lectures)Enzymes as drug targets and their inhibitors as model inhibitors. (4 Lectures)Solid phase synthesis and strategies for futuristic designs in organic chemistry.Photochemistry: simple concepts and applications (semiconductor photochemistry, solarenergy conversion by photovoltaic cells, photocatalysis, etc.); supramolecular photochemistry.(4 Lectures)Organic Materials: polymers (biodegradable polymers, conducting polymers, etc.), smart materials,OLEDs, intelligent gels, dyes, etc **References/Text Books:**	ORGANIC CHEMISTRY: FUNDAMENTALS AND APPLICATIONS

			1. Organic Chemistry: Structure, Mechanism,and Synthesis by R. J. Oulettle and J. D. Rawn2.Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments by K. Doxsee and J.Hutchinson3. Bioorganic Chemisty: A Chemical approach to enzyme action by H. Dugas4. Solid Phase organic synthesis: concepts strategies and applications by P. H. Toy and Y. Lam5. General Organic Chemistry, Janice Smith, McGrawHill, New York, USA, 20116. Organic Chemistry, W. H. Brown, C. S. Foote, B. L. Iverson and E. V. Anslyn, Brooks/Cole,Belmont, USA, 2012. 7. Principles and Applications of Photochemistry, Brian Wardle, Wiley & Sons, Chichester, UK., 2009.8. Chemistry of New Materials, FactsOn File, Inc. New York, USA, 2007.9. Love Drugs, Otto Snow, Thoth Press, USA, 2005.10. Molecules of Death, R. H. Waring, G. B. Steventon, S. C. Mitchell, Imperial College Press, London, UK, 2007	
CSO202	3-1-0-0-4		**Course Contents:** 1. Landmark experiments in physical chemistry2. Interplay of theory and experiments in modern physical chemistry3. Structure of atoms and molecules4. Dynamics of atoms and molecules5. Structure and dynamics of atoms and molecules interacting with radiation **References/Text Books:** 1. R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry2. D. A. McQuarrie, J. D. Simon, Physical Chemistry: A molecular approach3. K. J. Laidler, The World of Physical Chemistry4. C. E. Dykstra, Physical Chemistry A modern Introduction	ATOMS, MOLECULES AND PHOTONS
CSO202A	3-1-0-0-11	CHM102A	**Course Contents:** 1. Landmark experiments in physical chemistry2. Interplay of theory and experiments in modern physical chemistry3. Structure of atoms and molecules4. Dynamics of atoms and molecules5. Structure and dynamics of atoms and molecules interacting with radiation **References/Text Books:** 1. R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry2. D. A. McQuarrie, J. D. Simon, Physical Chemistry: A molecular approach3. K. J. Laidler, The World of Physical Chemistry4. C. E. Dykstra, Physical Chemistry A modern Introduction	ATOMS, MOLECULES AND PHOTONS
IDC600A	3-0-0-0-5		**Course Contents:** Introduction to HPC and scientific computing. Overview of major applications. Supercomputing architecture; multicores; shared memory; switch etc. Review of basics of C/Fortran programming. Programming in Message Passing Interface (MPI). Programming in OpenMP. Case study on one major application. **References/Text Books:** 1. P.S. Pacheco, An Introduction to Parallel Programming, Elsevier (2011). 2. M. Quinn, Parallel Programming in C and OpenMP, McGraw Hill Education (India) (2003). 3. A. Grama, A. Gupta, G. Karypis, and V. Kumar, Introduction to Parallel Computing, Pearson (200&).	INTRODUCTION TO HIGH PERFORMANCE COMPUTING FOR SCIENTISTS & ENGINEERS
IDC601A	3-0-0-0-9		**Course Contents:** Dynamical systems (map, flow, boolean, automata): Finite vs. infinite dimentional systems, Conservative vs. disspative systems, Phase space, Fixed points, Linear stability analysis, Poincare section, Numerical solution of maps and flows. Maps: Circle map, Logistic map and conjugate Tent map, Chaos, Lyapunov exponents, Period doubling route to chaos, Intermittency route to chaos, Crisis, Quasi periodic route to chaos. Autonomous flows: Hartman Grobman theorem (proff optional), Poincare Bendixon theorem (proof optional), Limit cycles, Hopf bifurcation, Flow on ntorus and quasi periodicity, Lorenz equation, Chaotic attractor, Lyapunov exponents, Routes to chaos. Non Autonomous flows: Floquet theory, Duffing oscillator, Chaos. Introduction to bifurcation theory and normal forms. Fractals, Topological dimension, Similarity dimension, Box dimension, Correlation dimention, Generalized dimensions, Lyapunov dimension. Some research topics: e.g., Synchronization, Phase space reconstruction, etc. **References/Text Books:**	DYNAMICAL SYSTEMS AND CHAOS

			1. S.H. Strogatz, Nonlinear Dynamics And Chaos: With Applications to Physics, Biology, Chemistry, And Engineering, Westview Press (2001). 2. R.C. Hilborn, Chaos and Nonlinear Dynamics, Oxford University Press (2001). 3. J. Argyris, G. Faust, M. Haase, & R. Friedrich, An Exploration of Dynamical Systems and Chaos, Springer (2015). 4. H.G. Schuster & W. Just, Deterministic Chaos: An Introduction, Wiley VCH (2005). 5. D. Jordan & P. Smith, Nonlinear Ordinary Differentioal Equations: An Introduction for Scientists and Engineers, Oxford University Press, 4th edition (2007). 6. J. Guchenheimer and P. Holmes, Nonlinear Oscillations, Dynamical Systems, and Bifurcations of Vector Fields, Springer (1983).	
SE331	3-0-0--4	CHM201N / CHM201R	**Course Contents:** States of matter and properties of gases: Description of states of matter, perfectgas equation of state, The Maxwell distribution of speeds, diffusion and effusion,real gases, intermolecular interactions, critical temperature, the van der Waalsand the Virial equation of states.Thermodynamics: First law and its implications, various relations between q,w, U, H, T, Cp and Cv. Second law; entropy and free energy changes. Chemicalpotential phase equilibrium. Raoults law, Henrys law and colligative properties.Chemical equilibrium. Electrochemisty, DebyeHuckel limiting law, electrochemicalcells.Chemical Kinetics: Phenomenological kinetics 1st, 2nd and 3rd order laws.Methods of determining order of chemical reactions. Chain reactions andexplosions, photochemical reactions and catalysis. Fast reactions, flow techniques,flash photolysis. Collision theory and fundamentals of activated complex theory. **References/Text Books:**	BASIC PHYSICAL CHEMISTRY
SE332	3-0-0-0-4		**Course Contents:** Nomenclature of organic molecules, structure and bonding, stereochemistry,reactive intermediates, substitution and elimination reactions, molecularrearrangements, photochemistry. **References/Text Books:**	BASIC ORGANIC CHEMISTRY
SE333	3-0-0-0-4		**Course Contents:** Various aspects of the energy and raw material supply: Coal, oil, natural gas,nuclear, and biomass as energy sources; Basic products of industrial synthesis:synthesis gas, methanol, formaldehyde, halogen derivatives of methane,chlorofluorohydrocarbons; Olefins: Historical perspective, cracking of hydrocarbons,ethylene, butanes, higher olefins, unbranched higher olefins and their use inmetathesis reactions, Acetylene: Significance and manufacturing process foracetylene, manufacture through calcium carbide, thermal process, applicationsof acetylene, 1, 3Diolefins: 1, 3Butadiene, industrial manufacture fromcracking, dehydrogenation, applications of butadiene, Synthesis using carbonmonoxide: Hydroformylation, industrial operations, utilization of oxo products,carbonylation of olefins;Oxidation products of ethylene: Ethylene oxide, processoperation, ethylene glycol, ethylene glycol ethers, acetaldeyde, acetic acid, aceticanhydride, Alcohols: Ethanol, propanol, butanols, amyl alcohols, aldol synthesis,polyhydric alcohols, neopentyl glycol Vinylhalogen and oxygen compounds: Vinylchloride, vinylidene chloride, vinylacetate, vinyl ethers; Polyamides: Adipic acid,hexamethylenediamine, adiponitrile, lactams; Propene conversion products:Propylene oxide, acetone, acrolein, allylchloride, acrylonitrile.; Aromatics: Sourceof feedstocks, coking of hard coal, isolation, special separation techniques,condensed aromatics, naphthalene, anthracene, hydrodealkylation. **References/Text Books:**	INDUSTRIAL ORGANIC CHEMISTRY
SE334	3-0-0-0-4		**Course Contents:** Buffers (their use in study of biomolecules), pH, pKa of aminoacids, D and L amino acid nomenclature ; Proteins: protein sequencing by chemical and mass & NMR spectroscopic methods, Use of spectroscopic tools in studying bimolecules. Primary (single letter amino acid codes), Ramachandran plot, secondary (alpha, 310, Betahelices, parallel and antiparallel betasheets, gamma 1 turns, betaturns), circular Dichroism of proteins, supersecondary structural motifs, tertiary (motifs and domains: some Important motifs like Rossman fold, helix turn helix, 4 helix bundles, beta barrel) and quaternary structure (Hemoglobin and Myoglobin).	BIOSYSTEMS

			Protein Engineering; Biophysical techniques to purify and study proteins. Dialysis, salting out and precipitation by organic solvents, Ion exchange, gel filtration, reversed phase, affinity chromatography, ultracentrifugation, gel electrophoresis; Nucleic acids: A, B and Z DNA structures, Method of replication, sequencing of nucleic acids (chemical, dideoxy and fluorescence), Prokaryotic Transcription, translation, genetic code, genomes, genes, over expression of recombinant proteins, mutagenesis (random and site directed). Polymerase chain reaction(PCR); Enzymes and their kinetics: MichaelisMenten kinetics, Reaction order,competitive, uncompetitive, noncompetitive and irreversible inhibition of enzymes. Effect of pH, temperature on enzymes activity; Metabolism: Photosynthesis, Calvins cycle, Glycolysis, Krebs cycle, electron transport, cofactors; **References/Text Books:**	
SE335	3-0-0--4		**Course Contents:** Introduction to symmetry: Symmetry elements, symmetry operations and symbols, multiple symmetry operations, symmetry operations on molecules; Symmetry and group theory: Definition of groups. Molecular point groups, classification of molecules into point groups, matrix representation of symmetry operations, characters and character tables, reducible and irreducible representations; Symmetry and molecular structure calculations: Introduction to quantum mechanics, Symmetry of wave functions of atoms and molecules, symmetry adapted linear combinations, molecular orbitals of diatomic and polyatomic molecules, Molecular orbitals of conjugated molecules (Huckel MOs) and of transition metal complexes; Symmetry and spectroscopy: Transition between stationary states, Microwave, Infrared and Raman spectra, The symmetry of normal vibrations,Selection rules from symmetry considerations, illustrative examples. The electronicspectra of some diatomic and polyatomic molecules, selection rules of electronictransition, vibronic analysis. Some important special effects such as the exclusion rule for centrosymmetric molecules, Fermi resonance etc.; Conservation of orbital symmetry and chemical reactions: Some illustrative examples such as WoodwardHoffmann rule of electrocyclic reactions; **References/Text Books:**	SYMMETRY IN CHEMISTRY
***** Department of CSE *****				
CS201	3-0-0-0-4		**Course Contents:** Notion of proof: proof by counterexample, the contrapositive, proof bycontradiction, inductive proofs, Algebra: Motivation of algebraic structures;review of basic group theory with emphasis to finite groups: subgroups andgroup homomorphism, Lagranges theorem. Commutative rings, ideals, Finitefields and their elementary properties. Some CS applications (e.g., RSA, errorcorrecting codes), Combinatorics: Basic counting techniques, pigeonhole principle,recurrence relations, generating functions, Polyas counting theorem. Basicsof graph theory. Introduction to probabilistic method in combinatorics. Formallogic: Propositional logic: proof system, semantics, completeness, compactness.First order logic: models, proof system, compactness, Examples of formalproofs in, say, number theory or group theory. Some advanced topics. E.g.,CS application of logic, introduction to modal and temporal logics, Or, formalnumber theory including incompleteness theorem. **References/Text Books:**	DISCRETE MATHEMATICS
CS201A	3-0-0-0-9		**Course Contents:** 1. Mathematical proofs, proofs by induction, by contradiction, proving the contrapositive.2. Basic counting techniques, pigeonhole principle, recurrence relations, generating functions, principle of inclusionand exclusion, Mobius inversion.3. Graphs, trees definitions. Connectivity, paths, cycles, Eulerian walks, Hamiltonian cycles, cliques, colourings,graph matching, planarity.4. Discrete probability. Sample space, events, probability basic laws, discrete random variable, expectation, linearityof expectation, independence, conditioning, Bayes theorem, Bernoulli, binomial and geometric distributions,moments and deviations, Markov, Tchebyshev 's inequalities, Chernoff bounds.5. Application of probabilistic methods in	MATHEMATICS FOR COMPUTER SCIENCE -I

			combinatorics and graph theory. **References/Text Books:** 1. Peter Cameron, Combinatorics: Topics, Techniques, Algorithms, Cambridge University Press, 1995.2. JH van Lint, RM Wilson, A Course in Combinatorics, 2nd Ed., Cambridge University Press, 2001.3. David Stirzaker, Elementary Probability, 2nd Ed., Cambridge University Press, 2003.4. Noga Alan, Joel Spencer, The Probabilistic Method, 3rd Ed., Wiley Interscience, 2008.5. R Graham, D Knuth, 0 Patashnik, Concrete Mathematics: A Foundation for Computer Science, 2nd Ed.,AddisonWesley, 1994.	
CS202A	3-0-0-0-5		**Course Contents:** 1. Propositional logic syntax and semantics.2. Tautologies, axiom system and deduction.3. Proof of soundness and completeness.4. First order logic syntax and semantics.5. Structures, models, satisfaction and validity.6. Axiomatization, soundness and completeness.7. Optional: some advanced topics. **References/Text Books:** 1. HD Ebbinghaus, J Flum, W Thomas, Mathematical Logic, 2nd Ed., Springer Verlag, 1994.2. HB Enderton, A Mathematical Introduction to Logic, 2nd Ed., Academic Press, 2001.3. RM Smullyan, First Order Logic, Dover Press, 1995.	MATHEMATICS FOR COMPUTER SCIENCE -II
CS203B	3-0-0-0-5		**Course Contents:** 1. Group theory: definition of groups, cosets and Lagrange's theorem, subgroups, normal subgroups, quotientgroups, group action and Burnside's lemma.2. Rings, Fields, integral domains basic definitions and properties. Field extensions, Chinese remaindering overintegers and polynomial rings. (optional: Introduction to finite fields.) **References/Text Books:** 1. IN Herstein, Abstract Algebra, 3rd Ed., Wiley, 1996.2. DS Dummit, RM Foote, Abstract Algebra, John Wiley, 2004.	MATHEMATICS FOR COMPUTER SCIENCE -III
CS210	3-0-0-0-4		**Course Contents:** 1. Randomaccessmachine model, concept of problem size, and asymptotic behaviour of time/space complexity.2. Estimation of time/space complexity by smooth functions and order notations.3. A simple example of worstcase time/space complexity analysis.4. Elementary datastructures: arrays, lists, queues, stacks and their applications.5. Binary search algorithm, binary trees, binarysearchtree datastructure.6. Balanced binarysearchtree: RedBlack trees.7. Hashing for insert, search, delete.8. Heap data structure.9. Efficient data structures, apart from those in items 6,7, and 8, for sets with the foHowing group of operations:(i) insert, delete, membership, (ii) insert, delete, minimum, (iii) union, intersection, dierence, (iv) disjointsetunion, nd.10. Sorting algorithms, including the average case analysis of quicksort.11. Greedy paradigm with examples.12. Divide and conquer paradigm with examples.13. Dynamicprogramming paradigm with examples.14. Denition of graphs, paths, trees, cycles. Data structures for graphs: adjacency lists, adjacency matrix.15. Graph algorithms: Depth First Search, Breadth First Search, Minimum Spanning Tree.Additional topics based on time and interest may be selected from the following list:16. Singlesource shortest path computation, topological sorting of a partially ordered set, convex hull computation,string matching algorithms, median computation, distributed algorithms. **References/Text Books:** 1. AV Aho, J Hopcroft, JD Ullman, Data Structures and Algorithms, Addison Wesley, 1983.2. TH Cormen, CF Leiserson, RL Rivest, C Stein, Introduction to Algorithms, 3rd Ed., MIT Press, 2009.3. AV Aho, J Hopcroft, JD Ullman, The Design and Analysis of Algorithms, AddisonWesley, 1974.4. MT Goodrich, R Tamassia, DM Mount, Data Structures and Algorithms in Java, 5th Ed., Wiley, 2010.(Equivalent book in C also exists.)	DATA STRUCTURES AND ALGORITHMS I
CS210A	3-0-3-0-12	ESC101A	**Course Contents:**	DATA STRUCTURES AND

			1. Randomaccessmachine model, concept of problem size, and asymptotic behaviour of time/space complexity.2. Estimation of time/space complexity by smooth functions and order notations.3. A simple example of worstcase time/space complexity analysis.4. Elementary datastructures: arrays, lists, queues, stacks and their applications.5. Binary search algorithm, binary trees, binarysearchtree datastructure.6. Balanced binarysearchtree: RedBlack trees.7. Hashing for insert, search, delete.8. Heap data structure.9. Efficient data structures, apart from those in items 6,7, and 8, for sets with the foHowing group of operations:(i) insert, delete, membership, (ii) insert, delete, minimum, (iii) union, intersection, dierence, (iv) disjointsetunion, nd.10. Sorting algorithms, including the average case analysis of quicksort.11. Greedy paradigm with examples.12. Divide and conquer paradigm with examples.13. Dynamicprogramming paradigm with examples.14. Denition of graphs, paths, trees, cycles. Data structures for graphs: adjacency lists, adjacency matrix.15. Graph algorithms: Depth First Search, Breadth First Search, Minimum Spanning Tree.Additional topics based on time and interest may be selected from the following list:16. Singlesource shortest path computation, topological sorting of a partially ordered set, convex hull computation,string matching algorithms, median computation, distributed algorithms. **References/Text Books:** 1. AV Aho, J Hopcroft, JD Ullman, Data Structures and Algorithms, Addison Wesley, 1983.2. TH Cormen, CF Leiserson, RL Rivest, C Stein, Introduction to Algorithms, 3rd Ed., MIT Press, 2009.3. AV Aho, J Hopcroft, JD Ullman, The Design and Analysis of Algorithms, AddisonWesley, 1974.4. MT Goodrich, R Tamassia, DM Mount, Data Structures and Algorithms in Java, 5th Ed., Wiley, 2010.(Equivalent book in C also exists.)	ALGORITHMS
CS220	3-0-2-0-5		**Course Contents:** Introduction, Overview of basic digital building blocks; truth tables; basicstructure of a digital computer, Number representation, Integer unsigned,signed (sign magnitude, 1s complement, 2s complement, rs complement);CharactersASCII coding, other coding schemes; Real numbersfixed and floatingpoint, IEEE754, Assembly language programming for some processor, Basicbuilding blocks for the ALU, Adder, Subtractor, Shifter, Multiplication and divisioncircuits, CPU Subblock, Datapath ALU, registers, CPU buses; Control pathmicroprogramming (only the idea), hardwired, logic; External interface, MemorySubblock, Memory organization; TechnologyROM, RAM, EPROM, Flash etc.Cache; Cache coherence protocol for uniprocessor (simple), I/O Subblock,I/O techniques interrupts, polling, DMA; Synchronous vs. Asynchronous I/O; Controllers, Peripherals, Disk drives; Printers impact, dot matrix, inkjet, laser; Plotters; Keyboards; Monitors; Advanced Concepts, Pipelining;Introduction to Advanced Processors. **References/Text Books:**	INTRODUCTION TO COMPUTER ORGANISATION
CS220A	3-0-3-0-12	ESC101A ESC201A	**Course Contents:** {a) Digital Design using HDLs. Simple circuit designs: For e.g. Counter, Multiplexer, Arithmetic circuits etc.Design of a Simple Processor: Includes register file, ALU, data paths.{b) FPGA Programming Programming on Xilinx Spartan 3E (or equivalent) FPGA.Handling of Inputs: through slide switches, through push buttons.Handling of Outputs: 7segment display, LED display, LCD display.The designs developed in Part! can be used to program the FPGA.5(c) Assembly Language Programming Programming in assembly language. The assignments should cover thefollowing concepts:Registers; different type of instructions (load, store, arithmetic, logic, branch); operand addressing modes;memory addressing modes; conditions (codes/flags and conditional branches) stack manipulation; procedurecalls; procedure call conventions (load/store of; arguments on stack, activation records); **References/Text Books:** 1. Computer Organization and Design: The Hardware/Software Interface, David A Patterson, John L. Hennessy,4th Edition, Morgan Kaufmann, 20092. Computer Architecture and Organization by William Stallings, PHI Pvt. Ltd., Eastern Economy Edition, SixthEdition, 20033. Structured Computer Organization by Andrew S Tanenbaum, PHI/Pearson, 4th Edition4. Computer Organization by V Carl Hamacher, Zvonks Vranesic, SafeaZaky, McGraw Hill, Vth Edition5. Computer System Architecture by M Morris Mano,	COMPUTER ORGANIZATION

			Prentice Hall of India, 20016. Computer Architecture and Organization by John P Hayes, 3rd Ed. McGraw Hill, 2002.7. Assembly Language, Online notes, http:/ /linuxassembly.orgj.8. Books related to HDL (Verilog, VHDL, BSV) programming.	
CS251	1-0-3-0-4		**Course Contents:** 1. Basic operating system commands. Students are expected to know the basic shell (e.g., bash) commands and should be able to understand the options and functioning of a command by reading the man and info pages.2. Editors. Again, students are expected to be familiar with at least one of the two editors vim and emacs. How ever, they should be able to utilize the multiple features of the editors (such as automatic indentation, ontextsensitive colouring, letypesensitive autowrap, etc.) and not use them simply as a typewriter.3. Version control. Students will need to completely know how at least one of the version control systems (e.g., cvs, svn, git, dares) work. They_should be able to check in, check out, resolve errors and put tags on a snapshot. On all subsequent assignments, they must use a form of version .control.4. Scripting and automation. Of the various types of shells (bash, csh, tcsh, ksh), the preferred choice is bash, although students should be familiar with the different command syntax in other shells as well. Also, they will need to know the various functions (e.g., seq, for) that a shell provides. The choice of the scripting language(per! or python) is open to students.5. Document preparation. Students will learn using latex for preparing documents. They should also know how to format properly the equations, gures, tables, theorems, etc. using different packages and options. For bibliography management, they should use bibtex, and must use it within the latex documents. For drawing gures and graphs, they can choose to learn some or all of the different softwares used popularly (they includegnuplot, xfig, etc.). 6. Hardware. Students will work handson to learn how to install hard drives, RAM, etc., and in general, assemble a computer from its different parts. **References/Text Books:** 1. Manuals.2. Online help that is available for different tools.	COMPUTING LABORATORY-I
CS251A	1-0-3-0-6	ESC101A	**Course Contents:** 1. Basic operating system commands. Students are expected to know the basic shell (e.g., bash) commands and should be able to understand the options and functioning of a command by reading the man and info pages.2. Editors. Again, students are expected to be familiar with at least one of the two editors vim and emacs. How ever, they should be able to utilize the multiple features of the editors (such as automatic indentation, ontextsensitive colouring, letypesensitive autowrap, etc.) and not use them simply as a typewriter.3. Version control. Students will need to completely know how at least one of the version control systems (e.g., cvs, svn, git, dares) work. They_should be able to check in, check out, resolve errors and put tags on a snapshot. On all subsequent assignments, they must use a form of version .control.4. Scripting and automation. Of the various types of shells (bash, csh, tcsh, ksh), the preferred choice is bash, although students should be familiar with the different command syntax in other shells as well. Also, they will need to know the various functions (e.g., seq, for) that a shell provides. The choice of the scripting language(per! or python) is open to students.5. Document preparation. Students will learn using latex for preparing documents. They should also know how to format properly the equations, gures, tables, theorems, etc. using different packages and options. For bibliography management, they should use bibtex, and must use it within the latex documents. For drawing gures and graphs, they can choose to learn some or all of the different softwares used popularly (they includegnuplot, xfig, etc.). 6. Hardware. Students will work handson to learn how to install hard drives, RAM, etc., and in general, assemble a computer from its different parts. **References/Text Books:** 1. Manuals.2. Online help that is available for different tools.	COMPUTING LABORATORY-I
CS252	1-0-6-0-4		**Course Contents:** 1. System administration: Students will learn to setup and manage a network server including a web server andan email server. They should also be familiar with various network protocols. Further, students will be able toadminister different. components of the system by using various monitoring tools. They should also learn simpleloadbalancing tools.2. Security: While setting up different network and database servers, students	COMPUTING LABORATORY II

			will learn to manage the securityissues including different attacks. Public key infrastructure (PKI) is a good example of how to setup, manage,and distribute certicates that are issued as authorization tools. As part of maintaining sys terns, students willneed to use system vulnerability and intrusion testing tools as well.3. Compiler tools: Students will need to learn the various lowlevel tools used routinely in compilers including lexand yacc.4. Programming environment tools: For efcient programming, students are expected to use various integrateddevelopment environments (IDEs) such as eclipse and debuggers such as gdb. They should also use tools foreffective tagging and browsing of source code. Finally, they will learn to use the build tools that are necessaryfor large software projects. **References/Text Books:** Course Reference : 1. Manuals.2. Online help that is available for different tools.	
CS252A	1-0-3-0-6	ESC101A CS251A	**Course Contents:** 1. System administration: Students will learn to setup and manage a network server including a web server andan email server. They should also be familiar with various network protocols. Further, students will be able toadminister different. components of the system by using various monitoring tools. They should also learn simpleloadbalancing tools.2. Security: While setting up different network and database servers, students will learn to manage the securityissues including different attacks. Public key infrastructure (PKI) is a good example of how to setup, manage,and distribute certicates that are issued as authorization tools. As part of maintaining sys terns, students willneed to use system vulnerability and intrusion testing tools as well.3. Compiler tools: Students will need to learn the various lowlevel tools used routinely in compilers including lexand yacc.4. Programming environment tools: For efcient programming, students are expected to use various integrateddevelopment environments (IDEs) such as eclipse and debuggers such as gdb. They should also use tools foreffective tagging and browsing of source code. Finally, they will learn to use the build tools that are necessaryfor large software projects. **References/Text Books:** 1. Manuals.2. Online help that is available for different tools.	COMPUTING LABORATORY II
CS300A	0-0-2-0-2		**Course Contents:** TECHNICAL COMMUNICATION **References/Text Books:**	TECHNICAL COMMUNICATION
CS315	3-0-0-0-4		**Course Contents:** Overview of file organisation techniques: sequential, direct, indexed, hashed,inverted, Btrees, Data models: relational, network, hierarchical, Relationalmodel: algebra, calculus, normal forms. Implementation of query languages,security and protection of data recovery methods, Concurrent operations ondata bases, introduction to distributed data base systems, case studies. **References/Text Books:** 1. H GarciaMolina, JD Ullman and Widom, Database Systems: The Complete Book,2nd Ed., PrenticeHall, 2008.2. A Silberschatz, H Korth and S Sudarshan, Database System Concepts, 6th Ed., McGrawHill, 2010.3. R Elmasri, S Navathe, Fundamentals of Database Systems, 6th edition, AddisonWesley, 2010.4. R Ramakrishnan, J Gehrke, Database Management Systems, 3rd Ed., McGrawHill, 2002.	PRINCIPLES OF DATA BASE SYSTEMS
CS315A	3-0-0-0-9	CS210A/ESO207A ESC101A	**Course Contents:** Overview of file organisation techniques: sequential, direct, indexed, hashed,inverted, Btrees, Data models: relational, network, hierarchical, Relationalmodel: algebra, calculus, normal forms. Implementation of query languages,security and protection of data recovery methods, Concurrent operations ondata bases, introduction to distributed data base systems, case studies. **References/Text Books:**	PRINCIPLES OF DATA BASE SYSTEMS

			1. H GarciaMolina, JD Ullman and Widom, Database Systems: The Complete Book,2nd Ed., PrenticeHall, 2008.2. A Silberschatz, H Korth and S Sudarshan, Database System Concepts, 6th Ed., McGrawHill, 2010.3. R Elmasri, S Navathe, Fundamentals of Database Systems, 6th edition, AddisonWesley, 2010.4. R Ramakrishnan, J Gehrke, Database Management Systems, 3rd Ed., McGrawHill, 2002.	
CS330	3-0-0-0-4		**Course Contents:** Introduction: Role of operating System; System Calls; Processes and ThreadsConcepts of Processes, Threads; Process Control BLock. CPU Scheduling: Examplesfrom contemporary OSes (UNIX and NT). InterProcess Communication MessagePassing, Mailboxes, Pipes; Examples from contemporary OSes (Unix and NT).Process Synchronization Critical Section Problem; Hardware Mechanism forsynchronization; Semaphores and Mutex objects; Classical Problems (ProducerConsumer, dining philosophers etc.); Monitors; Examples of synchronizationmechanisms such as from Java and Pthreads. Deadlocks and Detection,Prevention and avoidance mechanisms.Virtual Memory: Address binding process (compilation and linking); DynamicLinking; Segmentation; Paging Protection; Demand Paging; Page Replacementpolicies Thrashing, prepaging and other issues; swapping; examples fromcontemporary OSes (Linux, NT)Files and Directories: File organization in directories; File attributes; Operationson files; Directory attributes and operations on directories; Directory organizations;File and directory protections.File system implementation Concepts of mounting; Allocation mechanisms Contiguous, linked and indexed allocations; Free space management; caching;Examples of files systems from one or more of DOS, BSD, Linux, HPFSand NTFS;Device Drivers:Storage management Disk scheduling; Disk Management; Swapand swap management.Security and Protection Mechanisms: Password based protection; Encryptionand Decryption; System Threats Viruses, Wormholes, Trojan Horses etc. **References/Text Books:**	OPERATING SYSTEMS
CS330A	3-0-3-0-12	ESC101A,CS210A/ESO207A,CS220A	**Course Contents:** Introduction: Role of operating System; System Calls; Processes and ThreadsConcepts of Processes, Threads; Process Control BLock. CPU Scheduling: Examplesfrom contemporary OSes (UNIX and NT). InterProcess Communication MessagePassing, Mailboxes, Pipes; Examples from contemporary OSes (Unix and NT).Process Synchronization Critical Section Problem; Hardware Mechanism forsynchronization; Semaphores and Mutex objects; Classical Problems (ProducerConsumer, dining philosophers etc.); Monitors; Examples of synchronizationmechanisms such as from Java and Pthreads. Deadlocks and Detection,Prevention and avoidance mechanisms.Virtual Memory: Address binding process (compilation and linking); DynamicLinking; Segmentation; Paging Protection; Demand Paging; Page Replacementpolicies Thrashing, prepaging and other issues; swapping; examples fromcontemporary OSes (Linux, NT)Files and Directories: File organization in directories; File attributes; Operationson files; Directory attributes and operations on directories; Directory organizations;File and directory protections.File system implementation Concepts of mounting; Allocation mechanisms Contiguous, linked and indexed allocations; Free space management; caching;Examples of files systems from one or more of DOS, BSD, Linux, HPFSand NTFS;Device Drivers:Storage management Disk scheduling; Disk Management; Swapand swap management.Security and Protection Mechanisms: Password based protection; Encryptionand Decryption; System Threats Viruses, Wormholes, Trojan Horses etc. **References/Text Books:**	OPERATING SYSTEMS
CS335	3-0-4-0-5		**Course Contents:** Compiler structure: analysissynthesis model of compilation, various phasesof a compiler, tool based approach to compiler construction.Lexical analysis: interface with input, parser and symbol table, token, lexemeand patterns. Difficulties in lexical analysis. Error reporting. Implementation.Regular definition, Transition diagrams, LEX Syntax analysis: CFGs, ambiguity,associativity, precedence, top down parsing, recursive descent parsing,transformation on the grammars, predictive parsing, bottom up parsing, LRparsers (SLR, LALR, LR), YACC Syntax directed definitions: inherited and synthesized attributes, dependencygraph, evaluation order, bottom up and top down evaluation of attributes,L and Sattributed definitionsType	COMPILER DESIGN

			checking: type system, type expressions, structural and name equivalenceof types, type conversion, overloaded functions and operators, polymorphicfunctions, type checking in OO languagesRun time system: storage organization, activation tree, activation record,parameter passing, symbol table, dynamic storage allocation, garbage collectionIntermediate code generation: intermediate representations, translation ofdeclarations, assignments, control flow, boolean expressions and procedurecalls. Implementation issuesCode generation and instruction selection: issues, basic blocks and flow graphs,register allocation, code generation, DAG representation of programs, codegeneration from DAG, peep hole optimization, code generator generators,specifications of machineCode optimization: Introduction to Code optimization, dataflow analysis **References/Text Books:**	
CS335A	3-0-0-3-12	ESC101A CS210A CS220A CS340A	**Course Contents:** Compiler structure: analysissynthesis model of compilation, various phasesof a compiler, tool based approach to compiler construction.Lexical analysis: interface with input, parser and symbol table, token, lexemeand patterns. Difficulties in lexical analysis. Error reporting. Implementation.Regular definition, Transition diagrams, LEX Syntax analysis: CFGs, ambiguity,associativity, precedence, top down parsing, recursive descent parsing,transformation on the grammars, predictive parsing, bottom up parsing, LRparsers (SLR, LALR, LR), YACC Syntax directed definitions: inherited and synthesized attributes, dependencygraph, evaluation order, bottom up and top down evaluation of attributes,L and Sattributed definitionsType checking: type system, type expressions, structural and name equivalenceof types, type conversion, overloaded functions and operators, polymorphicfunctions, type checking in OO languagesRun time system: storage organization, activation tree, activation record,parameter passing, symbol table, dynamic storage allocation, garbage collectionIntermediate code generation: intermediate representations, translation ofdeclarations, assignments, control flow, boolean expressions and procedurecalls. Implementation issuesCode generation and instruction selection: issues, basic blocks and flow graphs,register allocation, code generation, DAG representation of programs, codegeneration from DAG, peep hole optimization, code generator generators,specifications of machineCode optimization: Introduction to Code optimization, dataflow analysis **References/Text Books:**	COMPILER DESIGN
CS340	3-0-0-0-4		**Course Contents:** Scope and motivation for theory of computation; informal introduction tocomputability and complexity; set membership problem as idealization ofcomputing problems; alphabets, strings, languages, automata; deterministicfinite automata; nondeterminism; equivalence of DFAs and NFAs; regularexpressions and their equivalence with finite automata; pumping lemma; someapplications of FAs (e.g., text pattern matching); decision properties of regularlanguages; MyhillNerode theorem; minimization of DFAs, Grammars as generativedevices; contextfree grammars, derivation, and parse trees; pushdown automata;equivalence with CFGs; normal forms of CFGs, pumping lemma for contextfreelanguages; decision and closure properties; some applications (e.g., YACC,markup languages, XML and document type definition, etc.), Why considerTuring machines?; basic TM model and its extensions; NDTMs, TM configurations;robustness of TM as a computing model; universal TM, Recursive and r.e.languages; notion of undecidability; undecidability of halting problem; reducibility;other undecidable problems; Rices theorem; separation of r.e. and recursivelanguages; existence of non r.e. languages; selfreference, recursion theorem;decidability of logical theories; implication to automated theorem proving,Motivation for examining feasibility/infeasibility distinction; definition of time and space complexity classes; P and NP, and their importance; polynomialtime reducibility; definition of NPcompleteness, and NPhardness; CookLevintheorem; some other NPcomplete problems, Brief review of the notion ofrandomized algorithms; probabilistic TMs; classes RP, BPP, and ZPP; relationshipsto P and NP; proof of inclusion of BPP in P/poly. **References/Text Books:**	THEORY OF COMPUTATION

CS340A	3-0-0-0-9	ESC101A,CS210A/ESO207A	**Course Contents:** Scope and motivation for theory of computation; informal introduction tocomputability and complexity; set membership problem as idealization ofcomputing problems; alphabets, strings, languages, automata; deterministicfinite automata; nondeterminism; equivalence of DFAs and NFAs; regularexpressions and their equivalence with finite automata; pumping lemma; someapplications of FAs (e.g., text pattern matching); decision properties of regularlanguages; MyhillNerode theorem; minimization of DFAs, Grammars as generativedevices; contextfree grammars, derivation, and parse trees; pushdown automata;equivalence with CFGs; normal forms of CFGs, pumping lemma for contextfreelanguages; decision and closure properties; some applications (e.g., YACC,markup languages, XML and document type definition, etc.), Why considerTuring machines?; basic TM model and its extensions; NDTMs, TM configurations;robustness of TM as a computing model; universal TM, Recursive and r.e.languages; notion of undecidability; undecidability of halting problem; reducibility;other undecidable problems; Rices theorem; separation of r.e. and recursivelanguages; existence of non r.e. languages; selfreference, recursion theorem;decidability of logical theories; implication to automated theorem proving,Motivation for examining feasibility/infeasibility distinction; definition of timeand space complexity classes; P and NP, and their importance; polynomialtime reducibility; definition of NPcompleteness, and NPhardness; CookLevintheorem; some other NPcomplete problems, Brief review of the notion ofrandomized algorithms; probabilistic TMs; classes RP, BPP, and ZPP; relationshipsto P and NP; proof of inclusion of BPP in P/poly. **References/Text Books:**	THEORY OF COMPUTATION
CS345	3-0-2-0-4		**Course Contents:** Max Flows: Max Flows (FordFulkerson and bipartite matching), Linear Algebra:LUP decomposition, inverting matrices, Fast Fourier Transform. Polynomialmultiplication, integer multiplication and division, Number Theoretic Algorithms:gcd, modulo arithmetic, Chinese remaindering, RSA, Linear Programming:formulation, simplex, primaldual, Geometric algorithms: convex hull, closestpair, intersection of line segments, polygon triangulation, Randomized Algorithms:identity testing, primality and mincut, Approximation Algorithms: maxcut,tsp, vertexcover etc, Backtracking, Other topics. These may include stringmatching,parallel algorithms, amortized analysis etc. **References/Text Books:**	ALGORITHMS-II
CS345A	3-0-0-0-9	ESC101A,CS210A/ESO207A	**Course Contents:** Max Flows: Max Flows (FordFulkerson and bipartite matching), Linear Algebra:LUP decomposition, inverting matrices, Fast Fourier Transform. Polynomialmultiplication, integer multiplication and division, Number Theoretic Algorithms:gcd, modulo arithmetic, Chinese remaindering, RSA, Linear Programming:formulation, simplex, primaldual, Geometric algorithms: convex hull, closestpair, intersection of line segments, polygon triangulation, Randomized Algorithms:identity testing, primality and mincut, Approximation Algorithms: maxcut,tsp, vertexcover etc, Backtracking, Other topics. These may include stringmatching,parallel algorithms, amortized analysis etc. **References/Text Books:**	ALGORITHMS -II
CS350	3-0-0-0-4		**Course Contents:** Brief history of development of programming languages, Introduction imperativeprogramming, functional programming, logic programming and object orientedprogramming, Values and types, Notion of variables, Lifetime of variableslocal,global and heap variables, Bindings and environments, bindables, scopeblockstructure, static and dynamic scoping, Abstraction procedural andfunction abstractions, Type systems monomorphic type systems. Introductionto polymorphism, Types of polymorphism overloading, parametric polymorphism,polymorphic types, Type checking and type inference inference rules formonomorphic types, introduction to polymorphic type inference, Functionalprogramming, Logic Programming, Object oriented programming.	PRINCIPLES OF PROGRAMMING LANGAUGES

			References/Text Books: 1. Martn Abadi, Luca Cardelli, A Theory of Objects, Springer 1996.2. Luca Cardelli, P Wegner, On Understanding Types, Data Abstraction and Polymorphism, ACM ComputingSurveys, 17{4), pp 471, 1985.3. M Hennessey, The Semantics of Programming Languages, John Wiley, 1990.4. J. LLoyd, Foundations of Logic Programming, Springer Verlag, 1984.5. L. C. Paulson, ML for the Working Programmer, 2nd Ed., Cambridge University Press, 1996.6. Benjamin C. Pierce, Types and programming languages, MIT Press, 2002.7. C. Reade, Elements of Functional Programming, Addison Wesley, 1989.8. P. van Roy and S. Haridi, Concepts, Techniques and Models of Computer Programming, MIT Press, 2004.9. Michael L Scott, Programming Language Pregmatics, 3rd Ed., Morgan Kaufmann, 2009	
CS350A	3-0-0-0-9	CS210A/ESO207A	**Course Contents:** Brief history of development of programming languages, Introduction imperativeprogramming, functional programming, logic programming and object orientedprogramming, Values and types, Notion of variables, Lifetime of variableslocal,global and heap variables, Bindings and environments, bindables, scopeblockstructure, static and dynamic scoping, Abstraction procedural andfunction abstractions, Type systems monomorphic type systems. Introductionto polymorphism, Types of polymorphism overloading, parametric polymorphism,polymorphic types, Type checking and type inference inference rules formonomorphic types, introduction to polymorphic type inference, Functionalprogramming, Logic Programming, Object oriented programming. **References/Text Books:**	PRINCIPLES OF PROGRAMMING LANGAUGES
CS355	1-0-4-0-4		**Course Contents:** Software management tools, CVS, Scripting tools, GUI programming tools,Language processing tools, Web programming tools. **References/Text Books:**	PROGRAMMING TOOLS AND TECHNIQUES
CS360	3-0-0-0-4		**Course Contents:** Introduction to Picture Synthesis and Analysis. Conceptual Framework of anInteractive Graphical Simulation System, Graphics hardware. Basic RasterGraphics Algorithms. Introduction to Simple Raster, Graphics Package (SRGP),Graphics Entities. Geometric Transformations. Object hierarchy. Segmentation.Interaction Techniques, Geometric Modeling in 3D. Viewing in 3D. Concept of Synthetic Camera. Dialogue Design. Graphics User Interfaces. WindowingSystems Graphi cal Modeling of Discrete events. Simulation of Discrete EventDisplays. Animation Techniques. Basic Rules for Animation. Graphical Simulationof continuous motion. Role of Virtual Reality in Graphical Simulation. **References/Text Books:**	INTRODUCTION TO COMPUTER GRAPHICS
CS360A	3-0-0-0-9		**Course Contents:** Introduction to Picture Synthesis and Analysis. Conceptual Framework of anInteractive Graphical Simulation System, Graphics hardware. Basic RasterGraphics Algorithms. Introduction to Simple Raster, Graphics Package (SRGP),Graphics Entities. Geometric Transformations. Object hierarchy. Segmentation.Interaction Techniques, Geometric Modeling in 3D. Viewing in 3D. Concept of Synthetic Camera. Dialogue Design. Graphics User Interfaces. WindowingSystems Graphi cal Modeling of Discrete events. Simulation of Discrete EventDisplays. Animation Techniques. Basic Rules for Animation. Graphical Simulationof continuous motion. Role of Virtual Reality in Graphical Simulation. **References/Text Books:**	INTRODUCTION TO COMPUTER GRAPHICS
CS365	3-0-0--4	ESO211/CS210	**Course Contents:** Introduction to AI. Agents and environments. Problem solving by search;uninformed search, informed ("heuristic") search, constrained satisfactionproblems, adversarial search, Knowledge representation and	ARTIFICIAL INTELLIGENCE PROGRAMMING

			reasoning; rulebased representations, logical formalisms, frames or object oriented systems,network based approaches and mixed representations. Theoremproving. Knowledgebases and expert systems. Overview of LISP and PROLOG. Reasoning in uncertainenvironments. Planning communication and multiagent systems. Learning Vision,NLP. **References/Text Books:** 1. Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Ed., Prentice Hall, 2009. Can alsouse 2nd Ed., Pearson Education International, 2003.2. Nils Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann, 1998.3. David Poole, Alan Mackworth, Artificial Intelligence: Foundations for Computational Agents, Cambridge Univ.Press, 2010.	
CS365A	3-0-0-0-9	ESO207A/CS210A	**Course Contents:** Introduction to AI. Agents and environments. Problem solving by search;uninformed search, informed ("heuristic") search, constrained satisfactionproblems, adversarial search, Knowledge representation and reasoning; rulebased representations, logical formalisms, frames or object oriented systems,network based approaches and mixed representations. Theoremproving. Knowledgebases and expert systems. Overview of LISP and PROLOG. Reasoning in uncertainenvironments. Planning communication and multiagent systems. Learning Vision,NLP. **References/Text Books:** 1. Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, 3rd Ed., Prentice Hall, 2009. Can alsouse 2nd Ed., Pearson Education International, 2003.2. Nils Nilsson, Artificial Intelligence: A New Synthesis, Morgan Kaufmann, 1998.3. David Poole, Alan Mackworth, Artificial Intelligence: Foundations for Computational Agents, Cambridge Univ.Press, 2010.	ARTIFICIAL INTELLIGENCE PROGRAMMING
CS395A	0-0-0-0-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UG PROJECT (UGP-I)
CS396A	0-0-0-0-9		**Course Contents:** UG PROJECT (UGPII) **References/Text Books:**	UG PROJECT (UGP-II)
CS397	0-0-0--4		**Course Contents:** This course is meant for a 3rd year BTech (CSE) student to study a topicof their interest, somewhat independently. A student may also carry out aproject in this course. In this course, there will be a faculty member associatedwith each student whose responsibility will be to suggest reading material,hold discussion sessions, monitor the progress of the student, examine thestudent, and give a grade at the end of the semester. **References/Text Books:**	SPECIAL TOPICS IN COMPUTER SCIENCE
CS422	3-0-0-0-4		**Course Contents:** Introduction: Overview of Computer Architecture, Performance evaluation ofprocessors, Pipelining, Superpipelines, Advanced pipelines, static and dynamicscheduling, Instruction level parallelism, loop unrolling, VLIW and Super scalarprocessors, Vector processing and array processing, Memory: bandwidth issues,memory organization, cache coherence, Symmetric multiprocessors (SMP),NUMAMPs, Massively parallel processors, Cache coherence protocols,Interconnection networks, I/O processing, parallel programming, Examples ofcontemporary architectures, AS (Reliability, Availability, Scalability) features. **References/Text Books:** 1. JL Hennessy, DA Patterson, Computer Architecture: A Quantitative Approach, 4th Ed., Morgan	COMPUTER ARCHITECTURE

			Kaufmann/ElsevierIndia, 2006.	
CS422A	3-0-0-0-9	CS220A	**Course Contents:** Introduction: Overview of Computer Architecture, Performance evaluation ofprocessors, Pipelining, Superpipelines, Advanced pipelines, static and dynamicscheduling, Instruction level parallelism, loop unrolling, VLIW and Super scalarprocessors, Vector processing and array processing, Memory: bandwidth issues,memory organization, cache coherence, Symmetric multiprocessors (SMP),NUMAMPs, Massively parallel processors, Cache coherence protocols,Interconnection networks, I/O processing, parallel programming, Examples ofcontemporary architectures, AS (Reliability, Availability, Scalability) features. **References/Text Books:** 1. JL Hennessy, DA Patterson, Computer Architecture: A Quantitative Approach, 4th Ed., Morgan Kaufmann/ElsevierIndia, 2006.	COMPUTER ARCHITECTURE
CS425	3-0-0-0-4		**Course Contents:** Introduction: Advantages of computer networks, LAN vs. WAN, ISO/OSI sevenlayerarchitecture, networks topologies, Physical Layer: transmission media,data encoding, Data Link Layer: Framing, Error detection and correction,Stopandwait protocol, Sliding window protocols, MAC Layer: Aloha protocols,CSMA/CD; Ethernet. Other examples of MAC protocols, Network Layer: Internetworking Tunneling, Encapsulation, Fragmentation. Internet Protocol (IP)Header structure, addresses, options, etc. Routing Algorithms and Routing protocols. Other related protocols, for example, ICMP, ARP, RARP, BOOTP, DHCP,Transport Layer: Transmission Control Protocol header, services, connectionmanagement, congestion control, sliding window, timers. User Datagram Protocol.Domain Name Service, Unix network programming, socket abstraction. clientserverarchitecture, Session, Presentation, Application Layers. Example protocols:Email (SMTP), Telnet, FTP, etc. **References/Text Books:** 1. AS Tanenbaum, DJ Wetherall, Computer Networks, 5th Ed., PrenticeHall, 2010.2. LL Peterson, BS Davie, Computer Networks: A Systems Approach, 5th Ed., MorganKauffman, 2011.3. JF Kurose, KW Ross, Computer Networking: A TopDownApproach, 5th Ed., AddisonWesley, 2009.4. W Stallings, Cryptography and Network Security, Principles and Practice, 5th Ed., PrenticeHall, 2010	COMPUTER NETWORKS
CS425A	3-0-0-0-9	ESC101A CS210A/ESO207A	**Course Contents:** Introduction: Advantages of computer networks, LAN vs. WAN, ISO/OSI sevenlayerarchitecture, networks topologies, Physical Layer: transmission media,data encoding, Data Link Layer: Framing, Error detection and correction,Stopandwait protocol, Sliding window protocols, MAC Layer: Aloha protocols,CSMA/CD; Ethernet. Other examples of MAC protocols, Network Layer: Internetworking Tunneling, Encapsulation, Fragmentation. Internet Protocol (IP)Header structure, addresses, options, etc. Routing Algorithms and Routing protocols. Other related protocols, for example, ICMP, ARP, RARP, BOOTP, DHCP,Transport Layer: Transmission Control Protocol header, services, connectionmanagement, congestion control, sliding window, timers. User Datagram Protocol.Domain Name Service, Unix network programming, socket abstraction. clientserverarchitecture, Session, Presentation, Application Layers. Example protocols:Email (SMTP), Telnet, FTP, etc. **References/Text Books:** Course Reference : 1. AS Tanenbaum, DJ Wetherall, Computer Networks, 5th Ed., PrenticeHall, 2010.2. LL Peterson, BS Davie, Computer Networks: A Systems Approach, 5th Ed., MorganKauffman, 2011.3. JF Kurose, KW Ross, Computer Networking: A TopDownApproach, 5th Ed., AddisonWesley, 2009.4. W Stallings, Cryptography and Network Security, Principles and Practice, 5th Ed., PrenticeHall, 2010	COMPUTER NETWORKS
CS433	3-0-0-0-4	ESC101N,CS220,CS330,ESO211	**Course Contents:** 1. Introduction: Why parallel computing; Ubiquity of parallel hardware/multicores; Processes and threads; Programming models: shared memory and message passing; Speedup and efciency; Amdahls Law.2.	PARALLEL PROGRAMMING

			Introduction to parallel hardware: Multicores and multiprocessors; shared memory and message passing architectures; cache hierarchy and coherence; sequential consistency.3. Introduction to parallel software: Steps involved in developing a parallel program; Depen dence analysis; Domain deco:rriposition; Task assignment: static and dynamic; Performance issues: 4C cache misses, inherent and artifactual comm'tmication, false sharing, computationtocommunication ratio as a guiding metric for decomposition,hot spots and staggered communication.4. Shared memory parallel programming: Synchronization: Locks and barriers; Hardware primitives for efcient lock implementation; Lock al gorithms; Relaxed consistency models; Highlevel language memory models (such Java and/or C++); Memory fences. Developing parallel programs with UNIX fork model: !PC with shared memory and message pass ing; UNIX semaphore and its aliornone semantic. Example case studies (see note below for some details). Developing parallel programs with POSIX thread library: Thread creation; Thread join; Mutex; Condition variables. Example case studies (see note below for some details). Developing parallel programs with OpenMP directives: Parallel for; Parallel section; Static, dy namic, guided, and runtime scheduling; Critical sections and atomic operations; Barriers; Reduction. Example case studies (see note below for some details).5. Message passing programming: Distributed memory model; Introduction to message passing interface (MPI); Synchronization as Send/Recv pair; Synchronous and asynchronous SendfRecv; Collective communication: Reduce, Broadcast, Data distribution, Scatter, Gather; MPI derived data types. Example case studies (see note below for some details). **References/Text Books:** Notes:1. The example case studies should be chosen to cover a wide variety of parallel algorithms drawn from nu meric aswell as nonnumeric domains. Possibilities include parallel sort, parallel prex, parallel search, graph algorithms,parallel ranking, reduction, algorithms using tree, fan, pipe paradigms, matrix computa tion, equation solvers,nbody simulation, ray tracing, etc.2. The instruction must accompany an adequate number of programming assignments demonstrating the con,cepts.3. The instructors are encouraged to offer large semesterlong programming projects.	
CS433A	3-0-0-0-9	ESC101A,CS210A,CS220A,CS330A	**Course Contents:** 1. Introduction: Why parallel computing; Ubiquity of parallel hardware/multicores; Processes and threads; Programming models: shared memory and message passing; Speedup and efciency; Amdahls Law.2. Introduction to parallel hardware: Multicores and multiprocessors; shared memory and message passing architectures; cache hierarchy and coherence; sequential consistency.3. Introduction to parallel software: Steps involved in developing a parallel program; Depen dence analysis; Domain deco:rriposition; Task assignment: static and dynamic; Performance issues: 4C cache misses, inherent and artifactual comm'tmication, false sharing, computationtocommunication ratio as a guiding metric for decomposition,hot spots and staggered communication.4. Shared memory parallel programming: Synchronization: Locks and barriers; Hardware primitives for efcient lock implementation; Lock al gorithms; Relaxed consistency models; Highlevel language memory models (such Java and/or C++); Memory fences. Developing parallel programs with UNIX fork model: !PC with shared memory and message pass ing; UNIX semaphore and its aliornone semantic. Example case studies (see note below for some details). Developing parallel programs with POSIX thread library: Thread creation; Thread join; Mutex; Condition variables. Example case studies (see note below for some details). Developing parallel programs with OpenMP directives: Parallel for; Parallel section; Static, dy namic, guided, and runtime scheduling; Critical sections and atomic operations; Barriers; Reduction. Example case studies (see note below for some details).5. Message passing programming: Distributed memory model; Introduction to message passing interface (MPI); Synchronization as Send/Recv pair; Synchronous and asynchronous SendfRecv; Collective communication: Reduce, Broadcast, Data distribution, Scatter, Gather; MPI derived data types. Example case studies (see note below for some details). **References/Text Books:** Notes:1. The example case studies should be chosen to cover a wide variety of parallel algorithms drawn from nu meric aswell as nonnumeric domains. Possibilities include parallel sort, parallel prex, parallel search, graph algorithms,parallel ranking, reduction, algorithms using tree, fan, pipe paradigms, matrix computa tion,	PARALLEL PROGRAMMING

			equation solvers,nbody simulation, ray tracing, etc.2. The instruction must accompany an adequate number of programming assignments demonstrating the con,cepts.3. The instructors are encouraged to offer large semesterlong programming projects.	
CS455	3-0-0-0-4		**Course Contents:** Introduction industrial strength software, problem of software development,problem of scale, basic processbased approach, etc. Software Process Models concept of processes, ETVX model for process specification, different processmodels and when they are useful, Requirement analysis and specification the basic problem, the sub phases in the phase, analysis techniques (structuredanalysis), specification, validation, function point analysis, Project planning effort, schedule, quality, project monitoring, and basic CM, Design principlesand structured design methodology partitioning, top down and bottomup,stepwise refinement, coupling and cohesion, Coding style, structuredprogramming, verification concepts. Testing testing purpose, levels of testing,black box testing, white box testing, different test case generation approaches,Other topics object oriented, metrics, standards, industrial practices. **References/Text Books:** 1. Ian Somerville, Software Engineering, 9th Ed., Pearson, 2010.2. C Ghezzi, M Jazayeri, D Mandrioli, FUndamentals of Software Engineering, 2nd Ed., PrenticeHall, 2002.3. RN Taylor, N Medvidovic, EM Dashofy, Software Architecture: Foundations, Theory and Practice, John Wiley,2009.4. R Jhala, R Majumdar, Software Model Checking, ACM Computing Surveys, 41{4), Article 21, 2009.5. AV Aho, MS Lam, R Sethi, JD Ullman, Compiler Design: Principles, Techniques and Tools, 2nd Ed., PrenticeHall,2006	INTRODUCTION TO SOFTWARE ENGINEERING
CS455A	3-0-0-0-9	CS210A CS202A	**Course Contents:** Introduction industrial strength software, problem of software development,problem of scale, basic processbased approach, etc. Software Process Models concept of processes, ETVX model for process specification, different processmodels and when they are useful, Requirement analysis and specification the basic problem, the sub phases in the phase, analysis techniques (structuredanalysis), specification, validation, function point analysis, Project planning effort, schedule, quality, project monitoring, and basic CM, Design principlesand structured design methodology partitioning, top down and bottomup,stepwise refinement, coupling and cohesion, Coding style, structuredprogramming, verification concepts. Testing testing purpose, levels of testing,black box testing, white box testing, different test case generation approaches,Other topics object oriented, metrics, standards, industrial practices. **References/Text Books:** 1. Ian Somerville, Software Engineering, 9th Ed., Pearson, 2010.2. C Ghezzi, M Jazayeri, D Mandrioli, FUndamentals of Software Engineering, 2nd Ed., PrenticeHall, 2002.3. RN Taylor, N Medvidovic, EM Dashofy, Software Architecture: Foundations, Theory and Practice, John Wiley,2009.4. R Jhala, R Majumdar, Software Model Checking, ACM Computing Surveys, 41{4), Article 21, 2009.5. AV Aho, MS Lam, R Sethi, JD Ullman, Compiler Design: Principles, Techniques and Tools, 2nd Ed., PrenticeHall,2006	INTRODUCTION TO SOFTWARE ENGINEERING
CS498	0-0-12-0-4		**Course Contents:** B TECH PROJECT **References/Text Books:**	B TECH PROJECT
CS498A	0-0-0--9		**Course Contents:** UG PROJECT (UGPIII) **References/Text Books:**	UNDER GRADUATE PROJECT-III
CS499	0-0-12-0-4		**Course Contents:** B TECH PROJECT	B TECH PROJECT

			References/Text Books:	
CS499.	0-0-0--4		**Course Contents:** B TECH PROJECT **References/Text Books:**	B. TECH PROJECT
CS601	3-0-0-0-4		**Course Contents:** Programming utilities, lab exercise for developing large system and applicationprograms. **References/Text Books:**	MATHEMATICS FOR COMPUTER SCIENCE
CS601A	3-0-0-0-9		**Course Contents:** Programming utilities, lab exercise for developing large system and applicationprograms. **References/Text Books:**	MATHEMATICS FOR COMPUTER SCIENCE
CS602	3-0-0-0-4		**Course Contents:** Basic concepts of operating systems, compilers, and data base managementsystems. **References/Text Books:**	DESIGN AND ANALYSIS OF ALGORITHMS
CS602A	3-0-0-0-9		**Course Contents:** Basic concepts of operating systems, compilers, and data base managementsystems. **References/Text Books:**	DESIGN AND ANALYSIS OF ALGORITHMS
CS618	3-0-0-0-4		**Course Contents:** Index structures Rtree, Mtree, VAfile, etc., Spacepartitioning versus datapartitioningmethods; Similarity queries Range search, kNN search, Selfjoin;Retrieval techniques Fagin's Algorithm, Threshold Algorithm, ProbabilisticFagin's; Vector Space embedding, properties; Dimensionality reduction SVD,PCA, FastMap, Wavelets, Fourier transform, etc.; Distance measures Lpnorm, Mahalanobis distance, KullbackLeibler divergence measure, Earth Mover'sDistance, etc.; Data compression Wavelets, Fourier, Voptimal histograms; **References/Text Books:**	INDEXING AND SEARCHING TECHNIQUES IN DATABASE
CS618A	3-0-0-0-9		**Course Contents:** Index structures Rtree, Mtree, VAfile, etc., Spacepartitioning versus datapartitioningmethods; Similarity queries Range search, kNN search, Selfjoin;Retrieval techniques Fagin's Algorithm, Threshold Algorithm, ProbabilisticFagin's; Vector Space embedding, properties; Dimensionality reduction SVD,PCA, FastMap, Wavelets, Fourier transform, etc.; Distance measures Lpnorm, Mahalanobis distance, KullbackLeibler divergence measure, Earth Mover'sDistance, etc.; Data compression Wavelets, Fourier, Voptimal histograms; **References/Text Books:**	INDEXING AND SEARCHING TECHNIQUES IN DATABASE
CS622	3-0-0--4		**Course Contents:** Singlethreaded execution, traditional microprocessors, DLP, ILP, TLP, memorywall, Parallel programming and performance issues, Shared memorymultiprocessors, Synchronization, smallscale symmetric multiprocessors on asnoopy bus, cache coherence on snoopy buses, Scalable multiprocessors,Directorybased cache coherence, Interconnection network, Memory consistencymodels, Software distributed shared memory, multithreading in hardware, Chipmultiprocessing, Current research and future trends. **References/Text Books:**	ADVANCED COMPUTER ARCHITECTURE

CS624	3-0-0--4	#	**Course Contents:** Current topics in the design, specifications and analysis of embedded systems.Contemporary topics such as specifications of embedded systems, analysisof embedded systems, interface to the realtime operating systems, designcase studies, design methodologies, etc. Other topics may include verificationof embedded systems like formal verification, cosimulation, etc., estimationof hardware and software costs, partitioning, synthesis (hardware, software,memory, bus), retargetable usage of the software, specification and verificationof the OS schedules, hard and soft realtime operating systems, and faulttolerant systems. **References/Text Books:**	TOPICS IN EMBEDED SYSTEMS
CS625	3-0-0--4		**Course Contents:** Introduction: Overview of computer networks, sevenlayer architecture, TCP/IP suite of protocols, etc. MAC protocols for highspeed LANs, MANs, andwireless LANs. (for example, FDDI, DQDB, HIPPI, Gigabit Ethernet, Wirelessethernet, etc.) Fast access technologies. (For example, ADSL, Cable Modem,etc.) ATM Networks. ATM layer. ATM Adaptation Layers. Congestion control.Signalling, Routing, QoS support, Neighbourdisconery, Autoconfiguration. Changesto other protocols. Application Programming Interface for IPv6. Mobility in networks. Mobile IP. Security related issues. IP Multicasting. Multicast routingprotocols, adderss assignments, session discovery, etc. TCP extensions forhighspeed networks, transactionoriented applications. Other new optionsin TCP. Network security at various layers. SecureHTTP, SSL, ESP, Authenticationheader, Key distribution protocols. Digital signatures, digital certificates. **References/Text Books:**	ADVANCED COMPUTER NETWORKS
CS625A	3-0-0-0-9		**Course Contents:** Introduction: Overview of computer networks, sevenlayer architecture, TCP/IP suite of protocols, etc. MAC protocols for highspeed LANs, MANs, andwireless LANs. (for example, FDDI, DQDB, HIPPI, Gigabit Ethernet, Wirelessethernet, etc.) Fast access technologies. (For example, ADSL, Cable Modem,etc.) ATM Networks. ATM layer. ATM Adaptation Layers. Congestion control.Signalling, Routing, QoS support, Neighbourdisconery, Autoconfiguration. Changesto other protocols. Application Programming Interface for IPv6. Mobility in networks. Mobile IP. Security related issues. IP Multicasting. Multicast routingprotocols, adderss assignments, session discovery, etc. TCP extensions forhighspeed networks, transactionoriented applications. Other new optionsin TCP. Network security at various layers. SecureHTTP, SSL, ESP, Authenticationheader, Key distribution protocols. Digital signatures, digital certificates. **References/Text Books:**	ADVANCED COMPUTER NETWORKS
CS628	3-0-0--4		**Course Contents:** Introduction: need and basic goals for computer security, security threatsetc.Cryptographic building blocks: Symmetric and asymmetric key cryptography,cryptographic hash functions, digital signature schemes etc., with representativeapplications for each. Operating System Security: Lowlevel protectionmechanisms, access control: models for access control, some confidentiality,integrity, and hybrid models of access control such as BellLa Padula, Biba,Chinese Wall etc., discretionary v/s mandatory access control.Case studies: Java access control policy specifications, SELinux security modeland implementation. Program flaws: Bugs which have security implicationssuch as buffer overflows, race conditions etc. Malicious code: Viruses, worms,Trojan horses; how they work and how to defend against them.Network Security: problems in network security; kinds of attacks, PKI, keyexchange protocols, example protocols such as PGP, Kerberos, IPSEC/VPN,SSL, S/MIME etc. Protocol vulnerabilities: examples of protocol vulnerabilitiessuch as in TCP/IP, denial of service attacks etc. Tools for network securitysuch as firewalls and intrusion detection systems.References **References/Text Books:**	COMPUTER SYSTEMS SECURITY
CS628A	3-0-0-0-9		**Course Contents:** Introduction: need and basic goals for computer security, security threatsetc.Cryptographic building blocks:	COMPUTER SYSTEMS SECURITY

			Symmetric and asymmetric key cryptography,cryptographic hash functions, digital signature schemes etc., with representativeapplications for each. Operating System Security: Lowlevel protectionmechanisms, access control: models for access control, some confidentiality,integrity, and hybrid models of access control such as BellLa Padula, Biba,Chinese Wall etc., discretionary v/s mandatory access control.Case studies: Java access control policy specifications, SELinux security modeland implementation. Program flaws: Bugs which have security implicationssuch as buffer overflows, race conditions etc. Malicious code: Viruses, worms,Trojan horses; how they work and how to defend against them.Network Security: problems in network security; kinds of attacks, PKI, keyexchange protocols, example protocols such as PGP, Kerberos, IPSEC/VPN,SSL, S/MIME etc. Protocol vulnerabilities: examples of protocol vulnerabilitiessuch as in TCP/IP, denial of service attacks etc. Tools for network securitysuch as firewalls and intrusion detection systems.References **References/Text Books:**	
CS632	3-0-0--4		**Course Contents:** Local area networks, concurrency control and recovery, distributed languagesand communication primitives, file servers, case studies of distributed systems. **References/Text Books:**	TOPICS IN DISTRIBUTED SYSTEMS
CS632A	3-0-0-0-9		**Course Contents:** Local area networks, concurrency control and recovery, distributed languagesand communication primitives, file servers, case studies of distributed systems. **References/Text Books:**	TOPICS IN DISTRIBUTED SYSTEMS
CS633	3----4		**Course Contents:** Introduction: Paradigms of parallel computing: Synchronous vector/array,SIMD, Systolic; Asynchronous MIMD, reduction paradigm. Hardware taxonomy:Flynns classifications, Handlers classifications. Software taxonomy: Kungstaxonomy, SPMD. Abstract parallel computational models: Combinational circuits,Sorting network, PRAM models, Interconnection RAMs. Parallelism approaches data parallelism, control parallelism. Performance Metrics: Laws governingperformance measurements. Metrics speedups, efficiency, utilization,communication overheads, single/multiple program performances, bench marks.Parallel Processors: Taxonomy and topologyshared memory mutliprocessors,distributed memory networks. Processor organization Static and dynamicinterconnections. Embeddings and simulations. Parallel Programming: Sharedmemory programming, distributed memory programming, object orientedprogramming, data parallel programming, functional and dataflow programming.Scheduling and Parallelization: Scheduling parallel programs. Loop scheduling.Parallelization of sequential programs. Parallel programming support environments. **References/Text Books:**	PARALLEL COMPUTING
CS634	3-0-0-0-4		**Course Contents:** Introduction: Mobile computing a vision for future, ubiquitous computing versusvirtual reality, software models for mobile computing. Data managementIssues. Distributed algorithms and mobility: structuring distributed algorithmsfor mobile computing environments, token ring algorithm. Publishing andaccessing data in the air: pull and push based data transfers, data disseminationby broadcast, treating air as cache, energy efficient indexing in air. Handoffmanagement: handoff detection, failures, channel assignments. LocationManagement: twotier HLRVLR scheme, mobile IP, hierarchical tree basedscheme, regional directories, distributed location management. Approximatequery processing: concept hierarchy, summary database, updates and viewmaintenance, approximate query processing. Mobile Transaction Models. MobileComputing: technological prospective: 1G, 2G and 3G network and services,the Internet, mobile computing and cellular telephony, voice and data serviceson 3G networks, battery problem and power dissipation, low energy processors.File system support for mobile computing: Coda and Bayou file	MOBILE COMPUTING

			systems.Adhoc network routing protocols: DSDV, GSR, FSR, DSR, AODV. **References/Text Books:**	
CS634A	3-0-0-0-9		**Course Contents:** Introduction: Mobile computing a vision for future, ubiquitous computing versusvirtual reality, software models for mobile computing. Data managementIssues. Distributed algorithms and mobility: structuring distributed algorithmsfor mobile computing environments, token ring algorithm. Publishing andaccessing data in the air: pull and push based data transfers, data disseminationby broadcast, treating air as cache, energy efficient indexing in air. Handoffmanagement: handoff detection, failures, channel assignments. LocationManagement: twotier HLRVLR scheme, mobile IP, hierarchical tree basedscheme, regional directories, distributed location management. Approximatequery processing: concept hierarchy, summary database, updates and viewmaintenance, approximate query processing. Mobile Transaction Models. MobileComputing: technological prospective: 1G, 2G and 3G network and services,the Internet, mobile computing and cellular telephony, voice and data serviceson 3G networks, battery problem and power dissipation, low energy processors.File system support for mobile computing: Coda and Bayou file systems.Adhoc network routing protocols: DSDV, GSR, FSR, DSR, AODV. **References/Text Books:**	MOBILE COMPUTING
CS639	3-0-0-0-4		**Course Contents:** Data flow Analysis; Interprocedural Analysis: functional, call string and graph reachability based approaches Abstract Interpretation; Weakest Precondition, Floyd Hoare Logic, Separation Logic; Software Model Checking: symbolic execution, state space reduction, state less model checking, counter example guided abstraction refinement, model checking of concurrent programs, Program Testing: program testing basics, automatic test case generation, directed testing. **References/Text Books:** 1. Edsger Wybe Dijkstra. A Discipline of Programming. Prentice Hall PTR, Upper Saddle River, NJ, USA, 1997. 2. David Gries. The Science of Programming. SpringerVerlag New York, Inc., Secaucus, NJ, USA, 1987. 3. S. S. Muchnick and N. D. Jones, editors. Program Flow Analysis: Theory and Applications. PrenticeHall: Englewood Cliffs, NJ, 1981. 4. Flemming Nielson, Hanne R. Nielson, and Chris Hankin. Principles of Program Analysis. SpringerVerlag New York, Inc., Secaucus, NJ, USA, 1999. 5. Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman. Compilers: Principles, Techniques, and Tools (2nd Edition). AddisonWesley Longman Publishing Co., Inc., Boston, MA, USA, 2006. 6. Michael Huth and Mark Ryan. Logic in Computer Science: Modelling and Reasoning about Systems. Cambridge University Press, New York, NY, USA, 2004. 7. Edmund M. Clarke, Jr., Orna Grumberg, and Doron A. Peled. Model checking. MIT Press, Cambridge, MA, USA, 1999.	PROGRAM ANALYSIS, VERIFICATION AND TESTING
CS639A	3-0-0-0-9	CS201A/CS210A/CS340A	**Course Contents:** Data flow Analysis; Interprocedural Analysis: functional, call string and graph reachability based approaches Abstract Interpretation; Weakest Precondition, Floyd Hoare Logic, Separation Logic; Software Model Checking: symbolic execution, state space reduction, state less model checking, counter example guided abstraction refinement, model checking of concurrent programs, Program Testing: program testing basics, automatic test case generation, directed testing. **References/Text Books:** 1. Edsger Wybe Dijkstra. A Discipline of Programming. Prentice Hall PTR, Upper Saddle River, NJ, USA, 1997. 2. David Gries. The Science of Programming. SpringerVerlag New York, Inc., Secaucus, NJ, USA, 1987. 3. S. S. Muchnick and N. D. Jones, editors. Program Flow Analysis: Theory and Applications. PrenticeHall: Englewood Cliffs, NJ, 1981. 4. Flemming Nielson, Hanne R. Nielson, and Chris Hankin. Principles of Program Analysis. SpringerVerlag New York, Inc., Secaucus, NJ, USA, 1999. 5. Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman. Compilers: Principles, Techniques, and Tools (2nd	PROGRAM ANALYSIS, VERIFICATION AND TESTING

			Edition). AddisonWesley Longman Publishing Co., Inc., Boston, MA, USA, 2006. 6. Michael Huth and Mark Ryan. Logic in Computer Science: Modelling and Reasoning about Systems. Cambridge University Press, New York, NY, USA, 2004. 7. Edmund M. Clarke, Jr., Orna Grumberg, and Doron A. Peled. Model checking. MIT Press, Cambridge, MA, USA, 1999.	
CS640	3-0-0--4	#	**Course Contents:** Complexity Classes. NP and coNP, Results on structure of NPcomplete sets,Sparse NPhard sets, Basic Inclusions and Separations, Nondeterministic SpaceClasses, Logarithmic Space, A PSPACE complete problem, Polynomial Hierarchy,PH through Alternating Quantifiers, Universal Relations, Probabilistic Classes,SchwartzZippel Lemma and BPP, BPP and its relationship with other ComplexityClasses **References/Text Books:**	COMPUTATIONAL COMPLEXITY
CS640A	3-0-0-0-9		**Course Contents:** Introduction to Computational Complexity. Complexity Classes. P and NPcompleteness. Hierarchy Theorems. Space Complexity. NL completeness. Savitchs Theorem. ImmermanSzelepsćenyi Theorem Polynomial Hierarchy. Alternating Turing Machines. TimeSpace Tradeofffor SAT. Circuit Complexity. Polynomial sized circuits. Uniformity. Circuitclasses NC and AC. Randomized Computations. RP, BPP, ZPP. Relationship between BPP and otherclasses. Randomized space complexity. Interactive Proofs. Various protocols. IP PSPACE. Quantum Computation. The class BQP. Grovers search algorithm. Introduction to PCP and Hardness of Approximation. NP ⊆ PCP(poly(n), 1) Communication Complexity. Definition and lower bound techniques. Circuit Lower Bounds. Lower bounds on AC0. Counting Complexity. The class #P. Todas Theorem. Tentative Topics (depending on availability of time). HardnessAmplification and Error Correcting Codes. Derandomization. Average case complexity. **References/Text Books:**	COMPUTATIONAL COMPLEXITY
CS641	3-0-0--4		**Course Contents:** Basics of finite fields. Private and Publickey cryptography, existing cryptosystemsand their security. Cryptanalysis of existing systems. Zeroknowledge protocols,Oneway functions. Advanced protocols for different applications, e.g. echeque,ecash etc. Network and System level security issues. **References/Text Books:**	MODERN CRYPTOLOGY
CS641A	3-0-0-0-9		**Course Contents:** Basics of finite fields. Private and Publickey cryptography, existing cryptosystemsand their security. Cryptanalysis of existing systems. Zeroknowledge protocols,Oneway functions. Advanced protocols for different applications, e.g. echeque,ecash etc. Network and System level security issues. **References/Text Books:**	MODERN CRYPTOLOGY
CS642	3-0-0--4		**Course Contents:** The course aims at a comprehensive overview of results on the circuit complexityclasses and their relationship with the Turing based classes. The topicsto be covered in the course are as follows: The class NC and its properties.Characterization of class P by circuits. The classes DLOG, NLOG, LogCFLand their properties. The class SC, proof of the relationship RL is a subsetof SC. The class NC1 and its characterizations. The class TC0 and itscharacterizations. The class ACC and its characterizations. The class AC0and its charecterizations. Lower bounds for AC0, for AC0[m] where m isa prime power and for TC02. **References/Text Books:**	CIRCUIT COMPLEXITY THEORY
CS644	3-0-0--4		**Course Contents:** Finite automata on infinite words and trees: Complementation, determinizationand algorithms for checking	FINITE AUTOMATA ON INFINITE INPUTS

			emptiness.Connections with logic: Finite automata and monadic second order (MSO)logic on words and trees. Decidability of MSO theory of various infinite graphs,methods of interpretation and unfolding.Applications: Decision procedures for temporal logics. Modelling, verificationand synthesis of systems. Effective theory of infinite games. **References/Text Books:**	
CS644A	3-0-0-0-9		**Course Contents:** Finite automata on infinite words and trees: Complementation, determinizationand algorithms for checking emptiness.Connections with logic: Finite automata and monadic second order (MSO)logic on words and trees. Decidability of MSO theory of various infinite graphs,methods of interpretation and unfolding.Applications: Decision procedures for temporal logics. Modelling, verificationand synthesis of systems. Effective theory of infinite games. **References/Text Books:**	FINITE AUTOMATA ON INFINITE INPUTS
CS645	3-0-0-0-4		**Course Contents:** Introduction. Disjoint set UnionFind algorithms. Redblack trees. Selectionalgorithms and application to convex hull. Planar graph separators. Priorityqueues. Fusion trees and their applications to integer sorting. Fheaps, Rheaps,Qheaps and AFheaps and general shortest paths and minimum spanningtrees algorithms. Polynomial time algorithms for matching. **References/Text Books:**	TOPICS IN DESIGN AND ANALYSIS OF ALGORITHMS
CS646	3-0-0--4		**Course Contents:** Complexity measure for parallel algorithms. Parallel combinatorial algorithms:permutations with and without repetitions, combinations, derangements. Parallelsearching algorithms: maximum/minimum, median, Kth largest/smallest element.Parallel sorting algorithms. Parallel graph algorithms: parallel graph searchand tree traversal algorithms, parallel algorithms for connectivity problems,parallel algorithms for path problems. **References/Text Books:**	PARALLEL ALGORITHMS
CS646A	3-0-0-0-9		**Course Contents:** Complexity measure for parallel algorithms. Parallel combinatorial algorithms:permutations with and without repetitions, combinations, derangements. Parallelsearching algorithms: maximum/minimum, median, Kth largest/smallest element.Parallel sorting algorithms. Parallel graph algorithms: parallel graph searchand tree traversal algorithms, parallel algorithms for connectivity problems,parallel algorithms for path problems. **References/Text Books:**	PARALLEL ALGORITHMS
CS647	3-0-0--4		**Course Contents:** The course intends to deal with advanced aspects of algorithm: design andanalysis including data structures, analysis and lower bound proofs, amortizedcomplexity of algorithms. Fibonacci heaps and selfadjusting search trees,Splay trees, linking and cutting trees. Stateoftheart algorithms for minimumspanning trees, shortest path problem. Network flows preflowpush algorithms,max flow algorithm, and scaling algorithms. Matching, blossoms, MicaliVaziranialgorithm. Lower bound theory for parallel computations. **References/Text Books:**	ADVANCED TOPICS IN ALGORITHMS & DATA STRCUTURES
CS647A	3-0-0-0-9		**Course Contents:** The course intends to deal with advanced aspects of algorithm: design andanalysis including data structures, analysis and lower bound proofs, amortizedcomplexity of algorithms. Fibonacci heaps and selfadjusting search trees,Splay trees, linking and cutting trees. Stateoftheart algorithms for minimumspanning trees,	ADVANCED TOPICS IN ALGORITHMS & DATA STRCUTURES

			shortest path problem. Network flows preflowpush algorithms,max flow algorithm, and scaling algorithms. Matching, blossoms, MicaliVaziranialgorithm. Lower bound theory for parallel computations. **References/Text Books:**	
CS648	3-0-0--4	#	**Course Contents:** Review of discrete probability; Notion of randomized algorithms, motivatingexamples; Markov, Chebyshev inequalities, Chernoff bounds; Probabilistic method;Hashing, fingerprinting; Random walks and Markov chains. Program checkers;Polynomial identities; Randomized complexity classes, Probabilistically checkableproofs; some number theoretic problems; Approximate counting. **References/Text Books:**	RANDOMIZED ALGORITHMS
CS648A	3-0-0-0-9		**Course Contents:** Review of discrete probability; Notion of randomized algorithms, motivatingexamples; Markov, Chebyshev inequalities, Chernoff bounds; Probabilistic method;Hashing, fingerprinting; Random walks and Markov chains. Program checkers;Polynomial identities; Randomized complexity classes, Probabilistically checkableproofs; some number theoretic problems; Approximate counting. **References/Text Books:**	RANDOMIZED ALGORITHMS
CS653	3-0-0--4		**Course Contents:** ML (CAML dialect); Xcalculus and combinators; abstraction and higher order functions; lazy and eager evaluation; types, polymorphism and type inference; Equations and pattern matching; SECD machine; denotational semantics of functional languages; implementing functional languages. **References/Text Books:**	FUNCTIONAL PROGRAMMING
CS653A	3-0-0-0-9		**Course Contents:** ML (CAML dialect); Xcalculus and combinators; abstraction and higher order functions; lazy and eager evaluation; types, polymorphism and type inference; Equations and pattern matching; SECD machine; denotational semantics of functional languages; implementing functional languages. **References/Text Books:**	FUNCTIONAL PROGRAMMING
CS654	3-0-0--4		**Course Contents:** In this course we study, typical software system structures (architectural styles),techniques for designing and implementing these structures, models forcharacterizing and reasoning about architectures, and tools for architecturalmodelling. Role of architecture in Software engineering; Enterprise Architectures,Zachmans Framework; Architectural Styles, Design Patterns; ArchitectureDescription Languages; Productline architectures; Component based development. **References/Text Books:**	SOFTWARE ARCHITECTURE
CS654A	3-0-0-0-9		**Course Contents:** In this course we study, typical software system structures (architectural styles),techniques for designing and implementing these structures, models forcharacterizing and reasoning about architectures, and tools for architecturalmodelling. Role of architecture in Software engineering; Enterprise Architectures,Zachmans Framework; Architectural Styles, Design Patterns; ArchitectureDescription Languages; Productline architectures; Component based development. **References/Text Books:**	SOFTWARE ARCHITECTURE

CS663	3-0-0--4		**Course Contents:** Historical perspective: complexity notions in classical geometry. Towardscomputational geometry, geometric preliminaries, models of computation.Geometric searching: point location problems, location of a point in a planarsubdivision, the slab method, the chain method, range searching problems.Convex hulls: problem statement and lower bounds. Grahams scan, Jarvissmarch, quick hull technique, convex hulls in more than one dimension, extensionand applications. Proximity: divide and conquer approach, locus approach;the Voronoi diagram, lower bounds, variants and generalizations. Intersections,hiddenline and hidden surface problem. The geometry of rectangles: applicationof the geometry of rectangles, measure and perimeter of a union of rectangles,intersection of rectangles and related problems. **References/Text Books:**	COMPUTATIONAL GEOMETRY
CS663A	3-0-0-0-9		**Course Contents:** Historical perspective: complexity notions in classical geometry. Towardscomputational geometry, geometric preliminaries, models of computation.Geometric searching: point location problems, location of a point in a planarsubdivision, the slab method, the chain method, range searching problems.Convex hulls: problem statement and lower bounds. Grahams scan, Jarvissmarch, quick hull technique, convex hulls in more than one dimension, extensionand applications. Proximity: divide and conquer approach, locus approach;the Voronoi diagram, lower bounds, variants and generalizations. Intersections,hiddenline and hidden surface problem. The geometry of rectangles: applicationof the geometry of rectangles, measure and perimeter of a union of rectangles,intersection of rectangles and related problems. **References/Text Books:**	COMPUTATIONAL GEOMETRY
CS671	3-0-0--4		**Course Contents:** A computational framework for natural language. A framework such as LFG,GPSG or Panini in some depth. Partial description of English or an Indianlanguage in the frame work, lexicon, algorithms and data structures forimplementation of the framework. Introduction to semantics and knowledgerepresentation. Some applications like machine translation, database interface. **References/Text Books:**	INTRODUCTION TO NATURAL LANGUAGE PROCESSING
CS671A	3-0-0-0-9		**Course Contents:** A computational framework for natural language. A framework such as LFG,GPSG or Panini in some depth. Partial description of English or an Indianlanguage in the frame work, lexicon, algorithms and data structures forimplementation of the framework. Introduction to semantics and knowledgerepresentation. Some applications like machine translation, database interface. **References/Text Books:**	INTRODUCTION TO NATURAL LANGUAGE PROCESSING
CS674	3-0-0--4		**Course Contents:** This course will explore different machine learning, knowledge discovery anddata mining approaches and techniques: Concept Learning, Decision TreeLearning, Clustering and instance based learning, Rule induction and inductivelearning, Bayesian networks and causality, Neural networks, Genetic algorithms,Reinforcement learning, Analytical, learning. **References/Text Books:**	MACHINE LEARNING & KNOWLEDGE DISCOVERY
CS676	3-0-0--4		**Course Contents:** Human and Computer Visioon, Image Representation and Modelling, Line andEdge detection, labeling, Image Segmentation. Pattern Recognition: Statistical,Structural, Neural and Hybrid Techniques. Training and Classification. DocumentAnalysis and Optical Charecter Recognition. Object Recognition Scene	COMPUTER VISION AND IMAGE PROCESSING

			Matchingand Analysis, Robotic Vision. Role of Knowledge. **References/Text Books:**	
CS676A	3-0-0-0-9		**Course Contents:** Human and Computer Visioon, Image Representation and Modelling, Line andEdge detection, labeling, Image Segmentation. Pattern Recognition: Statistical,Structural, Neural and Hybrid Techniques. Training and Classification. DocumentAnalysis and Optical Charecter Recognition. Object Recognition Scene Matchingand Analysis, Robotic Vision. Role of Knowledge. **References/Text Books:**	COMPUTER VISION AND IMAGE PROCESSING
CS678	3-0-0-0-4		**Course Contents:** Kernel based methods in machine learning have become a major paradigm in machine learning in the last decade. The methods have also found widespread application in pattern classification problems. This course aims to first discuss the basic principles of kernel based learning methods and then branch off into some areas of current research like : techniques for finding optimal kernels, error bound analysis novelty detection etc. **References/Text Books:**	LEARNING WITH KERNELS
CS678A	3-0-0-0-9		**Course Contents:** Kernel based methods in machine learning have become a major paradigm in machine learning in the last decade. The methods have also found widespread application in pattern classification problems. This course aims to first discuss the basic principles of kernel based learning methods and then branch off into some areas of current research like : techniques for finding optimal kernels, error bound analysis novelty detection etc. **References/Text Books:**	LEARNING WITH KERNELS
CS679	3-0-0-0-4		**Course Contents:** 1. Probability basics and common probability distributions. 2. Fitting Probability models (ML, MAP, Bayesian). 3. Normal distribution. 4. Regression 5. Classification. 6. Graphical models. 7. Temporal models. **References/Text Books:** Text Book : Computer Vision: Models, Learning and Inference by Simon J.D. Prince.References : Pattern Recognition and Machine Learning by Christopher M. Bishop. Prababilistic Graphical Models: Principles and Techniques by Daphne Koller and Nir Friedman.	MACHINE LEARNING FOR COMPUTER VISION
CS679A	3-0-0-0-9		**Course Contents:** 1. Probability basics and common probability distributions. 2. Fitting Probability models (ML, MAP, Bayesian). 3. Normal distribution. 4. Regression 5. Classification. 6. Graphical models. 7. Temporal models. **References/Text Books:** Text Book : Computer Vision: Models, Learning and Inference by Simon J.D. Prince.References : Pattern Recognition and Machine Learning by Christopher M. Bishop. Prababilistic Graphical Models: Principles and Techniques by Daphne Koller and Nir Friedman.	MACHINE LEARNING FOR COMPUTER VISION
CS680	3-0-0--4		**Course Contents:** Introduction: Basic definition and diagram; sources and sinks; monicity andepicity; isomorphisms of objects and morphisms; duality; Universal Structures:Initial terminal and zero; Category of sources and sinks; product; equalizer;regular epicity and monicity; pullback; completeness; kernel; Normal Categories:Normal hierarchy; extension of categories; factorization; chains and exactness;Morphism algebra: Biproduct; semiadditive category; Additive category; Functors:Natural transformation; categories on natural transformation; property preservingand reflecting functors; Diagram isomorphism; Similar categories;	CATEGORY THEORY

			generalizationof limit and colimit; Hreflection morphism and adjoint functor; Representablefunctors Category in context of another category; Application to Logic (Topoi);application to Programming Languages. **References/Text Books:**	
CS680A	3-0-0-0-9		**Course Contents:** Introduction: Basic definition and diagram; sources and sinks; monicity andepicity; isomorphisms of objects and morphisms; duality; Universal Structures:Initial terminal and zero; Category of sources and sinks; product; equalizer;regular epicity and monicity; pullback; completeness; kernel; Normal Categories:Normal hierarchy; extension of categories; factorization; chains and exactness;Morphism algebra: Biproduct; semiadditive category; Additive category; Functors:Natural transformation; categories on natural transformation; property preservingand reflecting functors; Diagram isomorphism; Similar categories; generalizationof limit and colimit; Hreflection morphism and adjoint functor; Representablefunctors Category in context of another category; Application to Logic (Topoi);application to Programming Languages. **References/Text Books:**	CATEGORY THEORY AND APPLICATIONS IN COMPUTING
CS681	3-0-0-0-4		**Course Contents:** Elementary operations: the complexity of basic operations like additions,multiplications for integers and polynomials. Polynomials: The complexity offactorization, irreducibility testing, ideal membership etc for polynomials overfinite fields. Motivating example: Reedsoloman codes. Integer Lattices: thecomplexity of finding a short vector in an integer lattice. Motivating example;polynomial factorization. Integers: The complexity of factorization, primalitytesting, discrete log computation etc for integers. Motivating examples: RSAand El Gamal cryptosystems. Elliptic curves: the complexity of addition, pointcounting etc. for elliptic curves. Motivating examples: Elliptic curve cryptosystemsand integer factoring. **References/Text Books:**	COMPUTATIONAL NUMBER THEORY AND ALGEBRA
CS681A	3-0-0-0-9		**Course Contents:** Elementary operations: the complexity of basic operations like additions,multiplications for integers and polynomials. Polynomials: The complexity offactorization, irreducibility testing, ideal membership etc for polynomials overfinite fields. Motivating example: Reedsoloman codes. Integer Lattices: thecomplexity of finding a short vector in an integer lattice. Motivating example;polynomial factorization. Integers: The complexity of factorization, primalitytesting, discrete log computation etc for integers. Motivating examples: RSAand El Gamal cryptosystems. Elliptic curves: the complexity of addition, pointcounting etc. for elliptic curves. Motivating examples: Elliptic curve cryptosystemsand integer factoring. **References/Text Books:**	COMPUTATIONAL NUMBER THEORY AND ALGEBRA
CS697	0-0-0--4		**Course Contents:** Special and advanced topics in different areas of Computer Science andEngineering will be covered under this course. **References/Text Books:**	SPECIAL TOPICS IN COMPUTER SCIENCE
CS697A	0-0-0-0-9		**Course Contents:** Special and advanced topics in different areas of Computer Science andEngineering will be covered under this course. **References/Text Books:**	SPECIAL TOPICS IN COMPUTER SCIENCE

CS698.	----6		**Course Contents:** B TECH PROJECT **References/Text Books:**	B TECH PROJECT
CS699	-0-0--		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
CS699.	0-0-0-0-		**Course Contents:** M TECH THESIS (FOR DUAL DEGREE ONLY) **References/Text Books:**	M TECH THESIS (FOR DUAL DEGREE ONLY)
CS719	3-0-0--4		**Course Contents:** Motivating applications: network monitoring, sensor networks, need for highlyefficient processing of high speed and high volume data streams, Spaceand time efficient randomized algorithms as a candidate solution, modelsof data streams. Basics of randomization: elementary probability theory,expectation, linearity of expectation, variance, Markov and Chebychevs inequality,Chernoff and Hoeffding (CH) tail inequalities, hash functions, limitedindependence, CHbounds for limited independence.Finding frequent items in data streams, Estimating distinct item queries,Estimating frequency moments, estimating join sizes, Approximate histogramsover data streams, Transforms over data streams, wavelets, fourier and DCTclustering over data streams, Applications to graphs. **References/Text Books:**	DATA STREAMING: ALGORITHMS & SYSTEMS
CS719A	3-0-0-0-9		**Course Contents:** Motivating applications: network monitoring, sensor networks, need for highlyefficient processing of high speed and high volume data streams, Spaceand time efficient randomized algorithms as a candidate solution, modelsof data streams. Basics of randomization: elementary probability theory,expectation, linearity of expectation, variance, Markov and Chebychevs inequality,Chernoff and Hoeffding (CH) tail inequalities, hash functions, limitedindependence, CHbounds for limited independence.Finding frequent items in data streams, Estimating distinct item queries,Estimating frequency moments, estimating join sizes, Approximate histogramsover data streams, Transforms over data streams, wavelets, fourier and DCTclustering over data streams, Applications to graphs. **References/Text Books:**	DATA STREAMING: ALGORITHMS & SYSTEMS
CS720	3-0-0--4		**Course Contents:** The course is primarily intended to familiarize students with the problemof testing large and complex electronic circuits. Various techniques to solvethis problem and concepts of design for easy testability (DFT) will be discussed.Topics related to faultmodeling and faultsimulation to evaluate the faultcoverageof test vectors will be covered in detail. The problem of reducedyield and reliability of circuits in presence of faults will be discussed andtechniques to improve the yield and reliability of these circuits by introducingfaulttolerance measures will also be covered.Various redundancy techniques like structural, time, information and softwareredundancy will also be discussed in detail. **References/Text Books:**	VLSI TESTING AND FAULT TOLERANCE
CS720A	3-0-0-0-9		**Course Contents:** The course is primarily intended to familiarize students with the problemof testing large and complex electronic circuits. Various techniques to solvethis problem and concepts of design for easy testability (DFT)	VLSI TESTING AND FAULT TOLERANCE

			will be discussed.Topics related to faultmodeling and faultsimulation to evaluate the faultcoverageof test vectors will be covered in detail. The problem of reducedyield and reliability of circuits in presence of faults will be discussed andtechniques to improve the yield and reliability of these circuits by introducingfaulttolerance measures will also be covered.Various redundancy techniques like structural, time, information and softwareredundancy will also be discussed in detail. **References/Text Books:**	
CS727	3-0-0--4		**Course Contents:** Today the Internet is being used for myriad of applications electronic publishing,electronic commerce, distance education, collaborative working, etc. This courseintends to investigate the underlying principles and practices that supportthese applications. Introduction to computer networks; Content preparationHTML, DHTML, VRML, SGML, XML and other markup schemes; Images compression, formats; Audio compression, formats; Content Delivery protocols HTTP and variants, Internet servers, proxy servers; Search engines;Data on the web; Content Display browsers, plugins, helper applications;Interactivity Java, ActiveX; Component technologies, Javabeans, CORBA;Security, Electronic payment systems, Firewalls, Encryption, Watermarks;Performance, Benchmarking the Web. **References/Text Books:**	TOPICS IN INTERNET TECHNOLOGIES
CS738	3-0-0--4		**Course Contents:** Introduction to Advanced topics, Compiler Algorithms Notation, Symbol tablestructure, Intermediate representation, Run time support, Producing codegenerators automatically, Control flow analysis, Data flow analysis, Dependenceanalysis and dependence graphs, Alias analysis, Introduction to optimizations,Early optimizations, Redundancy elimination, Loop optimizations, procedureoptimizations, Register allocation, Code scheduling, control flow and low leveloptimizations, Inter procedural Analysis and optimizations, Optimization formemory hierarchy, Case studies. **References/Text Books:**	ADVANCED COMPILER OPTIMIZATIONS
CS743	3-0-0--4		**Course Contents:** Review of important sequential graph algorithms. Introduction to parallel modelsfor computation. General techniques for fast parallel computations on vectorsand lists and their applications to design of efficient parallel graph algorithms.Parallel dynamic programming and its applications to expression graphs. Stateofart algorithms for depth first search of directed and undirected graphs.NCalgorithms for STnumbering and open ear decomposition. Parallel algorithmsfor graph optimization problems. Algorithms for graph coloring. Decompositionof graph into simpler subgraphs. Equivalence relations and classes in graphs.Parallel planarity testing. **References/Text Books:**	ADVANCED GRAPH ALGORITHMS
CS743A	3-0-0-0-9		**Course Contents:** Review of important sequential graph algorithms. Introduction to parallel modelsfor computation. General techniques for fast parallel computations on vectorsand lists and their applications to design of efficient parallel graph algorithms.Parallel dynamic programming and its applications to expression graphs. Stateofart algorithms for depth first search of directed and undirected graphs.NCalgorithms for STnumbering and open ear decomposition. Parallel algorithmsfor graph optimization problems. Algorithms for graph coloring. Decompositionof graph into simpler subgraphs. Equivalence relations and classes in graphs.Parallel planarity testing. **References/Text Books:**	ADVANCED GRAPH ALGORITHMS
CS744A	3-0-0-0-9		**Course Contents:**	PSEUDO-RANDOM

			Pseudorandom generators are efficiently computable functions that stretch and input random string to a much bigger sized string such that the output string appears random to resourcebounded computations. These functions have become one of the fundamental objects to study in complexity theory because of their utility. They are used to derandomize randomized algorithms, formalize notions of cryptographic security, obtain lower bounds on the complexity of problems etc. (unfortunately, as of now very few constructions of pseudo random generators are provably known although many are conjectured). In this course, we study pseudorandom generators and their connections in depth. The topics covered in the course are as follows :Pseudorandom generators: definitions and Existence. Pseudorandom generators of small stretch: Definitions of cryptographic security, Equivalence of one way functions and pseudorandom generators, Some functions conjectured to be oneway functions, Pseudorandom function generators. Pseudorandom generators of large stretch: Equivalence of lower bounds and pseudorandom generators, Known pseudorandom generators against small depth circuits and small space classes, Extractors and pseudorandom generators.Pseudorandom generators against arithmetic circuits: Equivalence of lower bounds and pseudorandom generators, A function conjectured to be pseudo random. **References/Text Books:**	GENERATORS
CS749A	3-0-0-0-9		**Course Contents:** ELLIPTIC CURVES OVER REALS: WEIERTRASS EQUATION, ENDOMORPHISMSELLIPTIC CURVES OVER COMPLEX NUMBERS:EQUIVALENCE WITH TORI, SYMMETRICS, DIVISORS, AND WEIL PAIRING. ELLIPTIC CURVES OVER RATIONALS. ELLIPTIC CURVES OVER FINITE FIELDS.APPLICATION PUBLIC KEY ENCRYPTION ALGORATHM. APPLICATIONS: PROOF OF FERMAT'S LAST THEOREM. **References/Text Books:**	ELLIPTIC CURVES AND THEIR APPLICATIONS
CS799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
ESC101A	3-1-3-0-14		**Course Contents:** Stored program concept (with simple computer simulator), machine language and instruction formats,assembly language for the simple computer. Integer representation, finite representation of real numbers,overflow, underflow, errors due to finite representations. Expressions, values and variables, types, lvalue,rvalue, unary, binary, ternary operations. Conditionals, ifthen, ifthenelse, nested conditionals, switchcase.Loops, for, while, repeat, loopinvariants, precondition, postcondition. Functions and return values,arguments, passbyvalue, effect of passing pointers (like passbyreference). Recursion. Arrays, enums,searching, sorting. Pointers, lists, dynamic data structures, stack, queue, graphs, trees related algorithms,memory and its management. Elementary complexity motivation, concrete complexity, big O notation.Linux tools, introduction to shell programming. Elementary numerical problem solving will addressedlargely through some labs e.g. root finding, solutions of systems of linear equations, integration, solution ofODEs. **References/Text Books:** 1. Brian W Kernighan and Dennis M Ritchie, The C Programming Language,2nd Ed. ANSI C version,Pearson, 2006.	FUNDAMENTAL OF COMPUTING
ESC101N	3-1-3-0-5		**Course Contents:** Stored program concept (with simple computer simulator), machine language and instruction formats,assembly language for the simple computer. Integer representation, finite representation of real numbers,overflow, underflow, errors due to finite representations. Expressions, values and variables, types, lvalue,rvalue, unary, binary, ternary operations. Conditionals, ifthen, ifthenelse, nested conditionals,	FUNDAMENTAL OF COMPUTING

			switchcase.Loops, for, while, repeat, loopinvariants, precondition, postcondition. Functions and return values,arguments, passbyvalue, effect of passing pointers (like passbyreference). Recursion. Arrays, enums,searching, sorting. Pointers, lists, dynamic data structures, stack, queue, graphs, trees related algorithms,memory and its management. Elementary complexity motivation, concrete complexity, big O notation.Linux tools, introduction to shell programming. Elementary numerical problem solving will addressedlargely through some labs e.g. root finding, solutions of systems of linear equations, integration, solution ofODEs. **References/Text Books:** 1. Brian W Kernighan and Dennis M Ritchie, The C Programming Language,2nd Ed. ANSI C version,Pearson, 2006.	
ESO207A	3-0-0-0-9		**Course Contents:** Order Analysis: Objectives of time analysis of algorithms; Bigoh and Theta notations, Data Structures: Arrays, Linked lists, Stacks (example: expression evaluation), Binary search trees, RedBlack trees, Hash tables, Sorting and Divide and Conquer Strategy: Mergesort; DandC with Matrix Multiplication as another example, Quicksort with average case analysis, Heaps and heapsort, Lower bound on comparisonbased sorting and Counting sort, Radix sort, Btrees, Dynamic Programming: methodology and examples (Fibonacci numbers, matrix sequence, multiplication, longest common subsequence, convex polygon triangulation), Greedy Method: Methodology, examples (lecture scheduling,process scheduling) and comparison with DP (more examples to come later in graph algorithms), Graph Algorithms: Basics of graphs and their representations, BFS, DFS, Topological sorting, Minimum spanning trees (Kruskal and Prims algorithms and brief discussions of disjoint set and Fibonacci heap data structures), Shortest Paths (Dijkstra, BellmanFord, FloydWarshall). **References/Text Books:**	DATA STRUCTURE & ALGORITHM
ESO211	3-0-0-0-4		**Course Contents:** Order Analysis: Objectives of time analysis of algorithms; Bigoh and Thetanotations, Data Structures: Arrays, Linked lists, Stacks (example: expressionevaluation), Binary search trees, RedBlack trees, Hash tables, Sorting and Divideand Conquer Strategy: Mergesort; DandC with Matrix Multiplication as anotherexample, Quicksort with average case analysis, Heaps and heapsort, Lowerbound on comparisonbased sorting and Counting sort, Radix sort, Btrees,Dynamic Programming: methodology and examples (Fibonacci numbers, matrixsequence, multiplication, longest common subsequence, convex polygontriangulation), Greedy Method: Methodology, examples (lecture scheduling,process scheduling) and comparison with DP (more examples to come later ingraph algorithms), Graph Algorithms: Basics of graphs and their representations,BFS, DFS, Topological sorting, Minimum spanning trees (Kruskal and Primsalgorithms and brief discussions of disjoint set and Fibonacci heap datastructures), Shortest Paths (Dijkstra, BellmanFord, FloydWarshall). **References/Text Books:**	DATA STRUCTURES AND ALGORITHMS
***** Department of DOSA *****				
PE102B	0-0-0--0	PE102A	**Course Contents:** There are two components in this course, namely: 1. Physical exercise2. Personality Development Activities.Activities under physical exercise: Warming up exercises: jogging, running, stretching, simpleexerCises and specific exercises. Formal and informal games. Exercises for development ofphysical fitness components like: 1. Strength 2. Speed 3. Endurance 4. Flexibility 5. CoordinateActivities. Intramural activities: Group sports.Personality development activities: There are five streams in this component: 1. Games andsports 2. Yoga 3. NSS 4. TaeKwonDo and 5. NCC. The students have to opt for one of theabove five streams. In Games and sports, the students choose one of the following 12 sports: 1.Atheletics 2. Badminton 3. Cricket 4. Hockey 5. Table Tennis 6. Tennis 7. Football. 8.Swimming 9. Basket ball10.	EVENING EXERCISE

			Volleyball11. Weightlifting 12. Squash.Fundamental skills are taught in the streams mentioned above. **References/Text Books:**	
***** Department of ECO *****				
ECO301A	3-0-0-0-9		**Course Contents:** Static games with complete information Nash Equilibrium; Dynamic games with complete information Subgame perfect Nash Equilbrium; Static games with incomplete information Bayesian Nash Equilibrium; Dynamic games with incomplete information Perfect Bayesian Nash Equilibrium, Sigmaling games; Adverse Selection and Moral Hazard; Exchange Economy and definition of Competitive Equilibrium; Pareto efficiency and Pareto set; One consumer one producer econnomy; Two sector production economy; First Fundamental theorem of Welfare Economics; Second Fundamental theorem of Welfare Economics; Pareto optimality and social welfare functions; Public goods and externalities; Property rights and Coase theorem; Social Choi d Theory **References/Text Books:**	MICROECONOMICS II
ECO321A	3-0-0-0-9	ECO221A	**Course Contents:** Microeconomic foundations of Macroeconomics, Representative agent model, Application of representative agent model in asset pricing, consumption theories etc., Longrun economic growth models, Models of shortrun economic fluctuations, Macroeconomic policy debates validation and application of growth/business cycle models. **References/Text Books:**	MACROECONOMICS-II
ECO341A	3-0-3-0-12	HSO201A/MSO201A	**Course Contents:** Classical Linear Regression Model (CLRM), Assumptions of the CLRM and its violation, Hypothesis Testing, Gauss Markov Theorem, Properties of the Estimator, Multiple Regression Model, Heteroscedasticity, Autocorrelation and Multicollinearity, Lagged Variables, Dummy Variables, Specification Bias, Simultaneous Equations, Introduction to Time Series, Discrete Choice, Limited Dependent Variable and Panel Data Models, Estimation ProceduresOrdinary Least Square(OLS), Generalized Least Squares(GLS), IV(Instrumental Variable), Maximum Likelihood Estimation(MLE) and Generalized Method ofMoments(GMM), Learning of Econometric Software: Eviews and Stata **References/Text Books:**	ECONOMETRICS I
ECO397A	0-0-2-0-2		**Course Contents:** TECHNICAL COMMUNICATION **References/Text Books:**	TECHNICAL COMMUNICATION
ECO398A	0-0-0-0-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UG PROJECT (UGP-I)
ECO405	3-1-0--4		**Course Contents:** Introduction; Economics of contracts (adverse selection and moral hazard);Hidden action, monitoring, and control; Efficient contracts; Transfer prices;Contingent claims; Principal agent models; Incomplete and incentive contracts;Implicit contracts; Auctions and bidding; Regulation of contracts **References/Text Books:**	CONTRACT ECONOMICS

ECO411A	3-0-0-0-9	ECO301A	**Course Contents:** Introduction: StructureConductPerformance (SCP) paradigm, Chicago School view, modem developments and relevance of industrial policy; Monopoly Power and Industrial Concentration; Oligopolistic Industries: competition in quantities and in prices, cartels and collusion; Strategic Behavior: firm entry, accommodation and exit, barriers to entry, predatory pricing and limit pricing; Empirical Studies of SCP Paradigm **References/Text Books:**	INDUSTRIAL ECONOMICS
ECO412A	3-0-0-0-9	ECO221A ECO201A/ECO101A	**Course Contents:** World Trade and Empirical Facts of International Trade with its Explanations, Neoclassical Trade Theories, Alternative and New Trade Theories, Trade PolicyInstruments and their Impact on Welfare, Trade and Income Distribution, International Factor Movements, Negotiations at the GATT and the WTO, Exchange Rate Movements, Past andPresent Arrangements of the International Monetary System including discussion on theEuropean Monetary System and Optimum Currency Area, Regional Trade Agreements, TradeCreation and Trade Diversion, Theories of Exchange Rate and BOP(Balance of Payments) andDifferent Approaches to the BOP. **References/Text Books:**	INTERNATIONAL ECONOMICS AND FINANCE
ECO413	3-1-0--4	ECO111/ECO112/ECO201/ECO231	**Course Contents:** Social accounting matrix; Leontiefs open and closed IO models; Multipliers andlinkages in the IO model; Organization of basic data for IO models; Identificationof the key sectors; Role of project in development planning; Project developmentcycles; Capital budgeting decisions; Commercial profit vs. social profitabilityanalysis; Methods of measurement of benefits and costs of projects; Case studies **References/Text Books:**	PLANNING TECHNQUE
ECO422	3-1-0-0-4		**Course Contents:** Introduction; Rationale for regulation and antitrust; Regulatory practices, rulesvs. implementation agencies; Regulatory capture; Discriminatory pricing; Controllingfranchises; Public enterprise regulation; Restructuring and deregulation of keysectors such as energy, transport etc.; Externalities, environmental concerns,and controls; Product quality, safety, and health issues; Patents; Copyrights;Trademark and Service Mark; Industrial Designs Registration; Protection ofLayout of Designs Integrated Circuit; Protection of New Plant Varieties; AntitrustPolicy and IPR; Agreements and IPR Linkages; Litigation; Continuous Issues inIPR (Such as Biotechnology and IPR, TRIPS and Access to Medicines, etc.). **References/Text Books:**	ECONOMICS OF REGULATION AND IPR
ECO434	3-1-0-0-4		**Course Contents:** Global trade in goods and services; Why study international trade and finance;Growth and trade; Basic theory of international trade; Theory of comparativeadvantage; Implications of HeckserOhlin theory; Alternative theories of trade;Empiricial Tests of Trade Therics; International trade and technical change;Economics of import tariff; Nontariff import barriers; Arguments for and againstprotection; Regional trading blocks; Trade policies for development; Internationalfactor movements; Exchange rate and open economy; Internal and ExternalBalance with Fixed and Flexible Exchange rate; Foreign exchange markets andexchange rates; Balance of payments; International monetary system; Benefitsand costs of the Globalication Process. **References/Text Books:**	INTERNATIONAL ECONOMICS
ECO498A	0-0-0-0-9		**Course Contents:** UG PROJECT (UGPIII) **References/Text Books:**	UNDER GRADUATE PROJECT-III

ECO502	3-0-0-0-4		**Course Contents:** Introduction: Optimal contracts under uncertainty, hidden information (adverse selection), or hidden action (moral hazard); Bilateral contracting: Hiddeninformation screening and signaling, hidden action moral hazard; Optimal contracting with multilateral asymmetric information: Auctions and trade under multilateral private information; moral hazard in teams, tournaments and organizations; Incomplete contracts: Institution design, implementation theory, bilateral and multilateral contracts **References/Text Books:** 1. Patrick Bolton and Mathias Dewatripont, Contract Theory (2005), The MIT Press.2. T.V. S. Rammohan Rao, Contract Economics (2004), New Age International.	APPLIED GAME THEORY
ECO535	3-1-0-0-4		**Course Contents:** Scope of public economics; Equity, social welfare and taxation; Taxation, incomesupport and social insurance; Taxation and individuals; Market failure andgovernment intervention; Optimal provision of public goods; Public expenditureand public debt; Modeling government behavior; Organization of public sector **References/Text Books:**	PUBLIC ECONOMICS
ECO751	3-0-0-0-4		**Course Contents:** Introduction; Economic Analysis of Property Law: An Economic Theory of Property,and Intellectual Property Rights; Economic Analysis of Contrat Law: EconomicTheory of Contract, and Economics of Remedies for Breach of Contract; EconomicAnalysis of Tort Law, and Economics of Tort Liability; Public Law and Economics:Legislative and Executive Participation and Discretion: Economic anaylsis ofjudicial review, and general Applications to Indian Institutes: Economic theoryof Corporation Law: The Theory of the Firm, Corporation and their Interaction,the Economic Reconstruction of Corporation Law, analysis of Specific Problemsof Corporation Law, Economic Analysis of Labour Law: Unions and Productivity,"WorkersProtective" Legislation, Issues in Employment discremination on groundsof Race Sex, and Age; and Economic Analysis of Competition Law: EconomicTheory of Competition Law, and Competition Policy in India. **References/Text Books:**	LAW AND ECONOMICS
***** Department of EE *****				
EE200	3-1-0-0-4		**Course Contents:** Continuous and discrete time signals; Fourier series, Fourier, Laplace and Ztransform techniques; DFT. Sampling Theorem. LTI systems: I/O description,impulse response and system functions, pole/ zero plots, FIR and IIR systems.Analog and digital filters. Networks: topological description, network theorems,Twoport analysis. **References/Text Books:**	SIGNALS, SYSTEMS AND NETWORKS
EE200A	3-1-0-0-11		**Course Contents:** Continuous and discrete time signals; Fourier series, Fourier, Laplace and Ztransform techniques; DFT. Sampling Theorem. LTI systems: I/O description,impulse response and system functions, pole/ zero plots, FIR and IIR systems.Analog and digital filters. Networks: topological description, network theorems,Twoport analysis. **References/Text Books:**	SIGNALS, SYSTEMS & NETWORKS
EE210	3-1-0-0-4		**Course Contents:** 1. 1V Characteristics and Large and SmallSignal Models of Diodes, BJTs, and MOSFETs2. Biasing3. Amplifiers4. Output Stages5. Frequency Response6. Feedback Amplifiers7. Stability and Compensation8.	MICROELECTRONICS-I

			Operational Amplifier **References/Text Books:** 1. Analysis and Design of Analog Integrated Circuits; P.R. Gray, P.J. Hurst, S.H. Lewis, andR.G. Meyer; Jolm Wiley & Sons, 4ili Edition, 20012. MOS Analog Circuits for Signal Processing; R. Gregorian and G.C. Ternes; John Wiley &Sons, 19863. Microelectronic Circuits; A.S. Sedra and K.C. Smith; Oxford University Press, 5th Edition,2004.4. Microelectronics; J. Milbnan and A. Grabel; McGrawHill, 2nd Edition, 1987.	
EE210A	3-1-0-0-11		**Course Contents:** 1. 1V Characteristics and Large and SmallSignal Models of Diodes, BJTs, and MOSFETs2. Biasing3. Amplifiers4. Output Stages5. Frequency Response6. Feedback Amplifiers7. Stability and Compensation8. Operational Amplifier **References/Text Books:** 1. Analysis and Design of Analog Integrated Circuits; P.R. Gray, P.J. Hurst, S.H. Lewis, andR.G. Meyer; Jolm Wiley & Sons, 4ili Edition, 20012. MOS Analog Circuits for Signal Processing; R. Gregorian and G.C. Ternes; John Wiley &Sons, 19863. Microelectronic Circuits; A.S. Sedra and K.C. Smith; Oxford University Press, 5th Edition,2004.4. Microelectronics; J. Milbnan and A. Grabel; McGrawHill, 2nd Edition, 1987.	MICROELECTRONICS-I
EE250	3-1-0-0-4		**Course Contents:** Negative feedback control systems, Linear timeinvariant dyanamic systems, Mason's gainformula, transfer function, frequency and time domain analysis, performance analysis,Nyquist stability criterion. Bode plots, Root locus. Feedback system design using Bode plotsand root locus. PID control. Nonlinear systems, circle criterion, antiwindup schemes.Statespace models. **References/Text Books:**	CONTROL SYSTEMS ANALYSIS
EE250A	3-1-0-0-11		**Course Contents:** Negative feedback control systems, Linear timeinvariant dyanamic systems, Mason's gainformula, transfer function, frequency and time domain analysis, performance analysis,Nyquist stability criterion. Bode plots, Root locus. Feedback system design using Bode plotsand root locus. PID control. Nonlinear systems, circle criterion, antiwindup schemes.Statespace models. **References/Text Books:**	CONTROL SYSTEMS ANALYSIS
EE301	3-0-0-0-4		**Course Contents:** Sampling and Reconstruction of continuous time signals, Characterization and properties ofdiscrete time signals and systems, Computation of the discrete time Fourier transform andits properties, Computation of the discrete Fourier transform and its properties, Fast Fouriertransform algorithms, The Ztransform and its properties, Transform analysis of linear timeinvariant systems, Implementation of structures for discrete time systems, Digital filter designtechniques, Homomorphic filtering, Applications of DSP in speech and image processing. **References/Text Books:** [1] DiscreteTime Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W.Schafer, and John R. Buck, Pearson Education India	DIGITAL SIGNAL PROCESSING
EE301A	3-0-0-0-9	EE200A	**Course Contents:** Sampling and Reconstruction of continuous time signals, Characterization and properties ofdiscrete time signals and systems, Computation of the discrete time Fourier transform andits properties, Computation of the discrete Fourier transform and its properties, Fast Fouriertransform algorithms, The Ztransform and its properties, Transform analysis of linear timeinvariant systems, Implementation of structures for discrete time systems, Digital filter designtechniques, Homomorphic filtering, Applications of DSP in speech and image	DIGITAL SIGNAL PROCESSING

			processing. **References/Text Books:** [1] DiscreteTime Signal Processing (Second Edition), Alan V. Oppenheim, Ronald W.Schafer, and John R. Buck, Pearson Education India	
EE311	3-0-0-0-4		**Course Contents:** 1. Semiconductors and Crystal Structures2.. Basic Semiconductor PhysicsEE3113. Excess Carriers and Transport Processes in Semiconductors4. Junction Diode5. Bipolar Junction Transistor (BJT)6. MOS Capacitor (MOSCAP)7. MetalOxideSemiconductor FieldEffect Transistor (MOSFET)8. Some Important Devices Tunnel Diode, Varactor Diode, Light Emitting Diode (LED),Photodetector, and Solar Cell **References/Text Books:** l. Solid State Electronic Devices, B.G. Streetman arid .S. Banerjee, Prentice Hall, 2000.2. Device Electronics for Integrated Circuits, R.S. Muller and T.l. Kamins, John Wiley, 2003.3. Introduction to Semiconductor Materials and Devices, M.S. Tyagi, John Wiley, 1991.4. Physics of Semiconductor Devices, M. Shur, Prentice Hall, .J 990.	MICROELECTRONICS II
EE311A	3-0-0-0-9	EE210A	**Course Contents:** 1. Semiconductors and Crystal Structures2.. Basic Semiconductor PhysicsEE3113. Excess Carriers and Transport Processes in Semiconductors4. Junction Diode5. Bipolar Junction Transistor (BJT)6. MOS Capacitor (MOSCAP)7. MetalOxideSemiconductor FieldEffect Transistor (MOSFET)8. Some Important Devices Tunnel Diode, Varactor Diode, Light Emitting Diode (LED),Photodetector, and Solar Cell **References/Text Books:** l. Solid State Electronic Devices, B.G. Streetman arid .S. Banerjee, Prentice Hall, 2000.2. Device Electronics for Integrated Circuits, R.S. Muller and T.l. Kamins, John Wiley, 2003.3. Introduction to Semiconductor Materials and Devices, M.S. Tyagi, John Wiley, 1991.4. Physics of Semiconductor Devices, M. Shur, Prentice Hall, .J 990.	MICROELECTRONICS II
EE320	3-1-0-0-4		**Course Contents:** Fourier transform theory for communication systems, Analog communication systems.Amplitude Modulation, Envelope Detection, Double Sideband (DSB), Single sideband (SSB) andVestigial Sideband (VSB) systems, BasebandPassband equivalence. Angle Modulation,Frequency Modulation, Phase Modulation, Spectrum of FM signals. Pulse Modulation,Quantization, Compression, Delta and DPCM Modulation. Probability, MAP detection, RandomProcesses, Strict and Wide Sense Stationarity Ergodicity, AWGN. Digital Communication systems,Optimality of Matched filter, BitError Rate (BER), Signal constellation theory, BPSK and QPSKmodulation. GSM/TDMA and IS95/CDMA cellular systems. Statistical Multiplexing and packetswitching, ALOHA, slotted ALOHA, Basics of queueing and trunking systems. **References/Text Books:**	PRINCIPLES OF COMMUNICATIONS
EE320A	3-1-0-0-11	EE200A	**Course Contents:** Fourier transform theory for communication systems, Analog communication systems.Amplitude Modulation, Envelope Detection, Double Sideband (DSB), Single sideband (SSB) andVestigial Sideband (VSB) systems, BasebandPassband equivalence. Angle Modulation,Frequency Modulation, Phase Modulation, Spectrum of FM signals. Pulse Modulation,Quantization, Compression, Delta and DPCM Modulation. Probability, MAP detection, RandomProcesses, Strict and Wide Sense Stationarity Ergodicity, AWGN. Digital Communication systems,Optimality of Matched filter, BitError Rate (BER), Signal constellation theory, BPSK and QPSKmodulation. GSM/TDMA and IS95/CDMA cellular systems. Statistical Multiplexing and packetswitching, ALOHA, slotted ALOHA, Basics of queueing and trunking	PRINCIPLES OF COMMUNICATION

			systems. **References/Text Books:**	
EE321	3-0-0-0-4		**Course Contents:** Information measures. Source coding. ISI & channel equalization, partialresponse signalling. Mary modulation systems, error probability calculations.PLLs and FM threshold extension. Error control coding, block and convolutioncodes. Combined modulation and coding, trellis coded modulation. Spreadspectrum systems. **References/Text Books:**	COMMUNICATION SYSTEMS
EE321A	3-0-0-0-9	EE320A	**Course Contents:** Information measures. Source coding. ISI & channel equalization, partialresponse signalling. Mary modulation systems, error probability calculations.PLLs and FM threshold extension. Error control coding, block and convolutioncodes. Combined modulation and coding, trellis coded modulation. Spreadspectrum systems. **References/Text Books:**	COMMUNICATION SYSTEMS
EE330	3-1-0-0-4		**Course Contents:** 1. Introduction to power system structure, types of components.2. Power Calculations, in balanced threephase Circuits, Method of Symmetrical Components forunbalanced threephase Circuits3. Different types of transformers and transformer Connections4. Inductance and capacitance calculations for transmission lines5. Models for short and long transmission lines, steadystate operation, shunt and seriescompensation, transients on transmission lines.6. Network models of power system using admittance and impedance matrices7. The Load flow problem, Equations for bus powers and their numerical solution using GaussSiedeland NewtonRaphson methods8. Analysis of faulted power systems using sequence networks.9. Basic stability analysis, derivation of swing equation ,equal area criteria, calculation of criticalclearing angle, numerical solution of swing equation.10. Basics ofEconomic operation, incremental fuel cost, allocation ofload between generators ina plant. **References/Text Books:** 1. Power System Analysis John J.Grainger & William D.Stevenson Jr, McGraw Hill19942., .Power System Analysis and design J.Duncan Glover, M.Sarma zd edition ,PWS PublishingCo Boston 20013. Power System Engineering, D.P.Kothari & I.J.Nagrath, Tata McGraw Hill2008	POWER SYSTEMS
EE330A	3-1-0-0-11		**Course Contents:** 1. Introduction to power system structure, types of components.2. Power Calculations, in balanced threephase Circuits, Method of Symmetrical Components forunbalanced threephase Circuits3. Different types of transformers and transformer Connections4. Inductance and capacitance calculations for transmission lines5. Models for short and long transmission lines, steadystate operation, shunt and seriescompensation, transients on transmission lines.6. Network models of power system using admittance and impedance matrices7. The Load flow problem, Equations for bus powers and their numerical solution using GaussSiedeland NewtonRaphson methods8. Analysis of faulted power systems using sequence networks.9. Basic stability analysis, derivation of swing equation ,equal area criteria, calculation of criticalclearing angle, numerical solution of swing equation.10. Basics ofEconomic operation, incremental fuel cost, allocation ofload between generators ina plant. **References/Text Books:** 1. Power System Analysis John J.Grainger & William D.Stevenson Jr, McGraw Hill19942., .Power System Analysis and design J.Duncan Glover, M.Sarma zd edition ,PWS PublishingCo Boston 20013. Power System Engineering, D.P.Kothari & I.J.Nagrath, Tata McGraw Hill2008	POWER SYSTEMS

EE340	3-1-0-0-4		**Course Contents:** I. Overview of Static Electric and Magnetic Fields, Steady Electric Currents;2. TimeVarying Electromagnetic Fields, Maxwell's Equations, Boundary Conditions;3. Plane Electromagnetic Waves, Propagation in Free Space and in Matter;4. Reflection and Refraction ofWaves at Conducting and Dielectric Boundary;5. Transmission Lines: TEM waves, Transmission Line Equations, Wave Propagation alongFinite Transmission Lines, Transients on Lines, The Smith Chart;6. Waveguides, Waves in Guided Media, Parallel Plate Waveguide, Rectangular Waveguide,Cavity Resonators;7. Basic Theory of Antennas and Radiation Characteristics, Elementary Types of Antennas. **References/Text Books:** I. Field and Wave Electromagnetics David K. Cheng, Second Edition, PearsonEducation, 2008.2. Engineering Electromagnetics W A Haytt & J A Buck, Seventh Edition, Tata McGrawHill, 2006.3. Electromagnetic Waves and Radiating Systems by E. C. Jordan and K. G. Bahnain,Second Edition, Prentice Hall Inc., Tata McGraw Hill4. Principles ofE!ectromagnetics Mathhew N.O. Sadiku, Fourth Edition, OxfordUniversity Press.5. Electromagnetics with Applications Kraus and Fleisch, Fifth Edition, McGraw Hill,1999.	ELECTROMAGNETIC THEORY
EE340A	3-1-0-0-11		**Course Contents:** I. Overview of Static Electric and Magnetic Fields, Steady Electric Currents;2. TimeVarying Electromagnetic Fields, Maxwell's Equations, Boundary Conditions;3. Plane Electromagnetic Waves, Propagation in Free Space and in Matter;4. Reflection and Refraction ofWaves at Conducting and Dielectric Boundary;5. Transmission Lines: TEM waves, Transmission Line Equations, Wave Propagation alongFinite Transmission Lines, Transients on Lines, The Smith Chart;6. Waveguides, Waves in Guided Media, Parallel Plate Waveguide, Rectangular Waveguide,Cavity Resonators;7. Basic Theory of Antennas and Radiation Characteristics, Elementary Types of Antennas. **References/Text Books:** I. Field and Wave Electromagnetics David K. Cheng, Second Edition, PearsonEducation, 2008.2. Engineering Electromagnetics W A Haytt & J A Buck, Seventh Edition, Tata McGrawHill, 2006.3. Electromagnetic Waves and Radiating Systems by E. C. Jordan and K. G. Bahnain,Second Edition, Prentice Hall Inc., Tata McGraw Hill4. Principles ofE!ectromagnetics Mathhew N.O. Sadiku, Fourth Edition, OxfordUniversity Press.5. Electromagnetics with Applications Kraus and Fleisch, Fifth Edition, McGraw Hill,1999.	ELECTROMAGNETIC THEORY
EE360	3-0-3-0-4		**Course Contents:** 1. Power Electronics components: Switching characteristics of power devices e.g. diodes, thyristors, GTOs, MOS transistors, IGBTs etc; snubber circnits, calculation of switching losses, resonantZVS and ZCS switching, calculation of device losses, magnetic components, capacitors.2. Controlled Converters: Basic Single phase and three phase rectifier configurations, various modesof operation, a.c .regulators, and reactive power compensators.3. Inverters: Basic Single phase and three phase VSI confignrations, modulation techniques forvoltage control, Basic CSI configurations and their operation.4. DCDC converters: Steadystate and dynamic analysis of Buck, Boost, BuckBoost and Cukconverters, switchmode power supplies. **References/Text Books:**	POWER ELECTRONICS
EE360A	3-0-0-0-9	ESC201A	**Course Contents:** 1. Power Electronics components: Switching characteristics of power devices e.g. diodes, thyristors, GTOs, MOS transistors, IGBTs etc; snubber circnits, calculation of switching losses, resonantZVS and ZCS switching, calculation of device losses, magnetic components, capacitors.2. Controlled Converters: Basic Single phase and three phase rectifier configurations, various modesof operation, a.c .regulators, and reactive power compensators.3. Inverters: Basic Single phase and three phase VSI confignrations, modulation techniques forvoltage control, Basic CSI configurations and their operation.4. DCDC converters: Steadystate	POWER ELECTRONICS

			and dynamic analysis of Buck, Boost, BuckBoost and Cukconverters, switchmode power supplies. **References/Text Books:**	
EE370	3-1-0-0-4		**Course Contents:** Digital and Analogue, Boolean and Binary Metric for Digital Circuits and Systems Transistors, Inverters, CMOS Inverter Inverter Parameters and design CombinatinaiCircuits, Logic Gates, NAND, NOR, XOR Logic Families, Static and Dynamic CMOSDesigns Sequential Circuit, Bi stability, Registers, Latches and Flipflop PipeliningArrayBased Logic Implementations Memories, Organisation, Cell Designs, Peripherals Digital Systems, CPU Register Transfers and Data Paths Sequencing and Control Instruction Sets Introduction to MicroprocessorsIntroduction to circuit simulators (SPICE) and hardware description languages (HDL) suchas VHDL and Verilog at appropriate places in the course. Software to be used for solvinghomework assignment problems, including some design problems. **References/Text Books:**	DIGITAL ELECTRONICS & MICROPROCESSOR TECHNOLOGY
EE370A	3-1-0-0-11		**Course Contents:** Digital and Analogue, Boolean and Binary Metric for Digital Circuits and Systems Transistors, Inverters, CMOS Inverter Inverter Parameters and design CombinatinaiCircuits, Logic Gates, NAND, NOR, XOR Logic Families, Static and Dynamic CMOSDesigns Sequential Circuit, Bi stability, Registers, Latches and Flipflop PipeliningArrayBased Logic Implementations Memories, Organisation, Cell Designs, Peripherals Digital Systems, CPU Register Transfers and Data Paths Sequencing and Control Instruction Sets Introduction to MicroprocessorsIntroduction to circuit simulators (SPICE) and hardware description languages (HDL) suchas VHDL and Verilog at appropriate places in the course. Software to be used for solvinghomework assignment problems, including some design problems. **References/Text Books:**	DIGITAL ELECTRONICS
EE380	0-2-6-0-4		**Course Contents:** Experiments from various areas of Electrical Engineering with emphasis on electronicdevices, circuits, control systems and machines.This course has three labs: Electronic Circuits Lab. (7 experiments),Control Systems Lab. (6 experiments) and EMEC Lab.(6 experiments) **References/Text Books:**	ELECTRICAL ENGINEERING LAB I
EE380.	0-2-6--4	ESC102N ESO210 EE210 EE250	**Course Contents:** Experiments from various areas of Electrical Engineering with emphasis on electronicdevices, circuits, control systems and machines.This course has three labs: Electronic Circuits Lab. (7 experiments),Control Systems Lab. (6 experiments) and EMEC Lab.(6 experiments) **References/Text Books:**	ELECTRICAL ENGINEERING LAB I
EE380A	0-2-6-0-12	ESC201AESO203AEE210A EE250A	**Course Contents:** Experiments from various areas of Electrical Engineering with emphasis on electronicdevices, circuits, control systems and machines.This course has three labs: Electronic Circuits Lab. (7 experiments),Control Systems Lab. (6 experiments) and EMEC Lab.(6 experiments) **References/Text Books:**	ELECTRICAL ENGINEERING LAB I
EE381	0-2-6-0-4	EE380	**Course Contents:** Experiments from various areas of Electrical Engineering with emphasis on digitalelectronics, communication, machines, drives and power systems, and electromagnetics.This course has three labs:	ELECTRICAL ENGINEERING LAB II

			Electronic Circuits Lab.II (7 experiments),DCMP Lab. (7 experiments) and EMEC Lab.(6 experiments) **References/Text Books:**	
EE381A	0-3-6-0-12	EE380A	**Course Contents:** Experiments from various areas of Electrical Engineering with emphasis on digitalelectronics, communication, machines, drives and power systems, and electromagnetics.This course has three labs: Electronic Circuits Lab.II (7 experiments),DCMP Lab. (7 experiments) and EMEC Lab.(6 experiments) **References/Text Books:**	ELECTRICAL ENGINEERING LABORATORY -II
EE390A	0-0-2-0-2		**Course Contents:** Technical Communication, definition and attributes. Ethics in communication. Technical Writing. Report and Article composition. How to write a Technical Brochure. Writing summary and abstracts of technical documents. Software tools for technical report writing. Listening Comprehension. Oral Communication and Presentation. Technical Presentation and use of multimedia. **References/Text Books:**	ELECTRICAL ENGINEERING COMMUNICATION SKILLS
EE392A	0-0-0-0-9		**Course Contents:** UG PROJECT (UGP II) **References/Text Books:**	UNDER GRADUATE PROJECT II
EE393A	0-0-2-0-4		**Course Contents:** ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT I **References/Text Books:**	ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT I
EE395A	0-0-0-0-9		**Course Contents:** ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT III **References/Text Books:**	ELECTRICAL ENGINEERING UNDER GRADUATE PROJECT III
EE399A	0-0-0-2-2		**Course Contents:** ELECTRICAL ENGINEERING COMMUNICATION SKILLS **References/Text Books:**	ELECTRICAL ENGINEERING COMMUNICATION SKILLS
EE416	3-0-0--4	EE210 EE340	**Course Contents:** LEDs, semiconductor lasers, modulation of laser sources. Avalanche and PINphotodetectors and their characteristics. Solar cells. Optical fibers and theircharacteristics. Integrated optics. Fiber optic communication systems, systemdesign consideration. **References/Text Books:**	OPTO-ELECTRONICS
EE416A	3-0-0-0-9		**Course Contents:** LEDs, semiconductor lasers, modulation of laser sources. Avalanche and PIN photodetectors and their characteristics. Solar cells. Optical fibers and their characteristics. Integrated optics. Fiber optic communication systems, system design consideration. **References/Text Books:**	OPTO-ELECTRONICS
EE442A	3-0-0-0-9		**Course Contents:**	ANTENNAS AND

			Retarded potential, radiation from current element and dipole, radiationpatterns, impedance, reciprocity. Various types of antennas, interferometers andmultielement arrays, Antenna Measurements. Ground wave propagation, terrainand earth curvature effects.Tropospheric propagation; fading, diffraction andscattering; Ionospheric Propagationrefractive index, critical frequencies, effectsof magnetic field. **References/Text Books:**	PROPAGATION
EE455	3-0-0--4		**Course Contents:** Measurement process; scales of measurement; configuration and functionaldescription of measurement systems; performance characteristics; sensingelements and transducers for measurement of motion, force, pressure, flow,temperature, light, vacuum, etc.; transducer interfacing; signal conditioning,transmission and recording; microprocessor based instrumentation. **References/Text Books:**	TRANSDUCERSAND INSTRUMENTATION
EE490.	0-0-0--8		**Course Contents:** PROJECT WORK **References/Text Books:**	PROJECT WORK
EE491	0-0-0--3		**Course Contents:** PROJECT I **References/Text Books:**	PROJECT I
EE491A	0-0-0-0-9		**Course Contents:** UG PROJECT (UGPIII) **References/Text Books:**	UNDER GRADUATE PROJECT -III
EE492	0-0-0--5	EE491	**Course Contents:** PROJECT II **References/Text Books:**	PROJECT II
EE600	3-0-0--4	#	**Course Contents:** Nature of definitions; Theory of measurement and scales; Symmetry, invarianceand groups; Groups in signals and systems; Algebraic and relational structuresof signal spaces and convolutional systems; Representation theory of groups,harmonic analysis and spectral theory for convolutional systems. **References/Text Books:**	MATHEMATICAL STRUCTURES OF SIGNALS & SYSTEMS
EE600A	3-0-0-0-9		**Course Contents:** Nature of definitions; Theory of measurement and scales; Symmetry, invarianceand groups; Groups in signals and systems; Algebraic and relational structuresof signal spaces and convolutional systems; Representation theory of groups,harmonic analysis and spectral theory for convolutional systems. **References/Text Books:**	MATHEMATICAL STRUCTURES OF SIGNALS & SYSTEMS
EE601	3-0-0--4	#	**Course Contents:** Generalized inverses, regularization of illposed problems. Eigen and singularvalue decompositions, generalized problems. Interpolation and approximationby least squares and minimax error criteria.	MATHEMATICAL METHODS IN SIGNAL PROCESSING

			Optimization techniques for linearand nonlinear problems. Applications in various areas of signal processing. **References/Text Books:**	
EE601A	3-0-0-0-9		**Course Contents:** Generalized inverses, regularization of illposed problems. Eigen and singularvalue decompositions, generalized problems. Interpolation and approximationby least squares and minimax error criteria. Optimization techniques for linearand nonlinear problems. Applications in various areas of signal processing. **References/Text Books:**	MATHEMATICAL METHODS IN SIGNAL PROCESSING
EE602	3-0-0--4		**Course Contents:** Power Spectrum EstimationParametric and Maximum Entropy Methods, Wiener,Kalman Filtering, LevinsonDurban Algorithms Least Square Method, AdaptiveFiltering, Nonstationary Signal Analysis, WignerVille Distribution, WaveletAnalysis. **References/Text Books:**	STATISTICAL SIGNAL PROCESSING-I
EE602A	3-0-0-0-9		**Course Contents:** Power Spectrum EstimationParametric and Maximum Entropy Methods, Wiener,Kalman Filtering, LevinsonDurban Algorithms Least Square Method, AdaptiveFiltering, Nonstationary Signal Analysis, WignerVille Distribution, WaveletAnalysis. **References/Text Books:**	STATISTICAL SIGNAL PROCESSING-I
EE604	3-0-0--4	#	**Course Contents:** Human visual system and image perception, monochrome & colour visionmodels, colour representation ; image sampling & quantization; 2D systems;image transforms; image coding; stochastic models for image representation;image enhancement, restoration & reconstruction. Image analysis usingmultiresolution techniques. **References/Text Books:**	IMAGE PROCESSING
EE604A	3-0-0-0-9		**Course Contents:** Human visual system and image perception, monochrome & colour visionmodels, colour representation ; image sampling & quantization; 2D systems;image transforms; image coding; stochastic models for image representation;image enhancement, restoration & reconstruction. Image analysis usingmultiresolution techniques. **References/Text Books:**	IMAGE PROCESSING
EE605	3-0-0--4		**Course Contents:** Discrete and Continuous time signals and systems, LTI systems, Convolution,Difference equations. Frequency domain representation: Fourier transform andits properties. Random discrete signals. Sampling and reconstruction: Changeof sampling rate. Normed vector spaces, basis, linear independence, orthogonality.Linear systems of equations. Over and Underdetermined systems. Row andColumn spaces, Null spaces. Least square and minimum norm solutions. Inverseand pseudo inverse, Symmetry transformations. Eigenvectors and eigenvalues.Hilbert transforms, band pass representations and complex envelope. Base bandpulse transmission, matched filtering, ISI, equalization. Coherent and noncoherentdetection. **References/Text Books:**	INTRODUCTION TO SIGNAL ANALYSIS

EE605A	3-0-0-0-9		**Course Contents:** Discrete and Continuous time signals and systems, LTI systems, Convolution,Difference equations. Frequency domain representation: Fourier transform andits properties. Random discrete signals. Sampling and reconstruction: Changeof sampling rate. Normed vector spaces, basis, linear independence, orthogonality.Linear systems of equations. Over and Underdetermined systems. Row andColumn spaces, Null spaces. Least square and minimum norm solutions. Inverseand pseudo inverse, Symmetry transformations. Eigenvectors and eigenvalues.Hilbert transforms, band pass representations and complex envelope. Base bandpulse transmission, matched filtering, ISI, equalization. Coherent and noncoherentdetection. **References/Text Books:**	INTRODUCTION TO SIGNAL ANALYSIS
EE606	3-0-3-0-5		**Course Contents:** DSP Architecture: Von Neumann vs. Harvard architecture, VelociTI architecture Memory management of Tl DSP processors C2X, C6X. Peripheral overview of Tl C2X, C6X processor. Code Composer Studio (CCS) overview, writing simple programs in assembly, linear assembly and C. Instruction set of Tl C2X/C6X processor. Optimization of assembly and C code. Pipelining. General Extension Language (GEL). Assembler, Linker. Interrupts RTDX. DSP/BIOSList of Experiments Introduction to Code Composer Studio1 Introduction to Code Composer Studio11 Introduction to the Addressing Modes FFT and Bit Reversal Operation FFT and its Applications Audio Codec and its Applications Real Time Data Exchange Using Matlab and Labview FIR filtering by interfacing Matlab with Code Composer Studio Introduction to Interrupts Digital communication using Binary Phase Shift Keying Current control of a threephase inverter with passive load Current control of a singlephase inverter with passive load PLL for a threephase ac system PLL for a singlephase system Current control of a threephase STA TCOM Speed control of an induction motor by V/f method **References/Text Books:** Rulph Chassaing, "Digital Signal Processing And Applications With The C6713 And C6416 DSK", Wileylnterscience, 2004. Thad B. Welch, Wright, H.G. Cameron, and Michael G. Morrow, "Real Time DigitalSignal Processing from Matlab to C with the TMS320C6x DSK', CRC, 2005. Steven A. Tretter, "Communication System Design Using DSP Algorithms:With Laboratory Experiments for the TMS320C6701 and TMS320C6711", Springer, 2003. Nasser Kehtarnavaz, "RealTime Digital Signal Processing Based On The TMS320C6000", Newnes Publishers, 2004. Rulph Chassaing, "DSP Applications Using C And The TMS320C6x DSK", Wiley Interscience, 2002. Shehrzad Qureshi, "Embedded Image Processing On The TMS320C6000 DSP: Examples in Code Composer Studio and MATLAB", Springer, 2006.	ARCHITECTURE AND APPLICATIONS OF DIGITAL SIGNAL PROCESSORS
EE606A	3-0-3-0-5		**Course Contents:** DSP Architecture: Von Neumann vs. Harvard architecture, VelociTI architecture Memory management of Tl DSP processors C2X, C6X. Peripheral overview of Tl C2X, C6X processor. Code Composer Studio (CCS) overview, writing simple programs in assembly, linear assembly and C. Instruction set of Tl C2X/C6X processor. Optimization of assembly and C code. Pipelining. General Extension Language (GEL). Assembler, Linker. Interrupts RTDX. DSP/BIOSList of Experiments Introduction to Code Composer Studio1 Introduction to Code Composer Studio11 Introduction to the Addressing Modes FFT and Bit Reversal Operation FFT and its Applications Audio Codec and its Applications Real Time Data Exchange Using Matlab and Labview FIR filtering by interfacing Matlab with Code Composer Studio Introduction to Interrupts Digital communication using Binary Phase Shift Keying Current control of a threephase inverter with passive load Current control of a singlephase inverter with passive load PLL for a threephase ac system PLL for a singlephase system Current control of a threephase STA TCOM Speed control of an induction motor by V/f method **References/Text Books:** Rulph Chassaing, "Digital Signal Processing And Applications With The C6713 And C6416 DSK",	ARCHITECTURE AND APPLICATIONS OF DIGITAL SIGNAL PROCESSORS

			WileyInterscience, 2004. Thad B. Welch, Wright, H.G. Cameron, and Michael G. Morrow, "Real Time DigitalSignal Processing from Matlab to C with the TMS320C6x DSK', CRC, 2005. Steven A. Tretter, "Communication System Design Using DSP Algorithms:With Laboratory Experiments for the TMS320C6701 and TMS320C6711", Springer, 2003. Nasser Kehtarnavaz, "RealTime Digital Signal Processing Based On The TMS320C6000", Newnes Publishers, 2004. Rulph Chassaing, "DSP Applications Using C And The TMS320C6x DSK", Wiley lnterscience, 2002. Shehrzad Qureshi, "Embedded Image Processing On The TMS320C6000 DSP: Examples in Code Composer Studio and MATLAB", Springer, 2006.	
EE607	3-0-0--4	#	**Course Contents:** Basics of functional Analysis; Basics of Fourier Analysis; Spectral Theory; TimeFrequency representations; Nonstationary Processes; Continuous WaveletTransforms; Discrete TimeFrequency Transforms; Multi resolution Analysis;TimeFrequency Localization; Signal Processing Applications; Image ProcessingApplications **References/Text Books:**	WAVELET TRANSFORMS FOR SIGNAL & IMAGE PROCESSING
EE607A	3-0-0-0-9		**Course Contents:** Basics of functional Analysis; Basics of Fourier Analysis; Spectral Theory; TimeFrequency representations; Nonstationary Processes; Continuous WaveletTransforms; Discrete TimeFrequency Transforms; Multi resolution Analysis;TimeFrequency Localization; Signal Processing Applications; Image ProcessingApplications **References/Text Books:**	WAVELET TRANSFORMS FOR SIGNAL & IMAGE PROCESSING
EE608	3-0-0--4	#	**Course Contents:** Representation of digital video including modeling of video image formation, spatiatemporal sampling over lattices, conversion of signals sampled on different lattices and sampling rate conversion of video signals.Twodimensional Motion Estimation: 2D Motion vs Apparent Motion, occlusion/Aperture problems, 2D Motion field Models, optical flow methods; blockbased methods, pelrecursive methods and Bayesian methods.Video filtering: Motion compensated filtering, including spatiatemporal spectrum, filtering along motion trajectories; Nois.e filtering, Video Restoration, including Modeling, Intraframe shift invariant I variant restoration, multiframe restoration; Standards conversion including practical Up/Down conversion Methods.Video compression: Basic concepts and techniques of video coding, lnterframe CompressionMethods, Video Compression Standards (MPEG2, MPEG4, H.264) Low bit rate Video Codecs,Embedded Video Codecs, Scalable Video coding. **References/Text Books:** 1. "Image and Video Processing", A.I. Bovik, Elosovier Academic Press, 2005.2. "Digital Pictures", A.N. Netravali, B.G. Haskell, Plenum Press, 1997.3. "Digital Video Transcoding", H. Sun, X. Chen and T. Chiang, CRC Press 2005.4. "Digital Video Processing", A. Murat Tekalp, Prentice Hall Signal Processing Series, 1995.5. "Wireless Video Communications", L. Hanzo, P.J. Cherriman, J. Streit, IEEE Series onDigital and Mobile Communication, 200 1 .	DIGITAL VIDEO SIGNAL PROCESSING
EE608A	3-0-0-0-9		**Course Contents:** Representation of digital video including modeling of video image formation, spatiatemporal sampling over lattices, conversion of signals sampled on different lattices and sampling rate conversion of video signals.Twodimensional Motion Estimation: 2D Motion vs Apparent Motion, occlusion/Aperture problems, 2D Motion field Models, optical flow methods; blockbased methods, pelrecursive methods and Bayesian methods.Video filtering: Motion compensated filtering, including spatiatemporal spectrum, filtering along motion trajectories; Nois.e filtering, Video Restoration, including Modeling, Intraframe shift invariant I variant restoration, multiframe restoration; Standards conversion including practical Up/Down conversion Methods.Video compression: Basic concepts and techniques of video coding, lnterframe	DIGITAL VIDEO SIGNAL PROCESSING

			CompressionMethods, Video Compression Standards (MPEG2, MPEG4, H.264) Low bit rate Video Codecs,Embedded Video Codecs, Scalable Video coding. **References/Text Books:** 1. "Image and Video Processing", A.I. Bovik, Elosovier Academic Press, 2005.2. "Digital Pictures", A.N. Netravali, B.G. Haskell, Plenum Press, 1997.3. "Digital Video Transcoding", H. Sun, X. Chen and T. Chiang, CRC Press 2005.4. "Digital Video Processing", A. Murat Tekalp, Prentice Hall Signal Processing Series, 1995.5. "Wireless Video Communications", L. Hanzo, P.J. Cherriman, J. Streit, IEEE Series onDigital and Mobile Communication, 200 1 .	
EE610	3-0-0--4	#	**Course Contents:** Analog MOS circuits, opamps, frequency and transient responses, stability andcompensation. Analog switches, sampleandhold circuits, switchedcapacitorcircuits. MOS inverters and gate circuits, interfacing, transmission gates. MOSmemory circuits. Digital building blocks multiplexers, decoders, shift registers,etc. Gate array, standard cell, and PLA based designs. Digital toAnalog andAnalogtoDigital converters. **References/Text Books:**	ANALOG/DIGITAL VLSI CIRCUITS
EE610A	3-0-0-0-9		**Course Contents:** Analog MOS circuits, opamps, frequency and transient responses, stability andcompensation. Analog switches, sampleandhold circuits, switchedcapacitorcircuits. MOS inverters and gate circuits, interfacing, transmission gates. MOSmemory circuits. Digital building blocks multiplexers, decoders, shift registers,etc. Gate array, standard cell, and PLA based designs. Digital toAnalog andAnalogtoDigital converters. **References/Text Books:**	ANALOG/DIGITAL VLSI CIRCUITS
EE611	3-0-0--4	#	**Course Contents:** Lectures: General Overview of Organic Semiconductors and Electronics; Introduction to some of the basics of Molecular Quantum Mechanics; Optical and Electrical Properties of Organic Semiconductor Material; Organic Thin Film Transistor (OTFT) physics and processing; Organic Light Emitting Diode (OLED) physics and processing; OLED passive and active matrix displays, OTFT circuits;Organic Solar Cell physics and processing; Research opportunities in organic electronics and the associated technologies.Labs: Fabrication of an organic device and its characterisation **References/Text Books:** The purpose of this course is (i) to give the student an introduction to the world of organi electronics and (ii) to help students appreciate practical organic electronic devices and th associated technologies.This course was started for the first time by Prof. Baquer Mazhari who offered it as EE698A I Spring 2005 and 2006. It was offered as EE698W by Dr. S. Sundar Kumar Iyer in Spring 2007 Summer courses have also been offered on this topic in the summers of 2005, 2006 and 2007 bhe faculty members involved in Samtel Centre for Display Technology, liT Kanpur	ORGANIC ELECTRONICS
EE611A	3-0-3-0-12		**Course Contents:** Lectures: General Overview of Organic Semiconductors and Electronics; Introduction to some of the basics of Molecular Quantum Mechanics; Optical and Electrical Properties of Organic Semiconductor Material; Organic Thin Film Transistor (OTFT) physics and processing; Organic Light Emitting Diode (OLED) physics and processing; OLED passive and active matrix displays, OTFT circuits;Organic Solar Cell physics and processing; Research opportunities in organic electronics and the associated technologies.Labs: Fabrication of an organic device and its characterisation **References/Text Books:** The purpose of this course is (i) to give the student an introduction to the world of organi electronics and (ii) to help students appreciate practical organic electronic devices and th associated technologies.This course	ORGANIC ELECTRONICS

			was started for the first time by Prof. Baquer Mazhari who offered it as EE698A I Spring 2005 and 2006. It was offered as EE698W by Dr. S. Sundar Kumar Iyer in Spring 2007 Summer courses have also been offered on this topic in the summers of 2005, 2006 and 2007 bhe faculty members involved in Samtel Centre for Display Technology, liT Kanpur	
EE612	3-0-0--4	#	**Course Contents:** Review of semiconductor physics radiative recombination. LEDs, optical cavity,DH and other lasers. PIN and APD detectors, detector noise. Optical fibers ray and mode theories, multimode and singlemode fibers, attenuation,dispersion. Gaussian beams. Power coupling, splices and connectors. **References/Text Books:**	FIBER OPTIC SYSTEMS I
EE612A	3-0-0-0-9		**Course Contents:** Review of semiconductor physics radiative recombination. LEDs, optical cavity,DH and other lasers. PIN and APD detectors, detector noise. Optical fibers ray and mode theories, multimode and singlemode fibers, attenuation,dispersion. Gaussian beams. Power coupling, splices and connectors. **References/Text Books:**	FIBER OPTIC SYSTEMS I
EE614	3-0-0--4	#	**Course Contents:** Basic semiconductor physics. Diodes (PN junction, Schottky, contact), JunctionTransistors (BJT, HBT), Field Effect Transistors (JEFT, MESFET, MOSFET, HEMT).Other semiconductor devices. **References/Text Books:**	SOLID STATE DEVICES I
EE614A	3-0-0-0-9		**Course Contents:** Basic semiconductor physics. Diodes (PN junction, Schottky, contact), JunctionTransistors (BJT, HBT), Field Effect Transistors (JEFT, MESFET, MOSFET, HEMT).Other semiconductor devices. **References/Text Books:**	SOLID STATE DEVICES I
EE615	3-0-0--4	EE614	**Course Contents:** Review of Semiconductor properties Crystal structure of semiconductors, bandtheory, occupation statistics, electrical properties, optical properties, recombinationkinetics, avalanche process in semiconductors, photon statistics; MESFETs;Transport in low dimensional structures: HEMTs: Hetrojunction BJTs; Design ofhigh frequency amplifiers and oscillators, Resonant tunneling structures, RTDoscillators; Intervalley scattering, Gunn diodes, IMPATT diodes; TRAPATTs; Mixerdiodes; Step recovery diodes; Introduction to epitaxial growth for thesestructures; elements of device fabrication. **References/Text Books:**	HIGH FREQUENCY SEMICONDUCTOR DEVICES AND CIRCUITS
EE616	3-0-0--4	#	**Course Contents:** Models for metalsemiconductor contacts and heterojunctions. MOSFET quantum theory of 2DEG, gradual channel approximation, charge control models,BSIM model, secondorder effects. MESFETShockley, velocity saturation anduniversal models. HEFT Basic and universal models. SPICE and smallsignalmodels. **References/Text Books:**	SEMICONDUCTOR DEVICE MODELLING
EE616A	3-0-0-0-9		**Course Contents:** Models for metalsemiconductor contacts and heterojunctions. MOSFET quantum theory of 2DEG, gradual channel approximation, charge control models,BSIM model, secondorder effects. MESFETShockley, velocity saturation anduniversal models. HEFT Basic and universal models. SPICE and smallsignalmodels.	SEMICONDUCTOR DEVICE MODELLING

			References/Text Books:	
EE618	3-0-0--4	#	**Course Contents:** IC components their characterization and design. Anaysis and design of basiclogic circuits. Linear ICs. Large Scale Integration. Computer simulation of ICsand layout design. High Voltage ICs. GaAs MESFET and GaAs ICs. Failure,reliability and yield of ICs. Fault modeling and testing. **References/Text Books:**	INTEGRATED CIRCUIT FABRICATION TECHNOLOGY
EE618A	3-0-0-0-9		**Course Contents:** IC components their characterization and design. Anaysis and design of basiclogic circuits. Linear ICs. Large Scale Integration. Computer simulation of ICsand layout design. High Voltage ICs. GaAs MESFET and GaAs ICs. Failure,reliability and yield of ICs. Fault modeling and testing. **References/Text Books:**	INTEGRATED CIRCUIT FABRICATION TECHNOLOGY
EE619	3-0-0-0-4		**Course Contents:** Emphasis on the synthesis based approach to VLSI Design. Relevant issues relatedto physical design automation such as placement, floor planning, routing andcompaction are covered. Combinational & sequential logic synthesis issues andalgotithms are discussed. Detailed coverage of HDLs and high level synthesisalgorithms and issues. **References/Text Books:**	VLSI SYSTEM DESIGN
EE619A	3-0-0-0-9		**Course Contents:** Emphasis on the synthesis based approach to VLSI Design. Relevant issues relatedto physical design automation such as placement, floor planning, routing andcompaction are covered. Combinational & sequential logic synthesis issues andalgotithms are discussed. Detailed coverage of HDLs and high level synthesisalgorithms and issues. **References/Text Books:**	VLSI SYSTEM DESIGN
EE621	3-0-0--4		**Course Contents:** Review of probability, random variables, random processes; representation ofnarrow band signals. Transmission of signals through LTI systems; Estimationand detection with random sequences; BAYES, MMSE, MAP, ML schemes. KLand sampling theorem representations, matched filter, ambiguity functions,Markov sequences, linear stochastic dynamical systems. **References/Text Books:**	REPRESENTATION AND ANALYSIS OF RANDOM SIGNALS
EE621A	3-0-0-0-9		**Course Contents:** Review of probability, random variables, random processes; representation ofnarrow band signals. Transmission of signals through LTI systems; Estimationand detection with random sequences; BAYES, MMSE, MAP, ML schemes. KLand sampling theorem representations, matched filter, ambiguity functions,Markov sequences, linear stochastic dynamical systems. **References/Text Books:**	REPRESENTATION AND ANALYSIS OF RANDOM SIGNALS
EE622	3-0-0--4	#	**Course Contents:** Rate Distortion Theory, Channel Coding Theorems, Digital Modulation Schemes,Trellis Coded Modulation, Digital Transmission over Bandlimited Channels, FadingMultipath Channels, Synchronization. Analog Modulation Schemes, Optimum/Suboptimum Receivers; Diversity Combining; Cellular Mobile	COMMUNICATION THEORY

			Communciation;Equalization. **References/Text Books:**	
EE622A	3-0-0-0-9		**Course Contents:** Rate Distortion Theory, Channel Coding Theorems, Digital Modulation Schemes,Trellis Coded Modulation, Digital Transmission over Bandlimited Channels, FadingMultipath Channels, Synchronization. Analog Modulation Schemes, Optimum/Suboptimum Receivers; Diversity Combining; Cellular Mobile Communciation;Equalization. **References/Text Books:**	COMMUNICATION THEORY
EE623	3-0-0--4	#	**Course Contents:** Classical Detection and Estimation Theory, Signal Representation, Detection ofsignals in Gaussian noise, Waveform estimation, Linear estimation problems,Wiener filtering, Kalman filtering. **References/Text Books:**	DETECTION & ESTIMATION THEORY
EE623A	3-0-0-0-9		**Course Contents:** Classical Detection and Estimation Theory, Signal Representation, Detection ofsignals in Gaussian noise, Waveform estimation, Linear estimation problems,Wiener filtering, Kalman filtering. **References/Text Books:**	DETECTION & ESTIMATION THEORY
EE624	3-0-0--4	#	**Course Contents:** Entropy and mutual information, rate distortion function, source coding, variablelength coding, discrete memoryless channels, capacity cost functions, channelcoding, linear block codes, cyclic codes. Convolutional codes, sequential andprobabilistic decoding, majority logic decoding, burst errorcorrecting codes. **References/Text Books:**	INFORMATION AND CODING THEORY
EE624A	3-0-0-0-9		**Course Contents:** Entropy and mutual information, rate distortion function, source coding, variablelength coding, discrete memoryless channels, capacity cost functions, channelcoding, linear block codes, cyclic codes. Convolutional codes, sequential andprobabilistic decoding, majority logic decoding, burst errorcorrecting codes. **References/Text Books:**	INFORMATION AND CODING THEORY
EE626	3-0-0--4	EE621	**Course Contents:** Martingale convergence theorem, stopping times, sequential analysis. ErgodicTheory: Measure preserving transformations, stationary processes, mixingconditions, ergodic theorem, ShannonMillanBreiman theorem. Markov chainsasymptoticstationarity, indecomposability, ergodicity. Continuous time processes:Separability, continuity, measurability, stochastic integral. **References/Text Books:**	TOPICS IN STOCHASTIC PROCESSES
EE626A	3-0-0-0-9		**Course Contents:** Martingale convergence theorem, stopping times, sequential analysis. ErgodicTheory: Measure preserving transformations, stationary processes, mixingconditions, ergodic theorem, ShannonMillanBreiman theorem. Markov chainsasymptoticstationarity, indecomposability, ergodicity. Continuous time processes:Separability, continuity, measurability, stochastic integral. **References/Text Books:**	TOPICS IN STOCHASTIC PROCESSES

EE627	3-0-0-0-4		**Course Contents:** Spectral and nonspectral analysis techniques; Modelbased coding techniques;Noise reduction and echo cancellation; Synthetic and coded speech qualityassessment; Selection of recognition unit; Modelbased recognition; Languagemodelling; Speaker Identification; Text analysis and texttospeech synthesis. **References/Text Books:**	SPEECH SIGNAL PROCESSING
EE627A	3-0-0-0-9		**Course Contents:** Spectral and nonspectral analysis techniques; Modelbased coding techniques;Noise reduction and echo cancellation; Synthetic and coded speech qualityassessment; Selection of recognition unit; Modelbased recognition; Languagemodelling; Speaker Identification; Text analysis and texttospeech synthesis. **References/Text Books:**	SPEECH SIGNAL PROCESSING
EE628	3-0-0--4	#	**Course Contents:** Cryptography and error control coding in communication and computing systems.Stream and block ciphers; DES; publickey cryptosystems; key management,authentication and digital signatures. Codes as ideals in finite commutativerings and group algebras. Joint coding and cryptography. **References/Text Books:**	TOPICS IN CRYPTOGRAPHY AND CODING
EE629	3-0-0--4		**Course Contents:** Network Architecture; time division multiplexing; digital switching; space & timedivision switching, cross point and memory requirements; blocking probabilities.traffic Analysis, models for circuit and packet switched systems, performancecomparison; ISDN. **References/Text Books:**	DIGITAL SWITCHING
EE629A	3-0-0-0-9		**Course Contents:** Network Architecture; time division multiplexing; digital switching; space & timedivision switching, cross point and memory requirements; blocking probabilities.traffic Analysis, models for circuit and packet switched systems, performancecomparison; ISDN. **References/Text Books:**	DIGITAL SWITCHING
EE630	3-0-3-0-5		**Course Contents:** Modern power systems operation and control, Power system deregulation; staticand dynamic modeling; Load flow and stability studies; Electromagneticphenomenon; Insulation and partial discharge. **References/Text Books:**	SIMULATON OF MODERN POWER SYSTEMS
EE630A	3-0-3-0-12		**Course Contents:** Modern power systems operation and control, Power system deregulation; staticand dynamic modeling; Load flow and stability studies; Electromagneticphenomenon; Insulation and partial discharge. **References/Text Books:**	SIMULATON OF MODERN POWER SYSTEMS
EE631	3-0-0--4	#	**Course Contents:** Detailed machine modeling, Modeling of turbinegenerator and associatedsystems, excitation systems and PSS, Transient stability and small signal stabilityfor large systems, SSR and system modeling for SSR studies, Voltage stability:PV and QV curves, static analysis, sensitivity and continuation method; Dynamicanalysis, local and global bifurcations, Control area, Margin prediction, Stabilityof ACDC systems.	ADVANCED POWER SYSTEM STABILITY

			References/Text Books:	
EE631A	3-0-0-0-9		**Course Contents:** Detailed machine modeling, Modeling of turbinegenerator and associatedsystems, excitation systems and PSS, Transient stability and small signal stabilityfor large systems, SSR and system modeling for SSR studies, Voltage stability:PV and QV curves, static analysis, sensitivity and continuation method; Dynamicanalysis, local and global bifurcations, Control area, Margin prediction, Stabilityof ACDC systems. **References/Text Books:**	ADVANCED POWER SYSTEM STABILITY
EE632	3-0-0--4	#	**Course Contents:** Economic load dispatch, loss formula, introduction to mathematical programming,hydrothermal scheduling systems, power system security, optimal real andreactive power dispatch, state estimation, load frequency control, energy controlcenter. **References/Text Books:**	ECONOMIC OPERATION & CONTROL OF POWER SYSTEMS
EE632A	3-0-0-0-9		**Course Contents:** Economic load dispatch, loss formula, introduction to mathematical programming,hydrothermal scheduling systems, power system security, optimal real andreactive power dispatch, state estimation, load frequency control, energy controlcenter. **References/Text Books:**	ECONOMIC OPERATION & CONTROL OF POWER SYSTEMS
EE633	3-0-0--4	#	**Course Contents:** Fundamentals of deregulation: Privatization and deregulation, Motivations forRestructuring the Power industry; Restructuring models and Trading Arrangements:Components of restructured systems, Independent System Operator (ISO):Functions and responsibilities, Trading arrangements (Pool, bilateral & multilateral),Open Access Transmission Systems; Different models of deregulation: U K Model,California model, Australian and New Zealand models, Deregulation in Asiaincluding India, Bidding strategies, Forward and Future market; Operation andcontrol: Old vs New, Available Transfer Capability, Congestion management,Ancillary services; Wheeling charges and pricing: Wheeling methodologies,pricing strategies. **References/Text Books:**	ELECTRIC POWER SYSTEM OPERATION AND MGMT. UNDER RESTRUCTURED ENVIRONMENT
EE633A	3-0-0-0-9		**Course Contents:** Fundamentals of deregulation: Privatization and deregulation, Motivations forRestructuring the Power industry; Restructuring models and Trading Arrangements:Components of restructured systems, Independent System Operator (ISO):Functions and responsibilities, Trading arrangements (Pool, bilateral & multilateral),Open Access Transmission Systems; Different models of deregulation: U K Model,California model, Australian and New Zealand models, Deregulation in Asiaincluding India, Bidding strategies, Forward and Future market; Operation andcontrol: Old vs New, Available Transfer Capability, Congestion management,Ancillary services; Wheeling charges and pricing: Wheeling methodologies,pricing strategies. **References/Text Books:**	ELECTRIC POWER SYSTEM OPERATION AND MGMT. UNDER RESTRUCTURED ENVIRONMENT
EE634	3-0-0--4	#	**Course Contents:** Properties of dielectrics and breakdown mechanisms ; composites and novelmaterials; insulators for outdoor applications. Issues in design of insulators and insulator systems. Overvoltages and insulation coordination in transmission networks. Generation and measurement of testing Voltages DC, AC, impulse andpulsed. Testing and Evaluation : Procedures and standards, ageing studies. On line and off line condition monitoring of substation equipment. Advances in measurement and diagnostic technologies : partial dischargemonitoring,	ELECTRICAL INSULATION IN POWER APPARATUS AND SYSTEMS

			space charge charge measurements, dielectric spectroscopy,etc. Lab demonstrations **References/Text Books:**	
EE634A	3-0-0-0-9		**Course Contents:** Properties of dielectrics and breakdown mechanisms ; composites and novelmaterials; insulators for outdoor applications. Issues in design of insulators and insulator systems. Overvoltages and insulation coordination in transmission networks. Generation and measurement of testing Voltages DC, AC, impulse andpulsed. Testing and Evaluation : Procedures and standards, ageing studies. On line and off line condition monitoring of substation equipment. Advances in measurement and diagnostic technologies : partial dischargemonitoring, space charge charge measurements, dielectric spectroscopy,etc. Lab demonstrations **References/Text Books:**	ELECTRICAL INSULATION IN POWER APPARATUS AND SYSTEMS
EE635	3-0-0--4	#	**Course Contents:** General aspects of DC transmission, converter circuits and their analysis, DClink controls, faults and abnormal operation and protection;Mechanism of activeand reactive power flow contro; Basic FACTS controllers: SVC, STATCOM, TCSC,TCPAR, UPFC; Modeling of FACTS Controllers; System static performanceimprovement with FACTS controllers; System dynamic performance improvementwith FACTS controllers **References/Text Books:**	HVDC TRANSMISSION & FLEXIBLE A C TRANSMISSION SYSTEMS
EE635A	3-0-0-0-9		**Course Contents:** General aspects of DC transmission, converter circuits and their analysis, DClink controls, faults and abnormal operation and protection;Mechanism of activeand reactive power flow contro; Basic FACTS controllers: SVC, STATCOM, TCSC,TCPAR, UPFC; Modeling of FACTS Controllers; System static performanceimprovement with FACTS controllers; System dynamic performance improvementwith FACTS controllers **References/Text Books:**	HVDC TRANSMISSION & FLEXIBLE A C TRANSMISSION SYSTEMS
EE636A	3-0-0-0-9		**Course Contents:** Advanced protective relaying, basic protection schemes, relay terminology, relays as comparators, static relays, application of solid state devices, differential relaying systems, distance relaying schemes, protection of multiterminal lines,new types of relaying criteria, special problems, digital protection. **References/Text Books:**	ADVANCED PROTECTIVE RELAYING
EE639	3-0-0-0-4		**Course Contents:** 1. Introduction: Linear vs Nonlinear effects in optical fiber, Important nonlinear effects and their impact on optical communication, applications of optical nonlinearities to signal processing2. Electromagnetic wave propagation in fibers: Wav_e equation for linear media, phase and group velocities, reflection and transmission of waves, structure of an optical fiber, wave equation in cylindrical coordinates, fiber modes, characteristics of LPm mode3. Dispersion in optical fibers: Chromatic dispersion in singlemode fibers, effect on pulse propagation, dispersion management and compensation, polarization mode dispersionfirst and second order models, effect on communication system , mitigation of PMD4. FourWave mixing (FWM): Mathematical description, phase matching, fiber parametric am plifiers using FWM, squeezed state and entangled photon pair generation using FWM , impact on communication system5. Nonlinear phase modulation: SelfPhase modulation, impact on communication system, modulation instability, CrossPhase modulation, impact on communication system6. Nonlinear Schrodinger equation (NLSE): Nonlinear polarization, nonlinear refractive in dex, derivation of NLSE, effect of dispersion only, effect of nonlinearity	NONLINEAR FIBER OPTICS

			only, soliton solutions,numerical .solution of the NLSE **References/Text Books:**	
EE640	3-0-0-0-4		**Course Contents:** Review of complex variables, conformal mappings, matrix calculus; SturmLiouville equation; Eigenvalue problem; Guiding structures; Scattering media;Greens function approach; Variational formulation, FEM, Generalised scatteringmatrix and planar circuit approach. **References/Text Books:**	COMPUTATIONAL ELECTROMAGNETICS
EE640A	3-0-0-0-9		**Course Contents:** Review of complex variables, conformal mappings, matrix calculus; SturmLiouville equation; Eigenvalue problem; Guiding structures; Scattering media;Greens function approach; Variational formulation, FEM, Generalised scatteringmatrix and planar circuit approach. **References/Text Books:**	COMPUTATIONAL ELECTROMAGNETICS
EE641	3-0-0--4	#	**Course Contents:** Transmission line theory; Greens function and integral transform techniques;Wave propagation and polarization parameters; reflection and transmissionacross an interface; waveguides, cavity resonators, scattering by cylinders,wedges, spheres etc. Geometric theory of diffraction. **References/Text Books:**	ADVANCED ENGINEERING ELECTROMAGNETICS
EE641A	3-0-0-0-9		**Course Contents:** Transmission line theory; Greens function and integral transform techniques;Wave propagation and polarization parameters; reflection and transmissionacross an interface; waveguides, cavity resonators, scattering by cylinders,wedges, spheres etc. Geometric theory of diffraction. **References/Text Books:**	ADVANCED ENGINEERING ELECTROMAGNETICS
EE642	3-0-0--4	EE340	**Course Contents:** Vector potential; antenna theorems and definitions; dipole, loop, slot radiators;aperture antennas; array theorems; pattern synthesis; self and mutual impedances;scanning antennas; signal processing antennas, travelling wave antennas;antenna measurements. **References/Text Books:**	ANTENNAS ANALYSIS & SYNTHESIS
EE642A	3-0-0-0-9		**Course Contents:** Vector potential; antenna theorems and definitions; dipole, loop, slot radiators;aperture antennas; array theorems; pattern synthesis; self and mutual impedances;scanning antennas; signal processing antennas, travelling wave antennas;antenna measurements. **References/Text Books:**	ANTENNAS ANALYSIS & SYNTHESIS
EE643	3-0-0--4	#	**Course Contents:** Statistical signal processing concepts, Basics of mobile wireless communications.Radiofrequency signal modeling and channel characterization. Smart antennasand generalized array signal processing. Source localization problem. Joint angleand delay estimation. Smart antenna array configurations. Mobile communicationsystems with smart antennas. **References/Text Books:**	SMART ANTENNAS FOR MOBILE COMMUNICATION

EE643A	3-0-0-0-9		**Course Contents:** Statistical signal processing concepts, Basics of mobile wireless communications.Radiofrequency signal modeling and channel characterization. Smart antennasand generalized array signal processing. Source localization problem. Joint angleand delay estimation. Smart antenna array configurations. Mobile communicationsystems with smart antennas. **References/Text Books:**	SMART ANTENNAS FOR MOBILE COMMUNICATION
EE645	3-0-0--4	EE340 EE210	**Course Contents:** Scattering parameters of nports, Conductor and dielectric losses in planartransmission lines, coupled lines, multiconductor lines, discontinuities, GaAsMESFET fabrication devices, High electron mobility transistor, Heterojunctionbipolar transistor fabrication and modeling, NMIC technology and design. **References/Text Books:**	MONOLITHIC MICROWAVE ICS
EE645A	3-0-0-0-9		**Course Contents:** Scattering parameters of nports, Conductor and dielectric losses in planartransmission lines, coupled lines, multiconductor lines, discontinuities, GaAsMESFET fabrication devices, High electron mobility transistor, Heterojunctionbipolar transistor fabrication and modeling, NMIC technology and design. **References/Text Books:**	MONOLITHIC MICROWAVE ICS
EE646	3-0-0--4		**Course Contents:** Optical communications: Introduction to basic optical communications anddevices. Optical multiplexing techniques Wavelength division multiplexing,Optical frequency division multiplexing, time division multiplexing, code divisionmultiplexing. Optical Networks: Conventional optical networks, SONET / SDH,FDDI, IEEE 802.3, DQDB, FCS, HIPPI etc. Multiple access optical networks,Topologies, Single channel networks, Multichannel networks, FTFR, FTTR, TTFRand TTTR, Single hop networks, Multihop networks, Multiaccess protocols forWDM networks, Switched optical networks. Optical amplification in allopticalnetworks. Alloptical subscriber access networks. Design issues. Optical switching:Motivation, Spatial light modulator, Relational and nonrelational switchingdevices, Fundamental limits on optical switching elements, Switching architectures,Freespace optical switching. Wavelength routed networks and other specialtopics. Soliton based networks, Optical networks management issues. **References/Text Books:**	PHOTONIC NETWORKS & SWITCHING
EE646A	3-0-0-0-9		**Course Contents:** Optical communications: Introduction to basic optical communications anddevices. Optical multiplexing techniques Wavelength division multiplexing,Optical frequency division multiplexing, time division multiplexing, code divisionmultiplexing. Optical Networks: Conventional optical networks, SONET / SDH,FDDI, IEEE 802.3, DQDB, FCS, HIPPI etc. Multiple access optical networks,Topologies, Single channel networks, Multichannel networks, FTFR, FTTR, TTFRand TTTR, Single hop networks, Multihop networks, Multiaccess protocols forWDM networks, Switched optical networks. Optical amplification in allopticalnetworks. Alloptical subscriber access networks. Design issues. Optical switching:Motivation, Spatial light modulator, Relational and nonrelational switchingdevices, Fundamental limits on optical switching elements, Switching architectures,Freespace optical switching. Wavelength routed networks and other specialtopics. Soliton based networks, Optical networks management issues. **References/Text Books:**	PHOTONIC NETWORKS & SWITCHING
EE647	2-0-3-0-4		**Course Contents:** Experiments in basic microwave measurements; passive and active circuitcharacterization using network analyser, spectrum analyser and noise figuremeter; PC based automated microwave measurements;	MICROWAVE MEASUREMENTS AND DESIGN

			integration ofmeasurement and design of microwave circuits. **References/Text Books:**	
EE647A	2-0-3-0-9		**Course Contents:** Experiments in basic microwave measurements; passive and active circuitcharacterization using network analyser, spectrum analyser and noise figuremeter; PC based automated microwave measurements; integration ofmeasurement and design of microwave circuits. **References/Text Books:**	MICROWAVE MEASUREMENTS AND DESIGN
EE648	3-0-0--4	EE340	**Course Contents:** Transmission lines for microwave circuits; waveguides, stripline, microstrip, slotline; microwave circuit design principles; passive circuits; impedance transformers,filters, hybrids, isolators etc., active circuits using semiconductor devices andtubes, detection and measurement of microwave signals. **References/Text Books:**	MICROWAVE CIRCUITS
EE648A	3-0-0-0-9		**Course Contents:** Transmission lines for microwave circuits; waveguides, stripline, microstrip, slotline; microwave circuit design principles; passive circuits; impedance transformers,filters, hybrids, isolators etc., active circuits using semiconductor devices andtubes, detection and measurement of microwave signals. **References/Text Books:**	MICROWAVE CIRCUITS
EE649	3-0-0-0-4		**Course Contents:** Introduction : Review of Electromagnetic Theory. Introduction to the Finite Element Method using electrostatic fields :Galerkin s method of weighted residuals, Minimum energy principle,Calculation of capacitance, electric field, electric forces from the potentialsolutions. Finite Element Concepts : Pre processing, shape functions, isoparmetricelements, meshing, solvers, post processing. finite Element Modeling : Conductive media, steady currents ; Magnetostaticfields, permanent Magnest, scalar and vector potentials ; Electromagneticfields. eddy current problems, modeling of moving parts ; modeling ofelectrical circuits. **References/Text Books:**	THE FINITE ELEMENT METHOD FOR ELECTRIC AND MAGNETIC FIELDS
EE649A	3-0-3-0-12		**Course Contents:** Introduction : Review of Electromagnetic Theory. Introduction to the Finite Element Method using electrostatic fields :Galerkin s method of weighted residuals, Minimum energy principle,Calculation of capacitance, electric field, electric forces from the potentialsolutions. Finite Element Concepts : Pre processing, shape functions, isoparmetricelements, meshing, solvers, post processing. finite Element Modeling : Conductive media, steady currents ; Magnetostaticfields, permanent Magnest, scalar and vector potentials ; Electromagneticfields. eddy current problems, modeling of moving parts ; modeling ofelectrical circuits. **References/Text Books:**	THE FINITE ELEMENT METHOD FOR ELECTRIC AND MAGNETIC FIELDS
EE650	3-0-0--4	#	**Course Contents:** Vector spaces, Linear systems, similarity transformations, Canonical forms,Controllability, Observability, Realisability etc. Minimal realization, Digital systems,Nonlinear systems, Phaseplane analysis, Poincare theorems, Lyapunov theorem,Circle and Popov criterion; Robust control, Linear Quadratic Regulator (LQR),Linear Quadratic Gaussian (LQG) control, Loop Transfer Recovery (LTR), Hinfinitycontrol.	BASICS OF MODERN CONTROL SYSTEMS

			References/Text Books:	
EE650A	3-0-0-0-9		**Course Contents:** Vector spaces, Linear systems, similarity transformations, Canonical forms,Controllability, Observability, Realisability etc. Minimal realization, Digital systems,Nonlinear systems, Phaseplane analysis, Poincare theorems, Lyapunov theorem,Circle and Popov criterion; Robust control, Linear Quadratic Regulator (LQR),Linear Quadratic Gaussian (LQG) control, Loop Transfer Recovery (LTR), Hinfinitycontrol. **References/Text Books:**	BASICS OF MODERN CONTROL SYSTEMS
EE653	3-0-0-0-4		**Course Contents:** Discretetime signals and systems, Ztransform, pulse transfer functions.Compensator design by root locus, error coefficients and frequency response.Statespace models of discrete time systems, controllability, observability,stability, state estimation, Kalman filtering. Linear regulation. Parameterestimation. **References/Text Books:**	DIGITAL CONTROL
EE653A	3-0-0-0-9		**Course Contents:** Discretetime signals and systems, Ztransform, pulse transfer functions.Compensator design by root locus, error coefficients and frequency response.Statespace models of discrete time systems, controllability, observability,stability, state estimation, Kalman filtering. Linear regulation. Parameterestimation. **References/Text Books:**	DIGITAL CONTROL
EE654	3-0-0--4	#	**Course Contents:** Linear Quadratic Regulators: return ratio & difference, sensitivity function.Kalmans optimality condition. Gain/phase margins, robustness to time delayand nonlinearity. Characterization of sensitivity. Kharitonov theorem robustness.Singular values properties, application in stability, robustness and sensitivity.Robustness of discrete time LQR systems. **References/Text Books:**	ROBUST CONTROL SYSTEMS
EE654A	3-0-0-0-9		**Course Contents:** Linear Quadratic Regulators: return ratio & difference, sensitivity function.Kalmans optimality condition. Gain/phase margins, robustness to time delayand nonlinearity. Characterization of sensitivity. Kharitonov theorem robustness.Singular values properties, application in stability, robustness and sensitivity.Robustness of discrete time LQR systems. **References/Text Books:**	ROBUST CONTROL SYSTEMS
EE658	3-0-0--4		**Course Contents:** Introduction, Uncertainity, Imprecision and Vagueness, Fuzzy systems, Briefhistory of Fuzzy logic, Foundation of Fuzzy Theory, Fuzzy Sets and Systems,Fuzzy Systems in Commercial Products, Research Fields in Fuzzy Theory, Classicalsets and Fuzzy sets, Classical Relations, Fuzzy relations, Membership Functions,Fuzzy to crisp conversions, Fuzzy arithmetic, Numbers, Vectors and the extensionprinciple, Classical logic and Fuzzy logic, Mathematical background of FuzzySystems, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Typesof Membership Functions, Basic Concepts (support, singleton, height, acutprojections), Fuzzy set operations, Sand T Norms, Properties of Fuzzy sets,Sets as Points in Hypercube, Cartesian Product, Crisp and Fuzzy Relations,Examples, Liguistic variables and hedges, Membership function design. BasicPrinciples of Inference in Fuzzy Logic, Fuzzy IFTHEN Rules, Canonical Form,Fuzzy Systems and Algorithms, Approximate Reasoning, Forms of Fuzzy Implication,Fuzzy Inference Engines, Graphical Techniques of Inference, Fuzzyifications/DeFuzzification, Fuzzy System Design and its Elements, Design options. FuzzyEvents, Fuzzy Measures, Possibility Distributions as Fuzzy Sets, Possibility vs,Probability, Fuzzy Systems as Universal Approximators, Additive Fuzzy Systems(standard additive	FUZZY SET, LOGIC & SYSTEMS & APPLICATIONS

			model). **References/Text Books:**	
EE658A	3-0-0-0-9		**Course Contents:** Introduction, Uncertainity, Imprecision and Vagueness, Fuzzy systems, Briefhistory of Fuzzy logic, Foundation of Fuzzy Theory, Fuzzy Sets and Systems,Fuzzy Systems in Commercial Products, Research Fields in Fuzzy Theory, Classicalsets and Fuzzy sets, Classical Relations, Fuzzy relations, Membership Functions,Fuzzy to crisp conversions, Fuzzy arithmetic, Numbers, Vectors and the extensionprinciple, Classical logic and Fuzzy logic, Mathematical background of FuzzySystems, Classical (Crisp) vs, Fuzzy sets, Representation of Fuzzy sets, Typesof Membership Functions, Basic Concepts (support, singleton, height, acutprojections), Fuzzy set operations, Sand T Norms, Properties of Fuzzy sets,Sets as Points in Hypercube, Cartesian Product, Crisp and Fuzzy Relations,Examples, Liguistic variables and hedges, Membership function design. BasicPrinciples of Inference in Fuzzy Logic, Fuzzy IFTHEN Rules, Canonical Form,Fuzzy Systems and Algorithms, Approximate Reasoning, Forms of Fuzzy Implication,Fuzzy Inference Engines, Graphical Techniques of Inference, Fuzzyifications/DeFuzzification, Fuzzy System Design and its Elements, Design options. FuzzyEvents, Fuzzy Measures, Possibility Distributions as Fuzzy Sets, Possibility vs,Probability, Fuzzy Systems as Universal Approximators, Additive Fuzzy Systems(standard additive model). **References/Text Books:**	FUZZY SET, LOGIC & SYSTEMS & APPLICATIONS
EE659	3-0-0-0-4		**Course Contents:** 1. Motivations and overview of of tomography, limited data settings, approximatetomography, multimodal tomography.2. Typical Models : Maxwells equations, Helmholtz equation, eikonal equation,radiative transfer equation and its diffusion approximation.3. Brief review of numerical solutions to the above models: finite element schemesand the method of moments (boundary element method).4. Linear tomography: Straight path tomography, Born and Rytov approximationsin diffraction tomography, algebraic reconstruction techniques.5. Regularized linear and nonlinear least squares solutions.6. Frechet derivative calculations , method of adjoints.7. Approximate tomography: Shape based tomography and topological derivatives.8. Introduction to stochastic reconstruction schemes, maximum likelihood andBayesian methods, posterior sampling.9. Applications: Diffuse optical tomography, electrical impedance tomography,refraction tomography, electromagnetic wave tomography, elastography,multimodal tomography. **References/Text Books:**	COMPUTATIONAL ASPECTS OF TOMOGRAPHIC IMAGING : MODELS TO INVERSIONS
EE659A	3-0-0-0-9		**Course Contents:** 1. Motivations and overview of of tomography, limited data settings, approximatetomography, multimodal tomography.2. Typical Models : Maxwells equations, Helmholtz equation, eikonal equation,radiative transfer equation and its diffusion approximation.3. Brief review of numerical solutions to the above models: finite element schemesand the method of moments (boundary element method).4. Linear tomography: Straight path tomography, Born and Rytov approximationsin diffraction tomography, algebraic reconstruction techniques.5. Regularized linear and nonlinear least squares solutions.6. Frechet derivative calculations , method of adjoints.7. Approximate tomography: Shape based tomography and topological derivatives.8. Introduction to stochastic reconstruction schemes, maximum likelihood andBayesian methods, posterior sampling.9. Applications: Diffuse optical tomography, electrical impedance tomography,refraction tomography, electromagnetic wave tomography, elastography,multimodal tomography. **References/Text Books:**	COMPUTATIONAL ASPECTS OF TOMOGRAPHIC IMAGING : MODELS TO INVERSIONS
EE660	3-0-3--5	#	**Course Contents:** Power semiconductor devices, BJT, MOSFET, IGBT, GTO and MCT: ACDCConverters; Forced communication; synchronous link converters, DCAC converters,buck, boost, buckboost, cuk, flyback	BASICS OF POWER ELECTRONIC CONVERTERS

			configuration, resonant converters, PWMinverters; active filters. **References/Text Books:**	
EE660A	3-0-3-0-12		**Course Contents:** Power semiconductor devices, BJT, MOSFET, IGBT, GTO and MCT: ACDCConverters; Forced communication; synchronous link converters, DCAC converters,buck, boost, buckboost, cuk, flyback configuration, resonant converters, PWMinverters; active filters. **References/Text Books:**	BASICS OF POWER ELECTRONIC CONVERTERS
EE661	3-0-0--4	#	**Course Contents:** Basics of flexible AC transmission systems, Controlled rectifier and energystorage plants, Tap changers and phase shifters, Thyristor controlled VARcompensation and series compensation, Modern (synchronous link converter)VAR compensators, Unified power flow controller (UPFC) and Interline power flowcontroller, Power quality conditioners, Power electronics in power generation. **References/Text Books:**	POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS
EE661A	3-0-0-0-9		**Course Contents:** Basics of flexible AC transmission systems, Controlled rectifier and energystorage plants, Tap changers and phase shifters, Thyristor controlled VARcompensation and series compensation, Modern (synchronous link converter)VAR compensators, Unified power flow controller (UPFC) and Interline power flowcontroller, Power quality conditioners, Power electronics in power generation. **References/Text Books:**	POWER ELECTRONICS APPLICATIONS IN POWER SYSTEMS
EE662	3-0-0--4		**Course Contents:** State space modeling and simulation of linear systems, Discrete time models,conventional controllers using small signal models, Fuzzy control, Variablestructure control, Hysteresis controllers, Output and state feedback switchingcontrollers **References/Text Books:**	CONTROL TECHNIQUES IN POWER ELECTRONICS
EE662A	3-0-0-0-9		**Course Contents:** State space modeling and simulation of linear systems, Discrete time models,conventional controllers using small signal models, Fuzzy control, Variablestructure control, Hysteresis controllers, Output and state feedback switchingcontrollers **References/Text Books:**	CONTROL TECHNIQUES IN POWER ELECTRONICS
EE664	3-0-0--4	#	**Course Contents:** Motor load dynamics, starting, braking & speed control of dc and ac motors.DC drives: converter and chopper control. AC Drives: Operation of inductionand synchronous motors from voltage and current inverters, slip power recovery,pump drives using ac line controller and selfcontrolled synchronous motor drives. **References/Text Books:**	FUNDAMENTALS OF ELECTRIC DRIVES
EE664A	3-0-0-0-9		**Course Contents:** Motor load dynamics, starting, braking & speed control of dc and ac motors.DC drives: converter and chopper control. AC Drives: Operation of inductionand synchronous motors from voltage and current inverters, slip power recovery,pump drives using ac line controller and selfcontrolled synchronous motor	FUNDAMENTALS OF ELECTRIC DRIVES

			drives. **References/Text Books:**	
EE665	3-0-0--4	#	**Course Contents:** Closed loop control of solid state DC drives, Scalar and vector control of inductionmotor, Direct torque and flux control of induction motor, Self controlledsynchronous motor drive, Vector control of synchronous motor, Switched reluctancemotor drive, Brushless DC motor drive, Permanent magnet drives, Industrialdrives. **References/Text Books:**	ADVANCED ELECTRIC DRIVES
EE665A	3-0-0-0-9		**Course Contents:** Closed loop control of solid state DC drives, Scalar and vector control of inductionmotor, Direct torque and flux control of induction motor, Self controlledsynchronous motor drive, Vector control of synchronous motor, Switched reluctancemotor drive, Brushless DC motor drive, Permanent magnet drives, Industrialdrives. **References/Text Books:**	ADVANCED ELECTRIC DRIVES
EE666	3-0-0-0-4		**Course Contents:** PWM inverters, Multilevel inverters, Neutral point controlled inverters, Softswitching converters: DCDC resonant link inverters, Hybrid resonant linkinverters, Quasi resonant link converters, Switched mode rectifiers, Synchronouslink converters. **References/Text Books:**	SPECIAL TOPICS IN POWER ELECTRONICS
EE666A	3-0-0-0-9		**Course Contents:** PWM inverters, Multilevel inverters, Neutral point controlled inverters, Softswitching converters: DCDC resonant link inverters, Hybrid resonant linkinverters, Quasi resonant link converters, Switched mode rectifiers, Synchronouslink converters. **References/Text Books:**	SPECIAL TOPICS IN POWER ELECTRONICS
EE667	3-0-0-0-4		**Course Contents:** Introduction: Entropy, Relative Entropy, Mutual Information Inequalities, Entropy rate. Ansymptotic Equipartition Property(AEP): Consequences of the AEP, Typical Sequences, ShannonMcMillanBreiman Theorem. Data Compression: Block to variable lenght codes, ShannonFano code, Huffman code, variable to fixed lenght coding Tunstal code, variable to variable length codes/ arithmetic code. Channel capacity: Discrete Memoryless Channel, Joint Typicality, Channel Coding Theorem and its converse, Feedback capacity, Source Channel Separation Theorem. Differential Entropy: Difinition, Properties. Gaussian Channel: Definition, Parallel Gaussian Channels, Channels with Colored Gaussian Noise, Gaussian Channels with Feedback. Rate Distortion Theory: Rate Distortion Function, Rate Distortion theorem and its converse, BlahutArimoto Algorithm. Universal Source Coding: Universal codes, LempelZiv codes; LZ 78, LZW, Slinding Window Lempel Ziv algorithm (LZ77). Network Information Theory: Gaussian MultiUser Channels, Multiple Access Channel, Broadeast Channel, Encoding of Correlated Sources. **References/Text Books:** 1. Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory", 2nd Edition , John Wiley & Sons, 2006. 2. James L. Massey, Lecture notes on "Applied Digital Information Theory 1". 3. Robert G. Gallager, "Information Theory and Reliable Communications". John Wiley & Sons, 1968. 4. David J.C. MacKay, "Information Theory, Inference, and Learning Algorithms", Cambridge University Press. 5. Robert Ash, "Information Theory", Dover Publications, 1965. 6. Raymond W. Yeung, "Information Theory and Network	INFORMATION THEORY

			Coding", Springer, 2006. 7. Abbas El Gamal and YoungHan Kim, "Network Information Theory", Cambridge University Press, 2012. 8. I. Csiszar and J. Korner, "Information Theory: Coding Theorems for Discrete Memoryless Systems" 2nd edition, Cambridge Univ. Press. 9. Papers from IEEE Transactions on Information Theory.	
EE667A	3-0-0-0-9		**Course Contents:** Introduction: Entropy, Relative Entropy, Mutual Information Inequalities, Entropy rate. Ansymptotic Equipartition Property(AEP): Consequences of the AEP, Typical Sequences, ShannonMcMillanBreiman Theorem. Data Compression: Block to variable lenght codes, ShannonFano code, Huffman code, variable to fixed lenght coding Tunstal code, variable to variable length codes/ arithmetic code. Channel capacity: Discrete Memoryless Channel, Joint Typicality, Channel Coding Theorem and its converse, Feedback capacity, Source Channel Separation Theorem. Differential Entropy: Difinition, Properties. Gaussian Channel: Definition, Parallel Gaussian Channels, Channels with Colored Gaussian Noise, Gaussian Channels with Feedback. Rate Distortion Theory: Rate Distortion Function, Rate Distortion theorem and its converse, BlahutArimoto Algorithm. Universal Source Coding: Universal codes, LempelZiv codes; LZ 78, LZW, Slinding Window Lempel Ziv algorithm (LZ77). Network Information Theory: Gaussian MultiUser Channels, Multiple Access Channel, Broadeast Channel, Encoding of Correlated Sources. **References/Text Books:** Course Reference : 1. Thomas M. Cover, Joy A. Thomas, "Elements of Information Theory", 2nd Edition , John Wiley & Sons, 2006. 2. James L. Massey, Lecture notes on "Applied Digital Information Theory 1". 3. Robert G. Gallager, "Information Theory and Reliable Communications". John Wiley & Sons, 1968. 4. David J.C. MacKay, "Information Theory, Inference, and Learning Algorithms", Cambridge University Press. 5. Robert Ash, "Information Theory", Dover Publications, 1965. 6. Raymond W. Yeung, "Information Theory and Network Coding", Springer, 2006. 7. Abbas El Gamal and YoungHan Kim, "Network Information Theory", Cambridge University Press, 2012. 8. I. Csiszar and J. Korner, "Information Theory: Coding Theorems for Discrete Memoryless Systems" 2nd edition, Cambridge Univ. Press. 9. Papers from IEEE Transactions on Information Theory.	INFORMATION THEORY
EE668	3-0-0-0-9		**Course Contents:** 1.Introduction: Types of codes, channel models, maximum likelihood decoding, Shannon's noisy channel coding theorem, FEC, ARQ, HARQ. 2. Linear Blaock Codes : Generator matrix, parity check matrix, syndrome, error detection, error correction, minimum distance of the code, dual code, weight enumeration and Mac Williams theorem. Examples of simple linear block codes. 3. Some linear block codes : Construction, properties and decoding of some popular block codes; Hamming codes, ReedMuller codes. 4. Bonds on codes : Hamming bound, Plotkin bound, Singleton Bound, Elias Bound, GilbertVarshmov Bound, Linear programming bounds. 5. New codes from old codes : Extending a code, puncturing a code, expunging a code, augmenting a code, shortening a code, direct sum construction. **References/Text Books:** 1. Shu Lin and Daniel J. Costello, Jr., "Error Control Coding", second ed., Prentice Hall, 2004. 2. F.J. Mac Williams, N.J.A. Sloance, "The Theory of ErrorCorrecting Codes', NorthHolland, Amsterdam, 1977. 3. R.E. Blahut, "Algebraic Codes for Data Transmission", 1st Ed., Cambridge Univ. Press 2003. 4. Todd K. Moon, "Error Correction Coding", 1st Ed., WileyInterscience, 2006. 5. Cary W. Huffman, Vera Pless, "Fundamentals of ErrorCorrecting Codes", 1st Edi. Cambridge Univ. Press, 2003. 6. Ezio Biglieri, "Coding for Wireless Channels", Springer, 2005. 7. Tom Richardson and Rudiger Urbanke, "Modern Coding Theory", Cambridge Univ. Press, 2008.	CODING THEORY
EE668A	3-0-0-0-9		**Course Contents:** 1.Introduction: Types of codes, channel models, maximum likelihood decoding, Shannon's noisy channel coding theorem, FEC, ARQ, HARQ. 2. Linear Blaock Codes : Generator matrix, parity check matrix, syndrome, error detection, error correction, minimum distance of the code, dual code, weight enumeration and Mac Williams theorem. Examples of simple linear block codes. 3. Some linear block codes :	CODING THEORY

			Construction, properties and decoding of some popular block codes; Hamming codes, ReedMuller codes. 4. Bonds on codes : Hamming bound, Plotkin bound, Singleton Bound, Elias Bound, GilbertVarshmov Bound, Linear programming bounds. 5. New codes from old codes : Extending a code, puncturing a code, expunging a code, augmenting a code, shortening a code, direct sum construction. **References/Text Books:** Course Reference : 1. Shu Lin and Daniel J. Costello, Jr., "Error Control Coding", second ed., Prentice Hall, 2004. 2. F.J. Mac Williams, N.J.A. Sloance, "The Theory of ErrorCorrecting Codes', NorthHolland, Amsterdam, 1977. 3. R.E. Blahut, "Algebraic Codes for Data Transmission", 1st Ed., Cambridge Univ. Press 2003. 4. Todd K. Moon, "Error Correction Coding", 1st Ed., WileyInterscience, 2006. 5. Cary W. Huffman, Vera Pless, "Fundamentals of ErrorCorrecting Codes", 1st Edi. Cambridge Univ. Press, 2003. 6. Ezio Biglieri, "Coding for Wireless Channels", Springer, 2005. 7. Tom Richardson and Rudiger Urbanke, "Modern Coding Theory", Cambridge Univ. Press, 2008.	
EE669	3-0-0-0-9		**Course Contents:** Introduction to simulation. Discrete time signals and systems. Modeling linear time invariant system. Modeling linear time varying system. Modeling memoryless nonlinear systems. Modeling nonlinear system with memory. Nonlinear differential equation models. Review of probability and randon processes. Monte Carlo simulation and randon number generation. Testing of random number generators. Modeling of functional blocks in communication systems. Wireless fading channel models. Discrete Markov fading channel models. Estimation of parameters in simulation. Estimation of performance measures from simulation. Importance sampling. Other performance estimation methods. Variance reduction techniques. Simulation optimization. Case Study. **References/Text Books:** Course Reference : 1. P. Balaban, K.S. Shanmugan, and B.W. Stuck, eds., ComputerAided Modeling, Analysis, and Design of Communication Systems, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1984. 2. P. Balaban, E. Biglieri, M.C. Jeruchim, H.T. Mouftah, C.H. Sauer, and K.S. Shanmugan, eds., ComputerAided Modeling, Analysis, and Design of Communication Systems II, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1988. 3. J.K. Townsend, A.F. Elrefaic, H. Meyr, and M. Pent, eds., ComputerAided Modeling, Analysis, and Design of Communication Links, vol.11, IEEE Journal on Selected Areas in Communications Apr. 1993. 4. K.S. Shanmugan, eds., Simulation and Implementation of Communication and Signal Processing Systems, vol. 32, IEEE Communication Magazine, July 1994.	SIMULATION OF COMMUNICATION SYSTEMS
EE669A	3-0-0-0-9		**Course Contents:** Introduction to simulation. Discrete time signals and systems. Modeling linear time invariant system. Modeling linear time varying system. Modeling memoryless nonlinear systems. Modeling nonlinear system with memory. Nonlinear differential equation models. Review of probability and randon processes. Monte Carlo simulation and randon number generation. Testing of random number generators. Modeling of functional blocks in communication systems. Wireless fading channel models. Discrete Markov fading channel models. Estimation of parameters in simulation. Estimation of performance measures from simulation. Importance sampling. Other performance estimation methods. Variance reduction techniques. Simulation optimization. Case Study. **References/Text Books:** 1. P. Balaban, K.S. Shanmugan, and B.W. Stuck, eds., ComputerAided Modeling, Analysis, and Design of Communication Systems, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1984. 2. P. Balaban, E. Biglieri, M.C. Jeruchim, H.T. Mouftah, C.H. Sauer, and K.S. Shanmugan, eds., ComputerAided Modeling, Analysis, and Design of Communication Systems II, vol. 6, IEEE Journal on Selected Areas in Communications, Jan. 1988. 3. J.K. Townsend, A.F. Elrefaic, H. Meyr, and M. Pent, eds., ComputerAided Modeling, Analysis, and Design of Communication Links, vol.11, IEEE Journal on Selected Areas in Communications Apr. 1993. 4. K.S. Shanmugan, eds., Simulation and Implementation of Communication	SIMULATION OF COMMUNICATION SYSTEMS

			and Signal Processing Systems, vol. 32, IEEE Communication Magazine, July 1994.	
EE670	3-0-0--4	#	**Course Contents:** Introduction to Wireless Communications, multipatchannel models, capacity of wireless channels, performanc of digital modulation techniques over wireless channels, combining techniques, multicarrier modulation, coding for wireless channels, overview of current wireless standards,MIMO techniques. **References/Text Books:** 1. Wireless Communications: Principles and Practice byTS Rappaport, PrenticeHall, second edition, 20022. Principles of Mobile Communications by GL Stuber,Kluwer Academic, second edition, 2001.3. Wireless Communications by AJ Goldsmith, CambridgeUniversity Press.4. Multiuser Detection by S Verdu, Cambridge UniversityPress, 1998.5. Modern Wireless Communications by S Haykin and MMoher, PrenticeHall, 2004.	WIRELESS COMMUNICATIONS
EE670A	3-0-0-0-9		**Course Contents:** Introduction to Wireless Communications, multipatchannel models, capacity of wireless channels, performanc of digital modulation techniques over wireless channels, combining techniques, multicarrier modulation, coding for wireless channels, overview of current wireless standards,MIMO techniques. **References/Text Books:** 1. Wireless Communications: Principles and Practice byTS Rappaport, PrenticeHall, second edition, 20022. Principles of Mobile Communications by GL Stuber,Kluwer Academic, second edition, 2001.3. Wireless Communications by AJ Goldsmith, CambridgeUniversity Press.4. Multiuser Detection by S Verdu, Cambridge UniversityPress, 1998.5. Modern Wireless Communications by S Haykin and MMoher, PrenticeHall, 2004.	WIRELESS COMMUNICATIONS
EE671	3-0-0--4	#	**Course Contents:** Theory of representation; Two computational pradigms; Multilayer networks;Autoassociative and heteroassociative nets; Learning in neural nets: Supervisedand unsupervised learning; Application of neural nets; Neural network simulators. **References/Text Books:**	NEURAL NETWORKS
EE671A	3-0-0-0-9		**Course Contents:** Theory of representation; Two computational pradigms; Multilayer networks;Autoassociative and heteroassociative nets; Learning in neural nets: Supervisedand unsupervised learning; Application of neural nets; Neural network simulators. **References/Text Books:**	NEURAL NETWORKS
EE673	3-0-0--4	#	**Course Contents:** OSI model, queueing theory, physical layer, error detection and correction,data link layer, ARQ strategies, framing, media access layer, modelling andanalysis of important media access control protocols, FDDI and DQDB MACprotocols for LANs and MANs, network layer, flow control & routing, TCP/IPprotocols, ATM. **References/Text Books:**	DIGITAL COMMUNICATION NETWORKS
EE673A	3-0-0-0-9		**Course Contents:** OSI model, queueing theory, physical layer, error detection and correction,data link layer, ARQ strategies, framing, media access layer, modelling andanalysis of important media access control protocols, FDDI and DQDB MACprotocols for LANs and MANs, network layer, flow control & routing, TCP/IPprotocols, ATM. **References/Text Books:**	DIGITAL COMMUNICATION NETWORKS

EE677	3-0-0--4	#	**Course Contents:** Knowledge representation, statespace techniques, logic, semantic networks,frames, script. Production system, object oriented and ANN models. Applicationsin robotic vision and processing of documents, natural languages and speech.Course Project involving extensive programming is compulsory.Combinational and sequential circuits, Logic families, Number systems, Arithmeticcircuits using SSI/MSI chips. Basic microprocessor architecture, Essentials ofa microcomputer system, Instruction sets, Machine cycles, Interrupt structures.Parallel /serial I/O, Analog I/O, DMA operation. Peripheral controllers. **References/Text Books:**	KNOWLEDGE BASED MAN MACHINE SYSTEMS
EE678A	3-0-0-0-9		**Course Contents:** Introduction to Motivation. Solar Radiations: Composition, spectrum Air Mass, optimal angle of panel, solar constant, Indias solar resource. Solar PV cell: Direct vs Indirect Band, Generation of carriers, drift and diffusion currents, PN Junction, IV characteristics of cell, fill factor, maximum short circuit current, maximum open circuit voltage, efficiency, fundamental and technological losses, electrical model of cell, effect of series and shunt resistances, optical losses and minimization techniques, Soloar PV Module: Series/parallel connection, IV characteristics of module, mismatching due to temperature and shading, Bypass and blocking diodes, overview of PV module fabrication, IV equation of module, standard test conditions, Review of dcdc buck & boost converters Maximum power point tracking: motivation, power extracted with resistive load, implementing variable resistance load, tracking using dcdc converter, direct vs indirect control, fractional open circuit voltage control, hill climbing method and issues, incremental conductance method, mppt extraction efficiency, effect of voltage ripple on efficiency. Battery charging: types and characteristics of battery, comparison of charging characteristics, popular technique for charging lead acid battery, charging using dcdc converter, PV charging circuits, stable operation of chargers. Solar Inverters: standalone vs grid connected, days of autonomy, payback period, Parity, grid feeding inverter, central inverters circuits, string inverters, earth leakage current, module inverters, features of grid feeding inverter, relevant standards, islanding. **References/Text Books:** 1. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall of India, 2011. 2. N. Mohan, T.M. Undeland & W.P. Robbins, Power Electronics: Converter, Applications & Design, John Wiley & Sons, 1989. 3. Chenming Calvin Hu, Moden Semiconductor Devices ofr Integrated Circuits, Prentice Hall, 2009 (Chapters1, 2 and 4). 4. Chenming Hu and Richard M White, Solar Cells: From basics to advanced systems, McGraw Hill Book Company, 1983 (Section 3, 7 and 3.8). 5. Antonio Luque and Steven Hegedus, Handbook of Photovoltaic Science and Engineering, John Wiley & Sons Ltd, 2010. 6. Erickson and Maksimovic, Fundamentals of Power Electronics, Springer, 2001 (Chapter 2, 3, 5 and 6). 7. T. Esram and P.L. Chapman, Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques, IEEE Trans, Energy Conversion, Vol.22, no.2, pp.439449, June 27.	POWER MANAGEMENT CIRCUITS
EE679	3-0-0--4	#	**Course Contents:** Review of probability and stochastic processes, Markov chains, Littles theorem,modelling & analysis of M/M/ queues, Burkes Theorem, Reversibility, Methodof stages, Analysis of M/G/1 queues, Queues with vacations, Work conservationprinciple, Priority queues, Queues served in cyclic order, Fluidflow and diffusionapproximations. **References/Text Books:**	QUEUEING SYSTEMS
EE680	2-3-0--4		**Course Contents:** Introduction, data flow and graphical programming techniques, Virtualinstrumentation (VI), advantages, VIs and SubVIs, Data acquisition methods,DAQ hardware, PC hardware; Structure, Operating system, ISA, PCI, USB, PCMICAbuses, Instrumentation buses. IEEE 488.1 and **References/Text Books:**	INTELLIGENT INSTRUMENTATION

EE680A	2-0-3-0-9		**Course Contents:** Introduction, data flow and graphical programming techniques, Virtualinstrumentation (VI), advantages, VIs and SubVIs, Data acquisition methods,DAQ hardware, PC hardware; Structure, Operating system, ISA, PCI, USB, PCMICAbuses, Instrumentation buses. IEEE 488.1 and **References/Text Books:**	INTELLIGENT INSTRUMENTATION
EE681	3-0-0-0-9		**Course Contents:** Introduction to Simulation. Introduction to SPICE and Compact Modeling. Integrated Resistor Modeling. Integrated MOS Varactor Modeling. MOSFET Modeling approaches : Threshold Voltage based modeling (BSIM3, MSIM4), Charge based modeling (BSIM6, EKV), Surface Potential based modeling(PSP). Quality of MOSFET Compect Models and Benchmark Tests. Layout Effects and Parameter Extraction. High Frequency Effects and RF Modeling. SOI MOSFET Modeling. Noise Modeling. Multigate MOSFETs. **References/Text Books:** C. Hu, "Modern Semiconductor Devices for Integrated Circuits," Pearson/Prentice Hall, New Jersey.Compac Modeling: Priciples, Techniques and Applications by Gennady Gildenblat, Springer. MOSFET Models for SPICE Simulation: Including BSIM3v3 and BSIM4 by William Liu, WileyIEEE Press.Chargebased MOS Transistor Modeling: The EKV Model for LowPower and RF IC Design by Christian C. Enz and Eric A. Vittoz, John Wiley & Sons.BSIM4 and MOSFET Modeling for IC Simulation by W. Liu and C. Hu, World Scientific Publishing Co.FinFETs and Other MultiGate Transistors (Integrated Circuits and Systems) by J.P. Coling (Editor).	COMPACT MODELING
EE681A	3-0-0-0-9		**Course Contents:** Introduction to Simulation. Introduction to SPICE and Compact Modeling. Integrated Resistor Modeling. Integrated MOS Varactor Modeling. MOSFET Modeling approaches : Threshold Voltage based modeling (BSIM3, MSIM4), Charge based modeling (BSIM6, EKV), Surface Potential based modeling(PSP). Quality of MOSFET Compect Models and Benchmark Tests. Layout Effects and Parameter Extraction. High Frequency Effects and RF Modeling. SOI MOSFET Modeling. Noise Modeling. Multigate MOSFETs. **References/Text Books:** C. Hu, "Modern Semiconductor Devices for Integrated Circuits," Pearson/Prentice Hall, New Jersey.Compac Modeling: Priciples, Techniques and Applications by Gennady Gildenblat, Springer. MOSFET Models for SPICE Simulation: Including BSIM3v3 and BSIM4 by William Liu, WileyIEEE Press.Chargebased MOS Transistor Modeling: The EKV Model for LowPower and RF IC Design by Christian C. Enz and Eric A. Vittoz, John Wiley & Sons.BSIM4 and MOSFET Modeling for IC Simulation by W. Liu and C. Hu, World Scientific Publishing Co.FinFETs and Other MultiGate Transistors (Integrated Circuits and Systems) by J.P. Coling (Editor).	COMPACT MODELING
EE682	3-0-0-0-4		**Course Contents:** Introduction 1Games with Perfect Information(Theory With Examples)1. Brief Revision ofNormal Games, Nash Equilibrium, Utility Theory2. Mixed Strategies3. Intro9uction to Basics of Wireless Communications4. Fading Channels and Diversity 55. BitError Rate Calculation for Wireless Communications6. CDMA, OFDM and MIMO technologies in Wireless7. Wireless Sensor Networks8. Supermodular and Potential Games and applications in CDMA wirelesscommunicationsApplications (I)1. Market Equilibrium and Pricing 72. Auctions (I) for Wireless Spectrum3. Wireless Networks: Introduction to Basics of Wireless,4. Resource Allocations in Wireless5. Admission Control, Routing in Sensor and AdHoc Networks,6. Modeling Network Traffic and Strategic Network Formation.7. Electoral Competitions and applications in Wireless Sensor NetworksGames with Imperfect Information5I. Bayesian Games, Extensive Games with Imperfect InformationApplication (II)I. Auctions (II): Radio Spectrum, With Arbitrary Distribution of Valuations 62. Signaling GamesNash Bargaining with Applications(I. Rubinstein Bargaining Model with Alternating Offers2. Nash Bargaining Solution 63. Relation of Axiomatic and Strategic Model4. Bargaining in Wireless Network.Auctions [Ill] and Mechanism Design with Applications1. Revenue Equivalence2. Mechanism and	GAME THEORY FOR WIRELESS COMMUNICATIONS

			Optimal Mechanisms for Wireless3. Efficient Mechanism: VickreyClarkeGroves Auction for Wireless 124. Application ofVCG in Resource Allocation for Wireless5. Dynamic Spectrum Auction in Cognitive Radio Networks6. Mechanisms in Networking and Wireless7. Applications and Case Studies in Wireless **References/Text Books:**	
EE683A	3-0-0-0-9		**Course Contents:** 1. Introduction to quantum mechanics and its tools: Motivation for quantum mechanics: early experiments; general principles of quantum mechanics: operator algebra, eigenstates, superposition, observables and expectation values, uncertainty relations, commutators, angular momentum, Dirac notation; potential wells and barriers, harmonic oscillator, Hydrogenic atom; time independent and dependent perturbation theory. 2. Device applications of quantum and wave phenomena : Density of states; practical examples of lowdimensional systems such as quantum wells, wires and dots: design, fabrication and characterization techniques; engineered electronic and optical properties of these lowdimensional materials; application in electronic, optoelectronic and photonic devices; current research efforts towards using quantum mechanical effects for developing efficient devices. **References/Text Books:** 1. R.L. Liboff, Introductory Quantum Mechanics (Addison Wesley). 2. A. Yariv, An Introduction to Theory and Applications of Quantum Mechanics (John Wiley & Sons). 3. S. Gasiorowicz, Quantum Physics (Wiley). 4. D.J. Griffiths, Introduction to Qauntum Mechanics (Pearson Prentice Hall). 5. J.H. Davies, The Physics of Lowdimensional Semiconductors (Cambridge University Press).	QUANTUM AND WAVE PHENOMENA
EE684A	3-0-0-0-9		**Course Contents:** 1. Introduction. 2. Light propagation in optical fibers. Single and multimode fibers, light guiding by fibers, material and waveguide dispersion, Polarization mode dispersion, Nonlinear effects: self and cross phase modulation, Raman and Brillouin scattering, four wave mixing etc. 3. Optical transmitters and modulation. External modulators: phase and intensity, bias control, Pulse shaping, pulse carving, Modulation formats Intensity modulation, RZ and NRZ amplitude modulation, Mary modulation using MachZehnder modulator, MSK, IQ modulation and optical OFDM. 4. Detection of optical signals. Direct detection: receiver structure, data recovery, signal to noise ratio, performance calculations for binary digital optical systems. Coherent detection: heterodyne, homodyne, DSP assisted coherent optical receiver, performance analysis. 5. Optical amplifiers. Principles of SOA and EDFA, single and double pump configurations, ASE noise in SOA and EDFA, OSNR calculations. 6. Optical link design. Power budget under linear and nonlinear effects, power penalty, dispersion tolerance in DWDM systems. **References/Text Books:** 1. M. Cvijetic and I.B. Djordjevic, Advanced optical communication systems and networks, Artech House, 2013. 2. S. Kumar and M.J. Deen, Fiberoptic communications: Fundamentals and applications, Wiley, 2014.	FIBER-OPTIC COMMUNICATIONS
EE685A	3-0-0-0-9		**Course Contents:** 1. Introduction. 2. Review of Semiconductors. 3. Epitaxial Growth of Semiconductors. 4. Semiconductor Optical Waveuides. 5. LED. 6. Diode Lasers. 7. Fabrication and Packaging. 8. Single mode Laser diodes plus Reliability. 9. PhotoDetectors. 10. External Modulators. 11. Photonic Integrations. **References/Text Books:** 1. Modular Series on Solid State Devices, Vol. VI, Ed: G.W. Neudek & R.F> Pierret: R.F. PIERRET, AddisionWesley. 2. Optical Fiber Communication Systems: W.B. JONES, HRW (1988). 3. Semiconductor Optoelectronic Devices: P.K. BHATTACHARYA, Prentice Hall. 4. Elements of Optoelectronics and Fiber Optics: C.L. CHEN, Irwin. 5. Handbook of Semiconductor Lasers and Photonic Integrated Circuits: Y. SUEMATSU & A.R. ADAMS, Chapman & Hall. 6. Optical Electronics in Modern Communication: A. YARIV, Oxford University Press. 7. Semiconductor Devices for HighSpeed Optoelectronics: GIOVANNI GHIONE, Cambridge Univ. Press.	SEMICONDUCTOR OPTICAL COMMUNICATION DEVICES

EE686	3-0-0-0-4		**Course Contents:** I. Introduction to electromagnetic theory and microwaves; review of Maxwell's equations,interaction of microwaves with the dielectric materials and the concept of effectivepermittivity, definition of microwave imaging, characterization and testing, the concept of using microwaves as the imaging and testing tool; basic parameters required for themicrowave imaging and their practical equivalents. 2. Review of transmission line theory and the equivalent network representation of field quantities at microwave frequencies, scattering parameters and the transmission matrix, the relationship between the scattering and transmission matrices. 3. Electromagnetic scattering theory: direct and inverse problems, the inverse problem from the mathematic point of view, basis of the electromagnetic scattering problem formulation for the microwave characterization and imaging applications. 4. Overview of the microwave methods for the material characterization and testing, resonant methods, cavity perturbation approach, reflection methods, transmission reflection methods. 5. Theory of transmission reflection methods for determining the permittivity and permeability of materials, various available algorithms, analytical approach, numerical optimization methods, formulation for the dispersive and anisotropic media. **References/Text Books:** 1.2.3.4.5.Jaleel Akhtar, Microwave Imaging: Reconstruction of One Dimensional Permittivity Profiles,Vdm Verlag Dr. Mueller, Germany, 2008.L.F. Chen, C.K. Ong, C.P. Neo, V.V. Vardhan and V.K. Verdhan, Microwave Electronics:Measurement and Materials Characterization, John Wiley & Sons, 2004.K.l. Hopcraft and P.R. Smith, Introduction to Electromagnetic Inverse Scattering, KluwerAcademic Publishers, The Netherlands, 1992.Matteo Pastorino, Microwave Imaging, John Wiley & Sons, 2010.Literature from various Journals relevant to specific topics.	MICROWAVE IMAGING CHARACTERIZATION AND NONDESTRUCTIVE TESTING
EE686A	3-0-0-0-9		**Course Contents:** I. Introduction to electromagnetic theory and microwaves; review of Maxwell's equations,interaction of microwaves with the dielectric materials and the concept of effectivepermittivity, definition of microwave imaging, characterization and testing, the concept of using microwaves as the imaging and testing tool; basic parameters required for themicrowave imaging and their practical equivalents. 2. Review of transmission line theory and the equivalent network representation of field quantities at microwave frequencies, scattering parameters and the transmission matrix, the relationship between the scattering and transmission matrices. 3. Electromagnetic scattering theory: direct and inverse problems, the inverse problem from the mathematic point of view, basis of the electromagnetic scattering problem formulation for the microwave characterization and imaging applications. 4. Overview of the microwave methods for the material characterization and testing, resonant methods, cavity perturbation approach, reflection methods, transmission reflection methods. 5. Theory of transmission reflection methods for determining the permittivity and permeability of materials, various available algorithms, analytical approach, numerical optimization methods, formulation for the dispersive and anisotropic media. **References/Text Books:** 1.2.3.4.5.Jaleel Akhtar, Microwave Imaging: Reconstruction of One Dimensional Permittivity Profiles,Vdm Verlag Dr. Mueller, Germany, 2008.L.F. Chen, C.K. Ong, C.P. Neo, V.V. Vardhan and V.K. Verdhan, Microwave Electronics:Measurement and Materials Characterization, John Wiley & Sons, 2004.K.l. Hopcraft and P.R. Smith, Introduction to Electromagnetic Inverse Scattering, KluwerAcademic Publishers, The Netherlands, 1992.Matteo Pastorino, Microwave Imaging, John Wiley & Sons, 2010.Literature from various Journals relevant to specific topics.	MICROWAVE IMAGING CHARACTERIZATION AND NONDESTRUCTIVE TESTING
EE698D	3-0-0-0-4		**Course Contents:** Solar radiations, solar PV modules, maximum power point tracking, partial shading,leakage currents, grounding techniques, panel optimizers, grid integration issues,module integrated inverters, standalone inverters and battery charge controllers. **References/Text Books:**	QUANTUM AND WAVE PHENOMENA WITH ELECTRICAL APPLICATION

EE698F	3-0-0--9		**Course Contents:** Solar radiations, solar PV modules, maximum power point tracking, partial shading,leakage currents, grounding techniques, panel optimizers, grid integration issues,module integrated inverters, standalone inverters and battery charge controllers. **References/Text Books:**	POWER ELECTRONICS IN SOLAR PHOTOVOLTAIC SYSTEMS
EE699	-0-0--		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
EE699.	0----9		**Course Contents:** M TECH THESIS (FOR DUAL DEGREE ONLY) **References/Text Books:**	M TECH THESIS (FOR DUAL DEGREE ONLY)
EE705	3-0-0-0-4		**Course Contents:** Norms of Signals, Vectors and Matrices,Positive Definite Functions, Positive Definite Matrices; Continuoustime Statespace Model, L TI Statespace Model, Nonlinear Statespace model, Equilibrium point and Linearization using first order Taylor series, Linearization technique for operating points other than origin; Lyapunov Stability Theory, Lyapunov stability of time invariant system, LaSalle's Invariance Theorem, Chetaev's Instability Theorem, Lyapunov stability of time varying system, Lyapunov's indirect method, Lyapunov stability for linear systems; Discretetime Systems, Discretetime L TI Statespace Model, Discretetime Nonlinear Statespace model, ARMAX and NARMAX Models, Lyapunov Stability for Discrete Time Systems; Modeling of Different Nonlinear Systems: Inertial Wheel Pendulum, Two Link Manipulator, Inverted Pendulum Mounted on A Cart, Induction Motor; Nonlinear Control Strategies: Feedback Linearization, Backstepping Design, Statefeedback linearizable systems.FeedForward Networks: Multilayered Neural Networks, Radial Basis Function Networks. Adaptive Learning Rate; Feedback Networks, Back Propagation Through Time (BPTT), Real Time Recurrent Learning (RTRL); Kohonen Self Organizing Map; System Identification Using Neural NetworksClassical sets, Fuzzy Sets, Concept of a fuzzy number, Operations on Fuzzy sets, Properties of Fuzzy Sets, Some Typical Membership Functions; Extension Principle of Fuzzy Sets, Crisp Relation, Fuzzy Relations, Projection of Fuzzy Relations, Cylindrical Extension of Fuzzy Relations, Relation Inference; FUzzy Rule Base and ApproximateReasonjng, Fuzzy Linguistic Variables, Linguistic modifier, Rulebase systems, Fuzzy Rulebase, Fuzzy Implication Relations, Fuzzy Compositional Rules, Inference mechanism compared, Approximate Reasoning; Fuzzy Logic Control (FLC), Mamdani Model, TakagiSugeno {TS) Fuzzy Model; System Identification Using TS Fuzzy Models,The TS Model From InputOutput Data, The TS Fuzzy Model Using Linearization. **References/Text Books:** 1. Alexander M. Meystel and James S. Albus , Intelligent Systems: Architecture, Design, Control , WileyInterscience, 20012 . Pedro Ponce Cruz and Fernando D. RamirezFigueroa, Intelligent Control Systems with LabVIEW(TM),Springer, 2009	INTELLIGENT SYSTEMS & CONTROL
EE705A	3-0-0-0-9		**Course Contents:** Norms of Signals, Vectors and Matrices,Positive Definite Functions, Positive Definite Matrices; Continuoustime Statespace Model, L TI Statespace Model, Nonlinear Statespace model, Equilibrium point and Linearization using first order Taylor series, Linearization technique for operating points other than origin; Lyapunov Stability Theory, Lyapunov stability of time invariant system, LaSalle's Invariance Theorem, Chetaev's Instability Theorem, Lyapunov stability of time varying system, Lyapunov's indirect method, Lyapunov stability for linear systems; Discretetime Systems, Discretetime L TI Statespace Model, Discretetime Nonlinear Statespace model, ARMAX and NARMAX Models, Lyapunov Stability for Discrete Time Systems; Modeling of Different Nonlinear Systems: Inertial Wheel Pendulum, Two Link Manipulator,	INTELLIGENT SYSTEMS & CONTROL

			Inverted Pendulum Mounted on A Cart, Induction Motor; Nonlinear Control Strategies: Feedback Linearization, Backstepping Design, Statefeedback linearizable systems.FeedForward Networks: Multilayered Neural Networks, Radial Basis Function Networks. Adaptive Learning Rate; Feedback Networks, Back Propagation Through Time (BPTT), Real Time Recurrent Learning (RTRL); Kohonen Self Organizing Map; System Identification Using Neural NetworksClassical sets, Fuzzy Sets, Concept of a fuzzy number, Operations on Fuzzy sets, Properties of Fuzzy Sets, Some Typical Membership Functions; Extension Principle of Fuzzy Sets, Crisp Relation, Fuzzy Relations, Projection of Fuzzy Relations, Cylindrical Extension of Fuzzy Relations, Relation Inference; FUzzy Rule Base and ApproximateReasonjng, Fuzzy Linguistic Variables, Linguistic modifier, Rulebase systems, Fuzzy Rulebase, Fuzzy Implication Relations, Fuzzy Compositional Rules, Inference mechanism compared, Approximate Reasoning; Fuzzy Logic Control (FLC), Mamdani Model, TakagiSugeno {TS) Fuzzy Model; System Identification Using TS Fuzzy Models,The TS Model From InputOutput Data, The TS Fuzzy Model Using Linearization. **References/Text Books:** 1. Alexander M. Meystel and James S. Albus , Intelligent Systems: Architecture, Design, Control , WileyInterscience, 20012 . Pedro Ponce Cruz and Fernando D. RamirezFigueroa, Intelligent Control Systems with LabVIEW(TM),Springer, 2009	
EE799	-0-0--		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
ESC102N	3-1-3-0-5		**Course Contents:** Stored program concept (with simple computer simulator), machine language and instruction formats,assembly language for the simple computer. Integer representation, finite representation of real numbers,overflow, underflow, errors due to finite representations. Expressions, values and variables, types, lvalue,rvalue, unary, binary, ternary operations. Conditionals, ifthen, ifthenelse, nested conditionals, switchcase.Loops, for, while, repeat, loopinvariants, precondition, postcondition. Functions and return values,arguments, passbyvalue, effect of passing pointers (like passbyreference). Recursion. Arrays, enums,searching, sorting. Pointers, lists, dynamic data structures, stack, queue, graphs, trees related algorithms,memory and its management. Elementary complexity motivation, concrete complexity, big O notation.Linux tools, introduction to shell programming. Elementary numerical problem solving will addressedlargely through some labs e.g. root finding, solutions of systems of linear equations, integration, solution ofODEs. Course Reference : 1. Brian W Kernighan and Dennis M Ritchie, The C Programming Language,2nd Ed. ANSI C version,Pearson, 2006. **References/Text Books:**	INTRODUCTION TO ELECTRONICS
ESC201A	3-1-3-0-14		**Course Contents:** Circuit analysis techniques (nodal, mesh, superposition, Thevenins, andNortons theorems); Transient analysis of capacitive and inductive circuits; Sinusoidal steadystateanalysis of circuits containing resistors, capacitors, and inductors; Transfer functions andfrequency response; Semiconductors; Diodes and diode circuits; MOSFETs and amplifiers; ICfabrication; Operational amplifier circuits and waveform generators; Number system, logic gates,logic minimization, combinational circuits; Field programmable gate arrays (FPGAs); Flipflops,sequential circuits, counters, shift registers; data converters (DAC, ADC). **References/Text Books:**	INTRODUCTION TO ELECTRONICS
ESO203A	3-1-2-0-13		**Course Contents:** Introduction to SinglePhase Circuits, Power Calculations, Magnetic Circuits,Mutually Coupled Circuits, Transformers, Equivalent Circuit and Performance,Analysis of ThreePhase Circuits, DirectCurrent Machines: Construction, EquivalentCircuit, TorqueSpeed Characteristics, Applications; Induction	INTRODUCTION TO ELECTRICAL ENGINEERING

			Machines:Construction Equivalent Circuit, Torquespeed Characteristics, Speed Control,Starting, Applications Synchronous Machines: Construction, Equivalent Circuit,Generator & Motor Operation Power Angle Characteristics, Hunting, PullOut,Stepper Motors and controls, Principles of Industrial Power Distribution. **References/Text Books:**	
ESO210	3-1-2-0-5		**Course Contents:** 1. Introduction, SinglePhase Circuits, Power Calculations, Analysis of ThreePhase Circuits,Mutually Coupled Circuits2. Transformers: Magnetic Circuits, Equivalent Circuit and Performance3. DirectCurrent Machines: Construction, Equivalent Circuit, TorqueSpeed Characteristics,Applications4. Induction Machines: Construction, Equivalent Circuit, Torquespeed characteristics, SpeedControl, Starting, Applications 5. Synchronous Machines: Construction, Equivalent Circuit, Generator & Motor Operation, /,Power Angle Characteristics, Hunting, PullOut '6. Special Topics: Industrial Power Distribution, HV cables Stepper Motors and controls,lLabomtmy Work: Nine experiments performed in the laboratory work cover the following.Power Circuit Measurements, SinglePhase Transfonners, D.C Motor & Generator,SinglePhase Induction Motor. **References/Text Books:** 1. Electric Machines and Power Electronics P.C.Sen, Second Edition, Wiley,'97 2. Basic Electrical Engineering D.P.Kothari & I.J.Nagrath, Tata McGraw Hill 3. Electric Machines 2nd edition, D.P.Kothari & I.J.Nagrath, Tata McGraw Hill 4. Electric Machinery, 4th/5thedition, A.E.Fitzgerald & C.Kingsley, Tata McGraw Hill	INTRODUCTION TO ELECTRICAL ENGINEERING
***** Department of EEM *****				
EEM613	3-0-0-4-4		**Course Contents:** Atmosphere as a Physical system, Introduction to Atmospheric Models: Simple Radiative model, Greenhouse Effect, Global Warming, Atmospheric Observations: The mean Temperature and Wind Fields, Gravity Waves, Rossby Waves, Ozone. Potential Temperature, Parcel Concepts, The Available Potential Energy, Moisture in the Atmosphere, The Saturated Adiabatic Lapse Rate, The Tephigram, Cloud Formation.Thermodynamics of Chemical Reactions, Chemical Kinetics, Bimolecular Reactions Photodissociation, Stratospheric Ozone, Chapman Chemistry, Catalytic Cycles, Transport of Chemicals, The Antarctic Ozone Hole.Aerosol Dynamics: Discrete and continuous aerosol size distributions; Thermodynamics o atmospheric aerosols; Homogeneous and heterogeneous nucleation; Coagulation and coagulation kernels; Condensation/evaporation, saturation vapour pressure corrections; Fluxes to a particle population; Sedimentation and dry deposition; Chemical equilibria; Heterogeneous reactions in aerosol aqueous phase; Aerosolcloud interactions. Aerosol and Global Climate: Trends in anthropogenic emissions and troposphere composition Solar and terrestrial radiation; Effect of pollutants on Earth's radiation budget; Radiatio cattering by aerosols and clouds; Models for global warming and cooling. **References/Text Books:** Andrews, D. G. An Introduction to Atmospheric Physics, Cambridge UniversityPress, Cambridge, 2000.Friedlander, S.K. Smoke, Dust and Haze: Fundamentals of Aerosol Dynamics, Oxford University Press, New York, 2000.Jacobson, M.Z. Fundamentals of Atmospheric Modelling, Cambridge UniversityPress, New York, 1999.Seinfeld, J.H. and Pandis, S. N. Atmospheric Chemistry and Physics: From AirPollution to climate Change, WileyInterscience, New York, 1998.Proposer: Dr. S. N. Tripathi, __ Environmental Engineering and ManagementProgramme	Atmospheric physics and chemistry _
EEM699	----		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M.TECH THESIS

** Department of ES **				
ES311A	3-0-2-0-11		**Course Contents:** Chemical and physical properties and identification of common rockforming (silicates, carbonates and oxides) minerals; crystallography, Unit cells, Crystal symmetry, classes and rotation. Systems, Plane and Bravais Lattices, Axial Ratios, Parameters, Miller Indices, Point Groups, Crystal Form, Zones, Crystal Habit, Stereographic Projection of Crystal Faces, Polymorphis and Pseudomorphs,Twinning; optical mineralogy, uniaxial, biaxial minerals; introductions to xray crystallography; crystal structures, chemistry, and origin nad significance of the rockforming minerals, Minearlogy of the Earth's crusts, upper mantle, lower mantle and its Core. **References/Text Books:** 1. Nasse, W. 2011. Introduction to Mineralogy (2 nd Ed.)Oxford University Press. 496 p. 2. Klein, C. & Dutrow, B. 2007. Manual of Mineral Science. Wiley. 716 p. 3. Putnis, A. 1992. An Introduction to Mineral Sciences Cambridge University Press. 480 p. 4. Sands, Donald (2012). Introduction to crystallography Courier Corporation. 5. Hammond, C. (2001). The basics of crystallography and diffractions, Oxford Science Publications. 6. Lovett, David (1999) Tensor properties of crystals, CRC Press.	CRYSTALLOGRAPHY AND MINERALOGY
ES312A	0-0-3-0-3		**Course Contents:** This course will provide an introduction to field work activities. How to use a Brunton Compass, reading of topographic maps, dip and strike measurements, and basics of lithological mapping. **References/Text Books:** 1. Robert R. Compton, Geology in the Field. July, 1985.2. Angela L. Coe, Geological Filed Techniques. October 25, 2010.3. Richard J. Lisle, Peter Brabham, John W. Barnes, Basic Geological Mapping, 5th Edition August 2011.	FIELD GEOLOGY-I
ES313A	3-0-0-0-9		**Course Contents:** Fundamental concepts of geomorphic system; Earth's energy balance, global heat transfer, topography and bathymetry, liberation and flux of sediments, hydrological cycle and water budget. Guiding Principles of earth's surface processes: Conservation, transport rules, event size and frequency; rates of processes and ages of landscapes. Whole Earth morphology and largescale topography; Exogenic and endogenic processes. The Surface water system: Drainage basins and river systems, river morphology and hydrology, hydraulic geometry and governing principles of open channel flow; river processes and landforms, river dynamics. The Groundwater system: Groundwater in hydrological cycle, groundwater flow and storage; chemistry of groundwater. The Atmospheric System: Atmospheric composition and mixing, atmospheric circulation, greenhouse effect. The Ocean and Coastal system: Coastal environment, waves, tides and currents. The relative movement of land and sea; coastal processes and landforms. Cryosphere growth and decay of ice sheets, controlling factors, Himalayan glaciers; Wind activity and geomorphic work, desertification and controlling factors. Global geomorphology and tectonics: Earth's physiography and landscape evolution; Landforms and tectonics of plate margins and plate interiors; Tectonic uplifts and denudation rates and controlling factors, Sea level change evidence, mechanism and effects; coupled tectonic surface process models. **References/Text Books:** 1. Summerfield, S.A. (1991) Global Geomorphology, Longman. 2. Ernst, W.G. (2002) Earth Systems: Processes and Issues, Cambridge University Press. 3. Richards, K.S. (1982) Rivers: forms and processes in alluvial channels, Metheun. 4. Kale, V. and Gupta, Introduction to Geomorphology, Orient Longman. 5. Merrits, D, Dewet, A. and Menking, K. (1998) Environmental Geology; An earth system science approach. W.H. Freeman.	GEOMORPHOLOGY AND EARTH SURFACE PROCESSES
ES314A	3-0-0-0-9		**Course Contents:** Introduction to geophysics, Earth as a planet and member of the solar system, origin and evolution of the	FUNDAMENTALS OF GEOPHYSICS

			Earth, Internal structure of the Earth; Concept of plate tectonics, plate motions and triple junctions; Gravitation, gravity anomalies and its variations, geoid, isostasy, rheology; Geomagnetic field, its origin and variations, paleomagnetism, and geomagnetic reversals; Introduction to seismology, seismic waves P, S and surface waves, seismograph, travel time curves and radial Earth structures, general properties of surface waves and normal modes, earthquake source theory, intensity and magnitude scales of earthquakes, PREM model, elastic rebound theory, global seismecity and tectonics, focal mechanisms, seismic anistropy; Heat within the Earth, thermal structure of continental and oceanic lithospheres at subduction zones and spreading centres, mantle convection. **References/Text Books:** 1. Lowrie, W., "Fundamentals of Geophysics", Cambridge University Press. 2. Fowler, C.M.R., 2004, "The Solid Earth: An Introduction to Global Geophysics", Cambridge University Press.3. Robert J. Lillie, 1999, "Whole Earth Geophysics: An Introductory Textbook for Geologists and Geophysicists", Prentice Hall.	
ES315A	3-0-2-0-11		**Course Contents:** This course will introduce igneous and metamorphic rocks and focus on the processes and principles involved in the generation of these rocks in a wide range of tectonic settings. Emphasis will be on developing skills necessary to understand and evaluate melt generation and crystallization, differentiation and chemical evolution of magma, and metamorphic processes etc. Topics to be discussed in detail are : Classification and Nomenclature of Igneous Rocks; Textures and Petrogenetic Interpretations; Thermodynamic evaluation of phase diagrams Phase Diagrams for Binary and Ternary Systems; Chemical Petrology: Major and minor element, and isotopic compositional variations; graphical and mathematical models of magme evolution; Fractionation of trace elements during melting and crystallization; Generation and diversification of magmas; Types of metamprphism; Classification of metamorphic rocks; textures; Metamorphic mineral assemblages and chemographic (ADF, AKF, and AFM) giagrams; Metamorphic Facies; Metamorphic Reactions. **References/Text Books:** 1. An Introduction to Igneous and Metamorphic Petrology by John D. Winter (Prentice Hall, 2nd edition). 2. The Interpretation of Igneous Rocks by Cox, Bell and Pankhurst (Chapman and Hall).3. Petrography of Igneous and Metamorphic Rocks by Philpotts (CBS, 1st edition, 2015)	IGNEOUS & METAMORPHIC PETROLOGY
ES411A	2-0-3-0-9		**Course Contents:** Concepts of deformation and structures in Earth and planetary systems; Concepts of Continuum, Solid, Fluid, Tensor, Force, Stress and Strain; Basics of rheology and deformation mechanisms; Structures associated with extensional, compressional, sliding tectonics and erosion; Fold morphology, kinematics and mechanism; Normal, reverse, oblique and strikeslip faults; Fold and thrust belts; Measurement and presentation of 1, 2 and 3D structural elements; Ductile shear zones; Polyphase (superposed) deformation and overpriting relationships; Application of Structural Geology. **References/Text Books:** 1. Ramsay, J.G., & Huber, M.I., 1983. The Techniques of Modern Structure Geology: V.1: Strain analysis. NY, Academic Press, 307 p.2. Ramsay, J.G., and Huber, M.I., 1987. The Techniques of Modern Structural Geology, V.2: Folds and Fractures, NY, Academic Press, 392 p.3. Ramsay, J.G., and Lisle, R.J., The Techniques of Modern Structural Geology, V.3: Applications of Continuum Mechanics in Structural Geology. Academi Press, 361 p.	STRUCTURAL GEOLOGY
ES412A	2-0-2-0-8		**Course Contents:** Basinal Sedimentary Systems: Sedimentary basisn and production of sediments; Transport of sediment grains; depositional processes and forms; Post depositional changes lithification and diagenesis. Sediment grain, Bedforms and Sedimentary Structures: Mechanics of sediment transport and transport laws; Grain size parameters and distribution, grain shape and form; primary grain fabric; Bedforms & inorganic primary sedimentary structures. Sedimentary Facies analysis: Concept of sedimentary facies; facies relationships; controlling factors; facies association and models; Fluvial environments and facies; Lacustrine facies, Deltaic	SEDIMENTARY PROCESSES & STRATIGRAPHIC PRINCIPLES

			environments and facies models. Clay Sedimentology: Origin of clay minerals, clay minerals in fluvial, aeolian and lacustrine environments, paleoenvironmental interpretations. Techniques in elastic sedimentology: Grain size determination; Xray diffraction; Heavy mineral analysis; cathodoluminescence microscopy. **References/Text Books:** 1. Allen P.A. and Allen J.R., Basin Analysis: Principles and Application, Blackwell publishing.2. Leeder M., Sedimentology and Sedimentary Basin: from Turbulence to Tectonics; Wiley Blackwell.3. Selley R.C., Applied Sedimentology; Academic Press.4. Reading , H.G., 2009, Sedimentary Environments: processes, facies and stratigraphy, Blackwell.	
ES413A	2-0-0-0-6		**Course Contents:** Internal structure of atoms, electronic structure, chemical bonding, and chemical properties of elements. Fundamentals of Thermodynamics and its application in Earth Sciences. Aquatic geochemistry, primary silicates and chemical weathering, acids and bases, dissolution and precipitation reactions, mineral stability diagrams, Eh pH diagrams, oxidation reduction reactions. The origin and evolution of Earth and the solar system through high temperature chemical processes, trace elements in igneous processes, modeling trace element partition during magma genesis. Radiogenic isotope geology and geochrolology. Stable isotope geochemistry. Earth's hydrosphere and its interaction with surficial rocks, sediments, soils, biosphere and the atmosphere. **References/Text Books:** 1. Principles and applications for Geochemistry (1998). Faure, G., Prentice Hall ISBN 10:0023364505, 2. Geochemistry : Pathways and Processes (2004). McSween, H.Y., Richardson, S.M., Uhle, M., Columbia University Press ISBN 10:0231124406, 3. Geochemistry (2013). White, W., Wiley Blackwell ISBN 10:047656686.	GEOCHEMISTRY
ES414A	0-0-6-0-6		**Course Contents:** This course is designed to provide practical experience in stratigraphy including field logging of stratigraphic sections, sedimentary facies identification and description, interpretation of sedimentary processes, depositional environments, postdepositional changes; soil profiles and soil forming processes. The students will also be taught geophysical data acquisition using available geophysical equipments (e.g., gravimeter, magnetometer, VLF electromegnetic equipment, resistivitimeter equipment, GPR, Scismic, and Global positioning system). **References/Text Books:** 1. Compton, R. (1985) Geology in the field, Wiley, 2. Lahee, F.H. (2002). Field geology, CBS publishers, 3. John Milson and Asger Eriksen, 2011, Field Geophysics (4th Edition): Wiley Blackwell, 4. Reynolds, J.M. (2011), An Introduction to Applied and Environmental Geophysics, Second Edition: Wiley, 5. Everett, M.E., 2013, Near surface applied geophysics: Cambridge University Press.	FIELD GEOLOGY II
ES415A	2-0-2-0-8		**Course Contents:** Spectra of earth's surface material; Basic principles of digital image processing point and algebric operations, filtering and neighbourhood processing, RGB HIS transformations, image fusion analysis, PCA, image classification and geometric operations; Modern platforms and techniques INSAR techniques and its applications, UAV, and airborne sensors. Basic principles of Geographic Information System (GIS) and its application decision support and uncertainty, multicriteria evaluation. Remote sensing applications River basin management, groundwater prospecting, lake and wetland studies, water quality mapping, vegetation Mapping and forestry applications; applications in glaciology and snow hydrology; snow cover mapping and prediction of snowmelt runoff; Coastal zone mapping and other related applications; Natural hazards floods, landslides, earthquakes; Mineral resources evalution. **References/Text Books:**	GEOLOGICAL REMOTE SENSING AND GIS

			1. Gupta, R.P. (1991), Remote Sensing Geology, Springer verlog, 2. Lio, J.G. an Mason, P. (2009). Essential image processing and GIS for remote sensing. Wiley Blackwell. 3. Lillesand, T.M. & Kiefer, R.W. (1994), Remote sensing and image interpretation, John Wiley & Sons. 4. Langley, P.A., Goodchild, M.F., Maguire, D.J. & Rhind. D.W. (1999), Geographical Information Systems, Vol. 1 & 2, John Wiley & Sons. 5. Carbonneau, P. and Piegay, H. (2012). Fluvial remote sensing for science and management. Wiley Blackwell.	
ES416A	2-0-2-0-8		**Course Contents:** Introduction to exploration geophysics; Gravity and Magnetic methods: History of gravity magnetic explorations, elementary theories of gravity and magnetic methods, densities and magnetic susceptibilities of rocks and minerals, brief on gravimeters and magnetometers, data reductions, gravitymagnetic anomalies, interpretation and applications; Electrical and electomagnetic methos: Electrical properties of rocks and minerals, self potentioal and its origin, concepts of D.C. resistivity, various electode configurations for sounding and profiling, interpretation of resistivity field data, induced polarization; Basic concept of EM induction, Maxwells equations, different EM methods, earth's natural electromagnetic field, magnetotellurics, various applications of EM;Seismic methods: Basics of seismic theory, Geometry of seismic wave paths, seismic events, feflection and refraction methods, seismic data acquisition system, convolutional model, basic processing steps, basic velocitydepth modeling, interpretation of seismic data. Radiometric methos: Principles of radioactivity, radioactivity of rocks and minerals, measuring instruments and applications; Well logging: Borehole environment, concepts of porosity, permeability and saturation, principles of electrical, nuclear, density and sonic logging and well log interpretation. **References/Text Books:** 1. Telford, W.M., Geldart, L.P., and Sheriff, R.E., 1990, Applied geophysics (2nd Edition), Cambridge University Press. 2. Keary, P., Brooks, M., and Hill, I., 2002, An introduction to geophysical exploration (3rd edition), Balckwell Publishing. 3. Everett, M.E., 2013, Nearsurface applied geopysics, Cambridge University Press. 4. Serra, O., 1987, Fundamentals of Welllog Interpretation, Elsevier. 5. Sheriff, R.E., and Geldart, L.P., 1995, Exploration Seismology, Cambridge University Press.	EXPLORATION GEOPHYSICS
ES417A	2-0-0-0-6		**Course Contents:** Overview of geologic and tectonic evolution of the Indian plate, major geologic and tectonic features of the Indian subcontinent, Geodynamics and major structural grains in the Indian subcontinent; Indian Mountain buildings in geological time and space; Cratons (Dharwar, Singbhum, Bastar, Bundelkhand, Aravalli etc.) and their development in the Archean; Proterozoic basins (Chhatisgarh, Cuddapath, Marwar, PranhitaGodavari and Vindhyan), Gondwana basin; Rifting, drifting, Palaeomagnetic interpretation and the evolution of India's continental margins; The concept of Large Indian Provinces in global context; Rajmahal and Deccan volcanic provinces; Plateau uplift (Deccan, Tibet and Shillong); Phanerozoic stratigraphic records of pennsular India; The Himalaya mountains; northward flight of India and collisional orogenesis; Classification of the Himalayan ranges; Himalayan foreland development and IndusGangaBrahmaputra plains. **References/Text Books:** 1. Ramakrishnan, M. and Vaidyanadhan, R., 2008. Geology of India: Vol: I and II, Geological Society of India Publication. 2. Wadia, D.N. 1919. Geology of India for students, McMillan and Co., Ltd. 466 p. 3. Valdiya, K.S., 2015. The Making of India Geodynamics Evolution, 2nd Edition (Society of Earth Scientist Series), Springer, 942 p.	GEOLOGICAL EVOLUTION OF INDIAN PLATE
ES418A	0-0-4-0-4	ES411A	**Course Contents:** General overview of geological structures in the field; Concept of orientation and scale in the field; Identification, measurement and presentation of different structural elements (lineation, cleavage, foliation, schistocity etc.) and their mutual relationships. Morphology and elements of fold, fractures, faults, shear zones and macrostructures; Strain analysis from deformed objects; Technique and ethics of geological samples collection; Large and small scale lithostructural mapping (on toposheet and white paper),	FIELD GEOLOGY III

			crosssections, and their interpretation for regional tectonics. **References/Text Books:** 1. Davis, G.H., & Reynolds, S.J., 1996. Structural Geology of rocks and Regions (2nd Ed): NY, John Wiley & sons, 776 p. 2. Lisle, R.J., 1995. Geological Structures & Maps, a Practical Guide. 2nd Ed., Butterworth / Heinmann, Woburn, 104 p. 3. Bennison, G.M., and K.A., Moseley, 1998. Geologic Structures & Maps; 6th edition. Arnold, London, 129 p.	
ES640	3-0-0-4-4		**Course Contents:** Principles: Earth System processes, geomorphic systems, Threshold and equilibrium; scale in geomorphology, key concepts in geomorphology, hydrologic cycle.Processes and Products: Exogenetic and endogenetic processes, climatic vs. geomorphic processes, soil and weathering system.The Surface water system: Drainage basins and river systems, river morphology and hydrology, fluvial erosion, transport and sedimentation, fluvial depositional landforms, geomorphometric concepts and drainage basin morphometryThe Groundwater system: Groundwater in hydrological cycle, water table, groundwater flow and storage; porosity and permeability, aquifers, chemistry of groundwater.The Atmospheric System: Atmospheric composition and mixing, atmospheric circulation, greenhouse effect.The Ocean and Coastal system: Coastal environment, waves, tides and currents, description and classification of coasts, shoreline development, coastal erosion and resulting topographic features, coastal deposition and landforms.Global geomorphology and tectonics: Earths physiography and landscape evolution; Landforms and tectonics of plate margins and plate interiors; Tectonic uplifts and denudation rates and controlling factors, Sea level change evidence, mechanism and effects; coupled tectonicsurface process models. **References/Text Books:** 1.Summerfield, S.A. (1991) Global Geomorphology, Longman.2.Ernst, W.G. (2000) Earth Systems: Processes and Issues, Cambridge University Press. 3.Richards, K.S. (1982) Rivers forms and processes in alluvial channels, Metheun.4.Kale, V. and Gupta, A. (2001) Introduction to Geomorphology, Orient Longman.5.Thronbury, W.D. (1969) Principles of geomorphology, John Wiley & Sons.6.Williams, M.J. (1998) Quaternary Environments, Arnold Publishers7.Reading, H.G. (1996) Sedimentary Environments. Blackwell.8.Merrits, D, Dewet, A. and Menking, K. (1998) Environmental Geology: An earth system science approach. W.H. Freeman.	EARTH SYSTEM PROCESSES
ES640A	3-0-0-0-9		**Course Contents:** Principles: Earth System processes, geomorphic systems, Threshold and equilibrium; scale in geomorphology, key concepts in geomorphology, hydrologic cycle.Processes and Products: Exogenetic and endogenetic processes, climatic vs. geomorphic processes, soil and weathering system.The Surface water system: Drainage basins and river systems, river morphology and hydrology, fluvial erosion, transport and sedimentation, fluvial depositional landforms, geomorphometric concepts and drainage basin morphometryThe Groundwater system: Groundwater in hydrological cycle, water table, groundwater flow and storage; porosity and permeability, aquifers, chemistry of groundwater.The Atmospheric System: Atmospheric composition and mixing, atmospheric circulation, greenhouse effect.The Ocean and Coastal system: Coastal environment, waves, tides and currents, description and classification of coasts, shoreline development, coastal erosion and resulting topographic features, coastal deposition and landforms.Global geomorphology and tectonics: Earths physiography and landscape evolution; Landforms and tectonics of plate margins and plate interiors; Tectonic uplifts and denudation rates and controlling factors, Sea level change evidence, mechanism and effects; coupled tectonicsurface process models. **References/Text Books:** 1.Summerfield, S.A. (1991) Global Geomorphology, Longman.2.Ernst, W.G. (2000) Earth Systems: Processes and Issues, Cambridge University Press. 3.Richards, K.S. (1982) Rivers forms and processes in alluvial channels, Metheun.4.Kale, V. and Gupta, A. (2001) Introduction to Geomorphology, Orient Longman.5.Thronbury, W.D. (1969) Principles of geomorphology, John Wiley & Sons.6.Williams, M.J. (1998) Quaternary Environments, Arnold Publishers7.Reading, H.G. (1996) Sedimentary Environments.	EARTH SYSTEM PROCESSES

			Blackwell.8.Merrits, D, Dewet, A. and Menking, K. (1998) Environmental Geology: An earth system science approach. W.H. Freeman.	
ES642	3-0-0-0-4		**Course Contents:** Course outline, grading policy, introduction to geochemical cycles, periodic table, Origin of the universe and Earth, Earths history from its creation to Anthropocene, The Basics: Nuclear (in) stability, isotopes, particles, modes of radioactive decay, chart of nuclides, nucleosynthesis, Nucleosynthesis continued, Thermodynamics, Radioactive decay, principles of geochronology and isochrons, radiogenic isotopes as geochronometer and process tracers, mixing and modeling calculations, RbSr, SmNd, UThPb and ReOs systematics, Cosmogenic radionuclides: 14C, 10Be, 26Al theory, models and applications, Discussion on assignments2 & 3, as well as reading material, Fractionation of stable isotopes, H, O, C, Discussion on assignment4 and reading material, Mass spectrometry: Measurement principles and methodology, techniques such as isotope dilution. **References/Text Books:** Principles and Applications of Geochemistry by Gunter Faure (2nd edition, Prentice Hall)Geochemistry: pathways and Processes by McSween, Richardson, Uhle (Columbia University Press)Geochemistry an Introduction by F. Albarede (Cambridge University Press)Introduction to Geochemistry by Krauskopf and Bird (McGrawHill)	GEOCHEMISTRY
ES642A	3-0-0-0-9		**Course Contents:** Course outline, grading policy, introduction to geochemical cycles, periodic table, Origin of the universe and Earth, Earths history from its creation to Anthropocene, The Basics: Nuclear (in) stability, isotopes, particles, modes of radioactive decay, chart of nuclides, nucleosynthesis, Nucleosynthesis continued, Thermodynamics, Radioactive decay, principles of geochronology and isochrons, radiogenic isotopes as geochronometer and process tracers, mixing and modeling calculations, RbSr, SmNd, UThPb and ReOs systematics, Cosmogenic radionuclides: 14C, 10Be, 26Al theory, models and applications, Discussion on assignments2 & 3, as well as reading material, Fractionation of stable isotopes, H, O, C, Discussion on assignment4 and reading material, Mass spectrometry: Measurement principles and methodology, techniques such as isotope dilution. **References/Text Books:** Principles and Applications of Geochemistry by Gunter Faure (2nd edition, Prentice Hall)Geochemistry: pathways and Processes by McSween, Richardson, Uhle (Columbia University Press)Geochemistry an Introduction by F. Albarede (Cambridge University Press)Introduction to Geochemistry by Krauskopf and Bird (McGrawHill)	GEOCHEMISTRY
ES646	3-0-0-4-4		**Course Contents:** Introduction to global climate: earths climate system, time scales of climate change, climate forcings and response systems, climate feedbacks and interactions.Earths radiation budget and circulation systems: Earths tilt and seasonal radiation, hydrological cycle, atmospheric circulation, monsoonal circulation, ocean circulation, oceanic conveyor belt.Climate archives and proxies: Methods of reconstructing climate, Ice sheet, sedimentary archives, biotic proxies, geological and geochemical proxies.Global climatic models: 1D, 2D and 3D atmospheric models, Global Circulation Models (GCMs), Ice sheet model, vegetation feedback, geochemical modelsQuaternary climates: Sea level changes, glacial/interglacial cycles, tectonicsclimate coupling, sea floor spreading, BLAG hypothesis, Upliftweathering hypothesis, carbon reservoir, vegetation dynamics, migration history, response of vegetation to climatic reversalsGeological records of climate change: Sedimentology, stable isotopes, geochemistry, geochronology relative and numerical methods, PreQuaternary climates, evolution of climate through geological time.Impacts of climate change: impacts on water resources rivers, oceans, lakes, ecological systems, socioeconomic impacts, mitigation strategies. **References/Text Books:** 1.Ruddiman, W.F. 2001. Earths Climate: past and Future. W.H. Freeman & Co.2.Bradley, R. S., 1999, Quaternary paleoclimatology. 3.Williams, M., Dunkereley, D., Decker, P.D., Kershaw, P. & Chappel, J. (1998) Quaternary Environments.4.Burroughs, W.J. (2001) Climate Change: A multidisplinary	GLOBAL CLIMATE CHANGE

			Approach.5.Merrits, D., Dewet, A. and Menking, K., (1998) Environmental geology; an earth system science approach, Freeman.	
ES646A	3-0-0-0-9		**Course Contents:** Introduction to global climate: earths climate system, time scales of climate change, climate forcings and response systems, climate feedbacks and interactions.Earths radiation budget and circulation systems: Earths tilt and seasonal radiation, hydrological cycle, atmospheric circulation, monsoonal circulation, ocean circulation, oceanic conveyor belt.Climate archives and proxies: Methods of reconstructing climate, Ice sheet, sedimentary archives, biotic proxies, geological and geochemical proxies.Global climatic models: 1D, 2D and 3D atmospheric models, Global Circulation Models (GCMs), Ice sheet model, vegetation feedback, geochemical modelsQuaternary climates: Sea level changes, glacial/interglacial cycles, tectonicsclimate coupling, sea floor spreading, BLAG hypothesis, Upliftweathering hypothesis, carbon reservoir, vegetation dynamics, migration history, response of vegetation to climatic reversalsGeological records of climate change: Sedimentology, stable isotopes, geochemistry, geochronology relative and numerical methods, PreQuaternary climates, evolution of climate through geological time.Impacts of climate change: impacts on water resources rivers, oceans, lakes, ecological systems, socioeconomic impacts, mitigation strategies. **References/Text Books:** 1.Ruddiman, W.F. 2001. Earths Climate: past and Future. W.H. Freeman & Co.2.Bradley, R. S., 1999, Quaternary paleoclimatology. 3.Williams, M., Dunkereley, D., Decker, P.D., Kershaw, P. & Chappel, J. (1998) Quaternary Environments.4.Burroughs, W.J. (2001) Climate Change: A multidisplinary Approach.5.Merrits, D., Dewet, A. and Menking, K., (1998) Environmental geology; an earth system science approach, Freeman.	GLOBAL CLIMATE CHANGE
ES652	3-0-0-4-4		**Course Contents:** This course will focus on the processes and principles involved in the generation of Earth materials, in particular, igneous and metamorphic rocks. Students will gain a broad overview of the Earth as dynamic system that produces a variety of igneous and metamorphic rocks in a wide range of tectonic settings with emphasis on developing skills necessary to understand and evaluate melt generation and crystallization, differentiation and chemical evolution of magma, and metamorphic processes etc. Topics to be discussed in detail are:Classification and Nomenclature of Igneous Rocks; Textures and Petrogenetic Interpretations; Thermodynamic evaluation of phase diagrams; Phase Rule and One Component System; Phase Diagrams for Binary Systems (Solid solution, Eutectic, and Peritectic systems) such as ForsteriteFayalite, AlbiteAnorthite, DiopsideAnorthite, OrthoclaseAlbite, and Forsteritesilica; Three component Systems (AnorthiteDiopsideForsterite, and AnorthiteForsteritesilica); Effect of P, T & fluids on Melting; Chemical Petrology: Major and minor element, and isotopic compositional variations; graphical and mathematical models of magma evolution; Fractionation of trace elements during melting and crystallization; Rare Earth Element (REE) patterns and modeling source magma composition; Generation and diversification of magmas; MidOcean Ridge Volcanism; Mantle Plumes and Ocean Island Basalts; Subduction related Arc magma generation; Types of metamorphism; Classification of metamorphic rocks; textures; Metamorphic mineral assemblagesand chemographic (ACF, AKF, and AFM) diagrams; Metamorphic Facies; Metamorphic Reactions. **References/Text Books:** Text: An Introduction to Igneous and Metamorphic Petrology by John D. Winter (Prentice Hall, 2nd edition)Recommended readings:1. The Interpretation of Igneous Rocks by Cox, Bell and Pankhurst (Chapman and Hall). 2. Principles of Igneous and Metamorphic Petrology by Anthony Philpotts and Jay Ague (Cambridge University Press; 2nd edition).3. Petrology: Igneous, Sedimentary and Metamorphic by Blatt, Tracy, and Owens (Freeman and Company)	IGNEOUS AND METAMORPHIC PETROLOGY
ES652A	3-0-0-0-9		**Course Contents:** This course will focus on the processes and principles involved in the generation of Earth materials, in particular, igneous and metamorphic rocks. Students will gain a broad overview of the Earth as dynamic	IGNEOUS AND METAMORPHIC PETROLOGY

			system that produces a variety of igneous and metamorphic rocks in a wide range of tectonic settings with emphasis on developing skills necessary to understand and evaluate melt generation and crystallization, differentiation and chemical evolution of magma, and metamorphic processes etc. Topics to be discussed in detail are:Classification and Nomenclature of Igneous Rocks; Textures and Petrogenetic Interpretations; Thermodynamic evaluation of phase diagrams; Phase Rule and One Component System; Phase Diagrams for Binary Systems (Solid solution, Eutectic, and Peritectic systems) such as ForsteriteFayalite, AlbiteAnorthite, DiopsideAnorthite, OrthoclaseAlbite, and Forsteritesilica; Three component Systems (AnorthiteDiopsideForsterite, and AnorthiteForsteritesilica); Effect of P, T & fluids on Melting; Chemical Petrology: Major and minor element, and isotopic compositional variations; graphical and mathematical models of magma evolution; Fractionation of trace elements during melting and crystallization; Rare Earth Element (REE) patterns and modeling source magma composition; Generation and diversification of magmas; MidOcean Ridge Volcanism; Mantle Plumes and Ocean Island Basalts; Subduction related Arc magma generation; Types of metamorphism; Classification of metamorphic rocks; textures; Metamorphic mineral assemblagesand chemographic (ACF, AKF, and AFM) diagrams; Metamorphic Facies; Metamorphic Reactions. **References/Text Books:** Text: An Introduction to Igneous and Metamorphic Petrology by John D. Winter (Prentice Hall, 2nd edition)Recommended readings:1. The Interpretation of Igneous Rocks by Cox, Bell and Pankhurst (Chapman and Hall). 2. Principles of Igneous and Metamorphic Petrology by Anthony Philpotts and Jay Ague (Cambridge University Press; 2nd edition).3. Petrology: Igneous, Sedimentary and Metamorphic by Blatt, Tracy, and Owens (Freeman and Company)	
ES659A	3-0-0-0-9		**Course Contents:** Crustal deformation and earthquakes (02); significance of seismicity (01); Identification of Prehistoric Earthquakes based on Primary and Secondary signatures preserved in landforms and sediment succession (03); Interpretation and Identification of Active Fault and associated Tectonic Landforms Photogeologic Mapping, onfault and offfault landforms, indentification and mapping of active faults and associated landforms in field, structural analysis of active faults & its implication to regional scale tectonics (04); Field Techniques in Paleoseismology, quantification of active fault scarp by precise mapping, identification of old (prehistoric) earthquake by trenching, mapping of deformed sedimentary succession by faulting, estimation of net displacement during single event, slip rate, magnitude of historic earthquake, recurrene interval, and prediction of future earthquake if possible (05); Identification and mapping of secondary effects due to strong seismic shaking identification of paleoliquefaction features (02); Dating techniques (01); Correlation of paleoseismic data with existing geodetic and geophysical data (01); Delineation of seismogenic faults (01).Paleotsunami geology Identification of Paleotsunami and Megasubduction zone earthquakes signatures in the coastal region along subduction zones (05); Understanding landlevel change caused by major earthquakes (02); decoupling the role of climate and tectonics (01); Understanding the effect of nearfield and farfield earthquakes from stratigraphic records (01); effects of near field and farfield tsunami (01). **References/Text Books:** 1. McCalpin, J.P., (1996), Paleoseismology, Academic Press, New York, p. 588. 2. Yeats, R.S., Sieh, K., Allen, C.R., (19997), Geology of Earthquakes, Oxford Univ. Press, 568. 3. Shiki, T., Tsuji, Y., Yamasaki, T., Minoura, K. Tsunamiites, Elsevier, Amsterdam. 4. Burbank, D. W. and Anderson, R.S. Tectonic Geomorphology, Blakwell Sciences, 287. 5. Bull, W. B. Tectonic Geomorphology of Mountains; A new Approach of Paleoseismology, Blackwell Sciences, 326.	ACTIVE TECTONICS AND PALEOSEISMOLOGY
ES699	----		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
ES799	----		**Course Contents:**	PH D THESIS

			Ph. D. Thesis **References/Text Books:**	
ESO213A	3-0-0-0-9		**Course Contents:** universe and its characteristics Solar System and Earth The primitive Earth Geological Time scale Origin of the life and major geological events Numerical Dating. Rocks, minerals and soils; Plate Tectonics and Mountain building, Deformation and Geodynamics Earthquakes; Volcanoes.Earth, Ocean, Land, Rivers, Atmosphere, Biosphere, Cryosphere and Climate; Energy budget; Carbon Cycle; Hydrological Cycle; Weathering and erosion.Coupled processoes in Earth System; climate change,Geological resourses (minerals,hydrocarbons and water); Sustainability and Anthropocene activities **References/Text Books:** 1. D.R.Prothero and R.H. Dott, Jr. Evolution of the Earth. 2010 (8th Ed.), McGraw Hill, 576p. 2. E.J. Tarbuck, F.K. Lutgens and D.G. Tasa. Earth: An introduction to Physical Geology, 2013 (11th Ed.). Prentice Hall. 912 p. 3. J. Grotzinger and T. Jordan, Understanding Earth, 2010 (6th Ed.). Freeman, 210p.	FUNDAMENTALS OF EARTH SCIENCES
***** Department of HSS *****				
ART101A	3-1-0-0-11		**Course Contents:** Indian Art from Ancient Times: Rock Paintings of Bhimbetka and Indus Valley Civilization;Early Indian Art (1" 10'h Century A.D.): Buddhist Art from Gandhara and Kushan School,Buddhist Arts of Samath, Ajanta and Ellora, Chalukyan Art of Badami, Rashrakuta Art ofDeccan; Medieval Indian Art (lO'h 14'h Century A.D.): Chola Art of Deccan Temples ofKhajuraho, Temple of Konark, Paintings of Lepakshi; 15th to 19th Century Art: MoghulMiniatures, Jain Miniature, Mysore and Tanjore Schools of Art, Guier and Kulu MiniaturesRajasthani and Pahari Schools, Company and Bazar Art; Contemporary and Modem Indian Art20th 21" Century: Individual Artists **References/Text Books:** *Indian Art A Concise History by Roy C. Craven*Early India From the Origins to AD 1300 by Romila Thapar*Moving Focus: Essays on Indian Art by K.G. Subramanyan*TheMakingofaNew'Indian'Art By Tapati Guha Thakurta*Indian Art (Oxford History of Art) by Partha Mitter*Faces of Indian Art Edited by Ina Puri	INDIAN ART AND CIVILIZATION
ART102	3-0-1--4		**Course Contents:** What is Art, What is art appreciation, History of Art Criticism, Methodology of Critical ArtAppreciation, , Elements and Principles of Visual Art, Characteristics of art of Prehistoric,Ancient, middle age, Dark Age, modem, post modem era in context of world art (Western,Indian, Oriental and Far Eastern Art), Introduction to methods and materials.Practice: Still life, Nature Study, Composition, Symmetry, Narrative Continuity, 2D and 3D Exercises **References/Text Books:** Jaoson's Basic History of Western Art by Penelope CaviesArt of Twentieth Century by Loredana ParmesaoiIndiao Art A Concise History by Roy C. CravenEarly India From the Origins to AD 1300 by Romila ThaparThe Story of Art E.H.GombrichDesign Basics by David A, Lauer, Holt, Rinehart aod WinstonBook on Far Eastern Art (Chinese aod Japaoese Art) Skira, Sharman Lee PublishersMoving Focus: Essays on Indian Art by K.G. SubramaoyaoThe Making of a New 'Indiao' Art by Tapati Guha ThakurtaIndiao Art (Oxford History of Art) by Partha MitterFaces ofindiao Art Edited by Ina Puri	INTRODUCTION TO ART CRITICISM AND APPRECIATION
ART102.	3-0-1-0-4		**Course Contents:** What is Art, What is art appreciation, History of Art Criticism, Methodology of Critical ArtAppreciation, , Elements and Principles of Visual Art, Characteristics of art of Prehistoric,Ancient, middle age, Dark Age, modem, post modem era in context of world art (Western,Indian, Oriental and Far Eastern Art), Introduction	INTRODUCTION TO ART CRITICISM AND APPRECIATION

			to methods and materials.Practice: Still life, Nature Study, Composition, Symmetry, Narrative Continuity, 2D and 3D Exercises **References/Text Books:** Jaoson's Basic History of Western Art by Penelope CaviesArt of Twentieth Century by Loredana ParmesaoiIndiao Art A Concise History by Roy C. CravenEarly India From the Origins to AD 1300 by Romila ThaparThe Story of Art E.H.GombrichDesign Basics by David A, Lauer, Holt, Rinehart aod WinstonBook on Far Eastern Art (Chinese aod Japaoese Art) Skira, Sharman Lee PublishersMoving Focus: Essays on Indian Art by K.G. SubramaoyaoThe Making of a New 'Indiao' Art by Tapati Guha ThakurtaIndiao Art (Oxford History of Art) by Partha MitterFaces ofindiao Art Edited by Ina Puri	
ART102A	3-1-0-0-11		**Course Contents:** Introduce fundamental visual skills and analytical skills, Critical thinking aboutvarious forms of art, and close observation of art and performing art.Principles of Analysis of Art, Art and perception, What is Style?, Style in Painting,Colour, Psychology of Colour Perception & Design, Space Illusion, Painting,Sculpture, Style in Sculpture Architecture, Style in Architecture, Space inArchitecture, Printmaking, Photography & Film, POP Art Comics, Advertisementsetc, Performing Art, Methodology of Criticism & Appreciation.Studio: 2D Exercise, Printmaking, 3D Exercises, Sculpture, Field Trip. **References/Text Books:**	INTRODUCTION TO ART APRECIATION & CRITICISM
ART103	3-1-0-0-4		**Course Contents:** What is Art? Cave Paintings: 14,00010,000 BC: Altamira Cave Paintings; The Art of theClassical Civilizations: 3,000 BCAD 500: 8000600 BC: Mesopotamia; 3000270 BC: Egypt;1230100 BC: Greece; 700 BCAD 325: Rome; 3251453: Byzantium; The Art ofthe MiddleAges: 4751500: 4751000: The Dark Ages; 10001350: The High Middle Ages; 13501500: TheLate Middle Ages; The Art of the Modern Period: 1500present: 14001550: Renaissance;15501700: Baroque; 17001800: Rococo and Classical; 17901850: Romantic; 18501910:Realism, Impressionism, Expressionism; 19101950: Cubism, Fauvism, Abstraction, Modernism,Dada; 1950present: Recent **References/Text Books:** Janson's Basic History of Western Art by Penelope CaviesArt of Twentieth Century by Loredana ParmesaniIndian Art A Concise History by Roy C. CravenEarly India From the Origins to AD 1300 by Romila ThaparThe Story of Art E.H.GombrichDesign Basics by David A, Lauer, Holt, Rinehart and WinstonBook on Far Eastern Art (Chinese and Japanese Art) Skira, Sharman Lee PublishersMoving Focus: Essays on Indian Art by K.G. SubramanyanThe Making of a New 'Indian' Art by Tapati Guha Thakurta Indian Art (Oxford History of Art) by Partha MitterFaces ofIndian Art Edited by Ina Puri	INTRODUCTION TO WESTERN ART
ART103A	3-1-0-0-11		**Course Contents:** What is Art? Cave Paintings: 14,00010,000 BC: Altamira Cave Paintings; The Art of theClassical Civilizations: 3,000 BCAD 500: 8000600 BC: Mesopotamia; 3000270 BC: Egypt;1230100 BC: Greece; 700 BCAD 325: Rome; 3251453: Byzantium; The Art ofthe MiddleAges: 4751500: 4751000: The Dark Ages; 10001350: The High Middle Ages; 13501500: TheLate Middle Ages; The Art of the Modern Period: 1500present: 14001550: Renaissance;15501700: Baroque; 17001800: Rococo and Classical; 17901850: Romantic; 18501910:Realism, Impressionism, Expressionism; 19101950: Cubism, Fauvism, Abstraction, Modernism,Dada; 1950present: Recent **References/Text Books:** Janson's Basic History of Western Art by Penelope CaviesArt of Twentieth Century by Loredana ParmesaniIndian Art A Concise History by Roy C. CravenEarly India From the Origins to AD 1300 by Romila ThaparThe Story of Art E.H.GombrichDesign Basics by David A, Lauer, Holt, Rinehart and WinstonBook on Far Eastern Art (Chinese and Japanese Art) Skira, Sharman Lee PublishersMoving Focus: Essays on Indian Art by K.G. SubramanyanThe Making of a New 'Indian' Art by Tapati Guha Thakurta	INTRODUCTION TO WESTERN ART

			Indian Art (Oxford History of Art) by Partha MitterFaces oflndian Art Edited by Ina Puri	
ART104A	3-1-0-0-11		**Course Contents:** Manmade Environment and Natural Environment Primary Function of EnclosedSpaceshelter building, material consideration, Introduction to Architecture whatis architecture, difference between building and architecture. **References/Text Books:**	ARCHITECTURE AND ENVIRONMENTAL DESIGN
ART105	3-0-1-0-4		**Course Contents:** TheoryCinematography, Production Process, Writing for Screen, Basics Picture Making, CameraAngles, Direction Time and Space continuity, Cuts, Art of Editing **References/Text Books:** The 5C's of Cinematography, MascelliDirecting the Documentary, Michail RabigerA History ofthe Cinema, Eric RhodeWriting for Screen and Television, TobiasSingle camera video production, Robert b. MusburgerAnother Cinema for Another Society, Gaston RobergeBrand Bollywood, BoseProducing and Directing the Short Film & Video, Irving & ReaThe Art of Cinema, B.D.GargaA compauion to Film Theory, Miller & Starn	INTRODUCTION TO THE ART OF VIDEO MAKING
ART105.	3-0-1-0-4		**Course Contents:** TheoryCinematography, Production Process, Writing for Screen, Basics Picture Making, CameraAngles, Direction Time and Space continuity, Cuts, Art of Editing **References/Text Books:** The 5C's of Cinematography, MascelliDirecting the Documentary, Michail RabigerA History ofthe Cinema, Eric RhodeWriting for Screen and Television, TobiasSingle camera video production, Robert b. MusburgerAnother Cinema for Another Society, Gaston RobergeBrand Bollywood, BoseProducing and Directing the Short Film & Video, Irving & ReaThe Art of Cinema, B.D.GargaA compauion to Film Theory, Miller & Starn	INTRODUCTION TO THE ART OF VIDEO MAKING
ART105A	3-0-2-0-11		**Course Contents:** TheoryCinematography, Production Process, Writing for Screen, Basics Picture Making, CameraAngles, Direction Time and Space continuity, Cuts, Art of Editing **References/Text Books:** The 5C's of Cinematography, MascelliDirecting the Documentary, Michail RabigerA History ofthe Cinema, Eric RhodeWriting for Screen and Television, TobiasSingle camera video production, Robert b. MusburgerAnother Cinema for Another Society, Gaston RobergeBrand Bollywood, BoseProducing and Directing the Short Film & Video, Irving & ReaThe Art of Cinema, B.D.GargaA compauion to Film Theory, Miller & Starn	INTRODUCTION TO THE ART OF VIDEO MAKING
ART106	3-0-0-0-9		**Course Contents:** 1. Space Two dimensional Spaces Illusion of Space One, two and multiple point perspective Three dimensional Spaces Space distribution Negative and Positive Space Object and ground relationship: Fore ground, middle ground, back ground Interactive Space2. Scale Natural space and natural scale Ideal space and ideal scale Scale Confusion in surreal space3. Illusion of motion Illusion of motion Anticipated and optical movement4. Line Line quality Line and Shape delineation5. Style of Visual Representation Form and Content Realistic, Semi abstract, Abstract, Typographic, Decorative StyleWhat is Art?6. Visual Harmony Unity Emphasis Balance Rhythm7. Visual Perception Compositional Arrangement Gestalt Principle of universal whole8. Shape and Volume Naturalism and distortion Naturalism and Idealism Abstract Expression Form and Pattern Rectilinear and Curvilinear Pattern9. Tone and Texture Tactile and Visual texture Trompeloeil10. Colour Colour and Value Colour theory Colour Combination Hue and Saturation Colour	ELEMENTS OF VISUAL REPRESENTATION

			Characteristics Cognitive perception Optical Colour Mixing11. Visual Culture Cultural Identity through Visual Interface Refinement of Expression Culture Specific Expressions Traditional and Contemporary Expression Tribal and Folk art Comic Art Applied and Commercial Art12. Medium of Representation (Method and Material)Process of Visual Communication (Thinking, looking and doing)13. Visual Analysis (Conclusion)EvaluationAssignments, Presentations, Examinations **References/Text Books:** Varieties of Visual ExperienceArt as image and idea Vol.6Edmund Burke FeldmanJanson, H. W. History of ArtNew York: PrenticeHall and HarryN.Abrams, Inc 1977De LucioMeyer, J. Visual Aesthetics,New York: Harper & Row 1974Design Basics,Second EditionDavid A. Lauer, Holt, Rinehart and WinstonRudolf Arnheim,Art and Visual Perception, A Psychology of the Creative Eye, CaliforniaE. H.Gombrich, Art and IllusionA study in the psychology of pictorial representationThe A. W. Mellon lectures in the fine arts, 1956Bollingen series XXXV: 5Princeton University Press, Princeton and OxfordLorendana Permesani, Art of the Twentieth Century, Movements, Theories, Schools and Tendencies 19002000, SKIRA	
ART106A	3-1-0-0-11		**Course Contents:** 1. Space Two dimensional Spaces Illusion of Space One, two and multiple point perspective Three dimensional Spaces Space distribution Negative and Positive Space Object and ground relationship: Fore ground, middle ground, back ground Interactive Space2. Scale Natural space and natural scale Ideal space and ideal scale Scale Confusion in surreal space3. Illusion of motion Illusion of motion Anticipated and optical movement4. Line Line quality Line and Shape delineation5. Style of Visual Representation Form and Content Realistic, Semi abstract, Abstract, Typographic, Decorative StyleWhat is Art?6. Visual Harmony Unity Emphasis Balance Rhythm7. Visual Perception Compositional Arrangement Gestalt Principle of universal whole8. Shape and Volume Naturalism and distortion Naturalism and Idealism Abstract Expression Form and Pattern Rectilinear and Curvilinear Pattern9. Tone and Texture Tactile and Visual texture Trompeloeil10. Colour Colour and Value Colour theory Colour Combination Hue and Saturation Colour Characteristics Cognitive perception Optical Colour Mixing11. Visual Culture Cultural Identity through Visual Interface Refinement of Expression Culture Specific Expressions Traditional and Contemporary Expression Tribal and Folk art Comic Art Applied and Commercial Art12. Medium of Representation (Method and Material)Process of Visual Communication (Thinking, looking and doing)13. Visual Analysis (Conclusion)EvaluationAssignments, Presentations, Examinations **References/Text Books:** Varieties of Visual ExperienceArt as image and idea Vol.6Edmund Burke FeldmanJanson, H. W. History of ArtNew York: PrenticeHall and HarryN.Abrams, Inc 1977De LucioMeyer, J. Visual Aesthetics,New York: Harper & Row 1974Design Basics,Second EditionDavid A. Lauer, Holt, Rinehart and WinstonRudolf Arnheim,Art and Visual Perception, A Psychology of the Creative Eye, CaliforniaE. H.Gombrich, Art and IllusionA study in the psychology of pictorial representationThe A. W. Mellon lectures in the fine arts, 1956Bollingen series XXXV: 5Princeton University Press, Princeton and OxfordLorendana Permesani, Art of the Twentieth Century, Movements, Theories, Schools and Tendencies 19002000, SKIRA	ELEMENTS OF VISUAL REPRESENTATION
ART401	3-0-0-0-4		**Course Contents:** This is a (theoretical) cinemastudy course, whichpresents a survey of the FarEastern films both as an art form forcreative expression and as a medium of mass communication. The coursewill broadly orient students to the theoretical fundamentals of thecinemastudies. The course will explore five major movie making countriesof the FarEast Japan, Korea, Mainland China, HongKong and Taiwan. Thefilms included in this course, span the decades between the post SecondWorld War era to the 21st century and they are mostly art house cinemasand are distinct in respect to their timeperiod, filmmakers,countrylanguage and genre. The course content comprise of vast level oftheoretical and textual study. **References/Text Books:** Berggreen, ShuLing Chen, and Rob Peaslee. "TransChinese imagination:film and crossStrait perception as a historical case study for contextualjournalism education." Asia Pacific Media Educator. Issue No.18.	APPRECIATING FAR-EASTERN CINEMA

			(Dec.2007): 155 170.Dai, Jinhua. "Hou HsiaoHsiens films: pursuing and escaping history."InterAsia Cultural Studies. Volume 9.Number 2 (2008): 239 250.Fang, Karen. "Arresting Cinema: Surveillance and the CityState in theRepresentation of Hong Kong." New Formations. 44.2 (2001): 12850.	
ART401A	3-0-0-0-9		**Course Contents:** This is a (theoretical) cinemastudy course, whichpresents a survey of the FarEastern films both as an art form forcreative expression and as a medium of mass communication. The coursewill broadly orient students to the theoretical fundamentals of thecinemastudies. The course will explore five major movie making countriesof the FarEast Japan, Korea, Mainland China, HongKong and Taiwan. Thefilms included in this course, span the decades between the post SecondWorld War era to the 21st century and they are mostly art house cinemasand are distinct in respect to their timeperiod, filmmakers,countrylanguage and genre. The course content comprise of vast level oftheoretical and textual study. **References/Text Books:** Berggreen, ShuLing Chen, and Rob Peaslee. "TransChinese imagination:film and crossStrait perception as a historical case study for contextualjournalism education." Asia Pacific Media Educator. Issue No.18. (Dec.2007): 155 170.Dai, Jinhua. "Hou HsiaoHsiens films: pursuing and escaping history."InterAsia Cultural Studies. Volume 9.Number 2 (2008): 239 250.Fang, Karen. "Arresting Cinema: Surveillance and the CityState in theRepresentation of Hong Kong." New Formations. 44.2 (2001): 12850.	APPRECIATING FAR-EASTERN CINEMA
ART402	3-0-1-0-4		**Course Contents:** Art movements from 1840s to 1960s will be discussed in class from anaesthetic and socioeconomic perspective. The study of movements will also be assisted with anexploration of philosophy of art wherever necessary.Art movements Impressionism, Post impressionism, Fauvism, Cubism, Futurism, Dadaism,Surrealism, Abstract expressionism, Pop art, Minimalism, Introduction to Post modernism.Philosophy of art Formalism (Clive Bell and Roger Fry), Dream in psycho analysis (Freud),Existentialism (Sartre, Camus), Modernism (Clement Greenberg) **References/Text Books:** I. Story of Modern Art, Cheney, Sheldon2. Art in theory: Charles Harrison & Paul Wood3. Abstract art: Anna Moszynska4. Shape ofthe pocket: John Berger5. Marg (Journal)6. Art India (Journal)	MODERN ART
ART402A	3-0-0-0-9		**Course Contents:** Art movements from 1840s to 1960s will be discussed in class from anaesthetic and socioeconomic perspective. The study of movements will also be assisted with anexploration of philosophy of art wherever necessary.Art movements Impressionism, Post impressionism, Fauvism, Cubism, Futurism, Dadaism,Surrealism, Abstract expressionism, Pop art, Minimalism, Introduction to Post modernism.Philosophy of art Formalism (Clive Bell and Roger Fry), Dream in psycho analysis (Freud),Existentialism (Sartre, Camus), Modernism (Clement Greenberg) **References/Text Books:** I. Story of Modern Art, Cheney, Sheldon2. Art in theory: Charles Harrison & Paul Wood3. Abstract art: Anna Moszynska4. Shape ofthe pocket: John Berger5. Marg (Journal)6. Art India (Journal)	MODERN ART
ART411	3-0-0-0-4		**Course Contents:** History of communication, Psychology of perception, Signs and symbols,Elements of visual display, Layout design, History of typography, Information structuring,Claymation, Visual branding, Case studies of campaigns.An overall understanding of above mentioned areas will be assisted through related projects oncomposition, typography,illustration techniques, story boarding, claymation, logo design and advertisement campaigns. **References/Text Books:** I. Art and Visual perception Rudolph Arnehiem2. Manufacturing Consent: The Political Economy of the	PRINCIPLES OF COMMUNICATION DESIGN

			Mass Media: Noam Chomsky3. Design and Form Johannes Itten4. The Visual Display of Quantitative Information: Edward Tufte5. Envisioning Information: Edward Tufte6. Visual Explanations: Images and Quantities, Evidence and Narrative: Edward Tufte7. Principles of ThreeDimensional design Stephen Luecking8. Principles of2D design Wucius Wong9. Principles of Form and Design Wucius Wong10. Pedagogical sketch book Paul K.leeII. Form (Journal)12. MAG INDIA (online database of advertising and marketing) www.magindia.com	
ART411A	3-0-0-0-9		**Course Contents:** History of communication, Psychology of perception, Signs and symbols,Elements of visual display, Layout design, History of typography, Information structuring,Claymation, Visual branding, Case studies of campaigns.An overall understanding of above mentioned areas will be assisted through related projects oncomposition, typography,illustration techniques, story boarding, claymation, logo design and advertisement campaigns. **References/Text Books:** I. Art and Visual perception Rudolph Arnehiem2. Manufacturing Consent: The Political Economy of the Mass Media: Noam Chomsky3. Design and Form Johannes Itten4. The Visual Display of Quantitative Information: Edward Tufte5. Envisioning Information: Edward Tufte6. Visual Explanations: Images and Quantities, Evidence and Narrative: Edward Tufte7. Principles of ThreeDimensional design Stephen Luecking8. Principles of2D design Wucius Wong9. Principles of Form and Design Wucius Wong10. Pedagogical sketch book Paul K.leeII. Form (Journal)12. MAG INDIA (online database of advertising and marketing) www.magindia.com	PRINCIPLES OF COMMUNICATION DESIGN
ART701	3-0-0-0-4		**Course Contents:** To familiarize students with variety of methodological approach in art criticismand analysis The course proposes to develop visual skills and analytical skillsin writing about various forms of art in using concepts and terminology. It alsowould enable research student to exercise skills in observation of various formsof visual media. The methodology of criticism is base on some of the followingauthors John Dewey (Criticism and Perception), Barkan, Fidmans, Jack Hobbs,and Solomns Phenomenological Model of Criticism, and Ducasses Language ofFeeling. The critical analysis would be based on Art and Perception, Principlesof Style, Styles in 2dimension and 3dimension visual art. **References/Text Books:**	METHODOLOGY: ART CRITICISM & APPRECIATION
ART701A	3-0-0-0-9		**Course Contents:** To familiarize students with variety of methodological approach in art criticismand analysis The course proposes to develop visual skills and analytical skillsin writing about various forms of art in using concepts and terminology. It alsowould enable research student to exercise skills in observation of various formsof visual media. The methodology of criticism is base on some of the followingauthors John Dewey (Criticism and Perception), Barkan, Fidmans, Jack Hobbs,and Solomns Phenomenological Model of Criticism, and Ducasses Language ofFeeling. The critical analysis would be based on Art and Perception, Principlesof Style, Styles in 2dimension and 3dimension visual art. **References/Text Books:**	METHODOLOGY: ART CRITICISM & APPRECIATION
ART704A	2-0-3-0-9		**Course Contents:** Theory: Prehistoric Art; Traditional Art as Medum of Communication Religious Art, Buddhist Art, Christian Art, and Hindu Art; Critical analysis of the following theories/ articles Plato's 'Art as Imitation'; aristotle's 'Theory on Art'; Leo Tolstory's Theory of Art and 'Art as the Communication of Feeling'; David Hume's 'Of the Standard of Taste'; susanne Langer's 'Art as Symbolic Expression : From Feeling and Form'; Arthur Danto's, 'The Art World'; POP Art and Comic Art; Art as Language of Expression in 2D and 3D media. **References/Text Books:**	ART A MEDIUM OF COMMUNICATION

ECO100	2-0-0--0		**Course Contents:** For whom the bell tolls; What is economics?; Basic concepts of supply anddemand; Central Problems of very economic society; Development, freedom andopportunities; Dilemma of development; Linkages between technology, economicsand environment; Business organizations and income; The role of economistin business and industry; The role of economist in societal development; Therole of economist in governance **References/Text Books:**	INTRODUCTION TO PROFESSION
ECO101	3-1-0-0-4		**Course Contents:** Definition and central problems of Economics, Microeconomics vs.Macroeconomics, Normative vs. Positive Economics, Stock vs. Flow variables; Aggregateeconomic variables: Gross domestic product (GDP), Gross national product (GNP), Nationalincome, Money supply, Price index and inflation rate, Unemployment rate, Exchange rate;Laws of demand and supply, Elasticity, Market equilibrium, Consumer and producer surplus,Price controls; Utility theory: Laws of diminishing marginal and equimarginal utility,Indifference curves and budget constraint, Optimizing conditions, Substitution and incomeeffects; Theory of production and cost: Law of variable proportion, Shortrun cost functions,Isoquant and isocost, Optimizing conditions, Longrun cost functions; Types of market:Perfect Competition, Monopoly, Oligopoly, Monopolistic Competition. **References/Text Books:** 1. Economics, by Paul A. Samuelson, any edition.2. Macroeconomics, by N. G. Mankiw, 6th edition.3. Microeconomics, by R. S. Pindyck, D. L. Rubinfeld and P. L. Mehta, 6th edition.4. Intermediate Microeconomics, by H. R. Varian, 6th edition.5. Microeconomic Theory, by J. M. Henderson and R. E. Quandt, 3rd edition.6. Microeconomic Analysis, by R. R. Barthwal, any edition.	INTRODUCTION TO ECONOMICS
ECO101A	3-1-0-0-11		**Course Contents:** Definition and central problems of Economics, Microeconomics vs.Macroeconomics, Normative vs. Positive Economics, Stock vs. Flow variables; Aggregateeconomic variables: Gross domestic product (GDP), Gross national product (GNP), Nationalincome, Money supply, Price index and inflation rate, Unemployment rate, Exchange rate;Laws of demand and supply, Elasticity, Market equilibrium, Consumer and producer surplus,Price controls; Utility theory: Laws of diminishing marginal and equimarginal utility,Indifference curves and budget constraint, Optimizing conditions, Substitution and incomeeffects; Theory of production and cost: Law of variable proportion, Shortrun cost functions,Isoquant and isocost, Optimizing conditions, Longrun cost functions; Types of market:Perfect Competition, Monopoly, Oligopoly, Monopolistic Competition. **References/Text Books:** 1. Economics, by Paul A. Samuelson, any edition.2. Macroeconomics, by N. G. Mankiw, 6th edition.3. Microeconomics, by R. S. Pindyck, D. L. Rubinfeld and P. L. Mehta, 6th edition.4. Intermediate Microeconomics, by H. R. Varian, 6th edition.5. Microeconomic Theory, by J. M. Henderson and R. E. Quandt, 3rd edition.6. Microeconomic Analysis, by R. R. Barthwal, any edition.	INTRODUCTION TO ECONOMICS
ECO201	3-1-0--4		**Course Contents:** Theory of consumer behavior; Theory of demand and supply; Production theory;Costs of production; Markets Perfect competition, Monopoly oligopoly; Theoryof distribution; Pricing. **References/Text Books:**	MICROECONOMICS - I
ECO201A	3-0-0-0-9		**Course Contents:** Theory of consumer behavior; Theory of demand and supply; Production theory;Costs of production; Markets Perfect competition, Monopoly oligopoly; Theoryof distribution; Pricing. **References/Text Books:**	MICROECONOMICS I

ECO202	3-1-0--4	ECO201/ECO111	**Course Contents:** Circular Flow of Income, Output and Expenditure, National IncomeAccounting Methods, Classical Model, Keynesian Cross Model, .Theories of Consumption andInvestment, Demand for Money, ISLM Model, Macroeconomic Problems, Balance of PaymentsAccount, Exchange Rate Systems, and Open Economy Macroeconomics. **References/Text Books:**	MACROECONOMICS
ECO221A	3-0-0-0-9	ECO201A/ECO101A	**Course Contents:** Circular Flow of Income, Output and Expenditure, National IncomeAccounting Methods, Classical Model, Keynesian Cross Model, .Theories of Consumption andInvestment, Demand for Money, ISLM Model, Macroeconomic Problems, Balance of PaymentsAccount, Exchange Rate Systems, and Open Economy Macroeconomics. **References/Text Books:**	MACROECONOMICS I
ECO231	3-1-0--4		**Course Contents:** Global economic issues and challenges; From global to national issues; Economicinstitutions: markets, government, and social groups; Indian economic issuesand policy; Indian agriculture and rural economy; Industrial economy; Policytowards social infrastructure; Trade and foreign exchange policy; Policy towardsinternational capital flow **References/Text Books:**	ECONOMIC PROBLEMS AND POLICY
ECO261	3-0-0-0-4		**Course Contents:** Basic Mathematical Logic; Set Theory; Review of Functions of a Single Variable and Its Application in Economics: Choice, Utility and Aggregation; Functions of Several Variables : Level Curves, Homogeneity and Homotheticity, Concavity and Convexity; Static Optimization: Unconstrained Optimization, Constrained Optimization with Equality and Inequality Constraints; The Envelope Theorem and Duality; Dynamics and Dynamic Optimization. **References/Text Books:**	INTRODUCTION TO MATHEMETICAL ECONOMICS
ECO261A	3-0-0-0-9		**Course Contents:** Basic Mathematical Logic; Set Theory; Review of Functions of a Single Variable and Its Application in Economics: Choice, Utility and Aggregation; Functions of Several Variables: Level Curves, Homogeneity and Homotheticity, Concavity and Convexity;Static Optimization: Unconstrained Optimization, Constrained Optimization with Equality and Inequality Constraints; The Envelope Theorem and Duality; Dynamics and DynamicOptimization. **References/Text Books:**	INTRODUCTION TO MATHEMATICAL ECONOMICS
ECO303	3-1-0-0-4		**Course Contents:** Static games with complete information Nash Equilibrium; Dynamic games with complete information Subgame perfect Nash Equilbrium; Static games with incomplete information Bayesian Nash Equilibrium; Dynamic games with incomplete information Perfect Bayesian Nash Equilibrium, Sigmaling games; Adverse Selection and Moral Hazard; Exchange Economy and definition of Competitive Equilibrium; Pareto efficiency and Pareto set; One consumer one producer econnomy; Two sector production economy; First Fundamental theorem of Welfare Economics; Second Fundamental theorem of Welfare Economics; Pareto optimality and social welfare functions; Public goods and externalities; Property rights and Coase theorem; Social Choi d Theory **References/Text Books:**	MICRO ECONOMICS II

ECO311	3-1-0-0-4		**Course Contents:** Economic growth versus economic development, indicators of economic development, economic inequality, poverty, population growth and economic development, models of dual economy, land tenancy arrangements, rural savings, rural or informal credit markets, history and institutions, role of governance in economic development. **References/Text Books:**	ECONOMETRIC METHODS
ECO311A	3-0-0-0-9		**Course Contents:** Economic growth versus economic development, indicators of economic development, economic inequality, poverty, population growth and economic development, models of dual economy, land tenancy arrangements, rural savings, rural or informal credit markets, history and institutions, role of governance in economic development. **References/Text Books:**	DEVELOPMENT ECONOMICS
ECO312	3-1-0-0-4		**Course Contents:** Economic theory and econometrics; Types of models; Sources of data;Microeconometric models; Models of the firm and industry; Applications todevelopment economics; Macroeconometric models; Models of internationaltrade and finance; Deterministic and stochastic models **References/Text Books:**	ECONOMETRIC PRACTICE
ECO321	3-1-0--4		**Course Contents:** Microeconomic foundations of Macroeconomics, Representative agent model, Application of representative agent model in asset pricing, consumption theories etc., Longrun economic growth models, Models of shortrun economic fluctuations, Macroeconomic policy debates validation and application of growth/business cycle models. **References/Text Books:**	INDUSTRIAL ECONOMICS
ECO332	3-1-0-0-4		**Course Contents:** Economic growth versus economic development, indicators of economic development, economic inequality, poverty, population growth and economic development, models of dual economy, land tenancy arrangements, rural savings, rural or informal credit markets, history and institutions, role of governance in economic development. **References/Text Books:**	DEVELOPMENT ECONOMICS
ECO333	3-1-0-0-4		**Course Contents:** Functions of Money and Interest Rates; Money Supply; Money Market; Regulatoryand promotional institutions; Banking institutions; and Term structure of InterestRates. **References/Text Books:**	MONEY AND BANKING
ECO341	3-1-0--4		**Course Contents:** Classical Linear Regression Model (CLRM), Assumptions of the CLRM and its violation, Hypothesis Testing, Gauss Markov Theorem, Properties of the Estimator, Multiple Regression Model, Heteroscedasticity, Autocorrelation and Multicollinearity, Lagged Variables, Dummy Variables, Specification Bias, Simultaneous Equations, Introduction to Time Series, Discrete Choice, Limited Dependent Variable and Panel Data Models, Estimation ProceduresOrdinary Least Square(OLS), Generalized Least Squares(GLS), IV(Instrumental Variable), Maximum Likelihood Estimation(MLE) and	ENVIRONMENTAL ECONOMICS AND POLICY

			Generalized Method ofMoments(GMM), Learning of Econometric Software: Eviews and Stata **References/Text Books:**	
ECO342	3-0-0-0-4		**Course Contents:** Non Linear Regression Models, Non Parametric Regression Models, Measurement Errors, Stochastic Regressor, Multinomial and Conditional Logit Models, Ordered Logit Models, Nested Logit Models, Random Parameter Models, Truncation, Censoring and Sample Selection Models, Duration and Event Count Models, Dynamic Panel Data Models, Time Series Models including ARCH,GARCH and Multivariate GARCH Models, DEA and Stochastic Frontier Models, Total Factor Productivity Estimation, Levinsohn Petrin Approach of Measurement of Productivity, Single and Multiple Equation GMM Procedures, Application of Econometric Models to Trade, Finance, Microeconomics, Development Economics, Growth, Macroeconomics, Industry, among others. **References/Text Books:**	ECONOMETRICS II
ECO342A	3-1-1-0-12		**Course Contents:** Non Linear Regression Models, Non Parametric Regression Models, Measurement Errors, Stochastic Regressor, Multinomial and Conditional Logit Models, Ordered Logit Models, Nested Logit Models, Random Parameter Models, Truncation, Censoring and Sample Selection Models, Duration and Event Count Models, Dynamic Panel Data Models, Time Series Models including ARCH,GARCH and Multivariate GARCH Models, DEA and Stochastic Frontier Models, Total Factor Productivity Estimation, Levinsohn Petrin Approach of Measurement of Productivity, Single and Multiple Equation GMM Procedures, Application of Econometric Models to Trade, Finance, Microeconomics, Development Economics, Growth, Macroeconomics, Industry, among others. **References/Text Books:**	ECONOMETRICS II
ECO371A	3-0-0-0-0		**Course Contents:** Unbounded Operators, Matrix representation, Selfadjointness Criterion, Quadratic Forms, Differential Operators, Selfadjoint Extensions, Functional Calculus, Spectra of Selfadjoint Operators, Semianalytic vectors, Theorems of Nelson and Nussbaum, States and Observables, Superselection Rules, Position and Momentum, An Uncertainty Principle of Bargmann, Canonical Commutation Relations, Schrodinger representations, Schrodinger Operators, Selfadjointness, A Theorem of Kato, Spectral Theory for Schrodinger Operators, Discrete Spectrum, Essential Spectrum **References/Text Books:** * N. Akhiezer, I. Glazman, Theory of Linear Operators in Hilbert Space II, Dover, 1961.* J. Blank, P. Exner, M. Havlivcek, Hilbert Space Operators in Quantum Physics, Springer, 2008.* T. Kato, Perturbation Theory, Springer, 1976.* M. Miklavcic, Applied Functional Analysis and Partial Differential Equations, World Scientific, 1998.* M. Reed and B. Simon, Methods of Modern Mathematical Physics II, Academic Press, 1975.	PUBLIC ECONOMICS AND PUBLIC POLICY
ECO399A	0-0-0-2-9		**Course Contents:** UG PROJECT II **References/Text Books:**	UG PROJECT -II
ECO402	3-1-0-0-4		**Course Contents:** Microeconomic foundations of Macroeconomics, Representativeagent model, Application of representative agent model in asset pricing, consumption theoriesetc., Longrun economic growth models, Models of shortrun economic fluctuations,Macroeconomic policy debates validation and application of growth/business	MACROECONOMICS II

			cycle models. **References/Text Books:** 1. Aghion, A. and Howitt P. The Economics of Growth, MIT Press, 2009.2. Barro, R. Macroeconomics A Modern Approach, 5th Edition, MIT Press.3. Mankiw, G. Macroeconomics, 7th Edition, Worth Publishers.	
ECO404	3-1-0-0-4		**Course Contents:** Introduction; Social Choice : How much environmental protection; Market failure:Public bad and externatities; Internalisation of externalities; Regulations :Emission Fees & marketable permits; Environmental valuation; Hedonic pricemethod, household production, model & consolouted markets method;Tronsboundary pollotion Sustainable development; Economics of natural resources,Natural resorces accounting;The environmental issues and policies in India. **References/Text Books:**	HISTORY OF ECONOMIC THOUGHT
ECO407	3-1-0-0-4		**Course Contents:** Demand for money; Supply of money; Monetary aggregates; Neutrality of money;Money in a growth model; Money in an OLG model; Central bank goals, targets,and instruments; Time consistent versus discretionary policies; Credible monetarypolicy **References/Text Books:**	MONETARY ECONOMICS
ECO408	3-1-0-0-4		**Course Contents:** Introduction; The Solow growth model; Infinitehorizon and overlappinggenerationmodels; New growth theory; Realbusinesscycle theory; Traditional Keynesiantheories of fluctuations; Incomplete nominal adjustment; Consumption andinvestment; Search frictions and unemployment; Inflation and monetary policy;Budget deficits and fiscal policy **References/Text Books:**	ADVANCED MACRO ECONOMICS
ECO408A	3-0-0-0-9		**Course Contents:** Introduction; The Solow growth model; Infinitehorizon and overlappinggenerationmodels; New growth theory; Realbusinesscycle theory; Traditional Keynesiantheories of fluctuations; Incomplete nominal adjustment; Consumption andinvestment; Search frictions and unemployment; Inflation and monetary policy;Budget deficits and fiscal policy **References/Text Books:**	ADVANCED MACRO ECONOMICS
ECO413A	3-0-0-0-9		**Course Contents:** India in a Global Perspective (broad comparison with developed, developing and emerging economies), Trends in Aggregate Economic Activities (trends in Indian national income and related variables, primary, secondary and service sector growth etc),Agriculture (Green Revolution, productivity, land reforms, farming methods etc), Industry (industrial policy resolutions, growth, industrial bottlenecks, structural reforms etc), and Infrastructure (education, poverty alleviation programmes, energy, transport etc) **References/Text Books:**	INDIAN ECONOMIC PROBLEMS
ECO423	3-1-0-0-4		**Course Contents:** Basic accounting principles; Basics of financial markets; Return, risk and riskaversion; How securities are traded?; Mutual funds and the institutionalenvironment; Portfolio selection; The capital asset pricing model; Index modelsand the arbitrage pricing theory; Empirical evidence of market returns; Marketefficiency; Bond prices and yields; The term structure of interest rates; Managingbond portfolio; Security analysis; Options	FINANCIAL ECONOMICS

			and other derivatives; Option valuation;Futures and forward markets; Portfolio management techniques **References/Text Books:**	
ECO423A	3-0-0-0-9	ECO101A/ECO101/ECO201A/ECO201	**Course Contents:** Basic accounting principles; Basics of financial markets; Return, risk and riskaversion; How securities are traded?; Mutual funds and the institutionalenvironment; Portfolio selection; The capital asset pricing model; Index modelsand the arbitrage pricing theory; Empirical evidence of market returns; Marketefficiency; Bond prices and yields; The term structure of interest rates; Managingbond portfolio; Security analysis; Options and other derivatives; Option valuation;Futures and forward markets; Portfolio management techniques **References/Text Books:**	FINANCIAL ECONOMICS
ECO424	3-1-0-0-4		**Course Contents:** Introduction to economic analysis of law; Economic theory of property law;Contracts and warranties; and Economic theory of tort law in addition, Thecourse focuses on any are of the following madule(s) : Economic crimes andpenalties; Economic theory of administrative law; Corporations and corporatefinance; Economic analysis of labor law; Economic analysis of competition law;Project assignment **References/Text Books:**	ECONOMIC ANALYSIS OF LAW
ECO424A	3-0-0-0-9	ECO101A/ECO201A/ECO101/ECO201	**Course Contents:** Introduction to economic analysis of law; Economic theory of property law;Contracts and warranties; and Economic theory of tort law in addition, Thecourse focuses on any are of the following madule(s) : Economic crimes andpenalties; Economic theory of administrative law; Corporations and corporatefinance; Economic analysis of labor law; Economic analysis of competition law;Project assignment **References/Text Books:**	ECONOMIC ANALYSIS OF LAW
ECO501	3-1-0-0-4		**Course Contents:** (Basic Mathematical Logic; Set Theory; Review of Functions of a Single Variable and Its Application in Economics: Choice, Utility and Aggregation; Functions of Several Variables: Level Curves, Homogeneity and Homotheticity, Concavity and Convexity; Static Optimization: Unconstrained Optimization, Constrained Optimization with Equality andInequality Constraints; The Envelope Theorem and Duality; Dynamics and Dynamic Optimization. **References/Text Books:** 1. Shyam Divan & Armin Rosencranz, Environmental Law and Policy in India, OxfordUniversity Press2. R Rajagopalan, Environmental Studies, Oxford University Press3. Charles D. Kolstad, Environmental Economics, Oxford University Press4. Trade and Environment, by Hiiksn Nordstrom & Scott Vaughan, WTO5. Natural Resource and Environmental Economics, Roger Perman, Yue Ma, JamesMcGilvray, and Michael Common6. Environmental Economics for three Huggers and other Skeptics, William K. Jaeger7. Renewable Resources: The Fishery and Wildlife, David Pearce8. Renewable Resources: The Tropical Forest, David Pearce9. Economic Theory of Exhaustible Resource: R Ranganathan10. Environmental Economics: Hartwick & Olewaler	ENVIROMENTAL ECONOMICS AND POLICY
ECO501A	3-0-0-0-9	ECO201A/ECO101A	**Course Contents:** Price mechanism and its limitations to mitigate externalities, economic instruments to promote sustainable development, missing market methods to set market prices for environmental goods and services, renewable and nonrenewable resources and environmental policy. **References/Text Books:** 1. Shyam Divan & Armin Rosencranz, Environmental Law and Policy in India, OxfordUniversity Press2. R	ENVIROMENTAL ECONOMICS AND POLICY

			Rajagopalan, Environmental Studies, Oxford University Press3. Charles D. Kolstad, Environmental Economics, Oxford University Press4. Trade and Environment, by Hiiksn Nordstrom & Scott Vaughan, WTO5. Natural Resource and Environmental Economics, Roger Perman, Yue Ma, JamesMcGilvray, and Michael Common6. Environmental Economics for three Huggers and other Skeptics, William K. Jaeger7. Renewable Resources: The Fishery and Wildlife, David Pearce8. Renewable Resources: The Tropical Forest, David Pearce9. Economic Theory of Exhaustible Resource: R Ranganathan10. Environmental Economics: Hartwick & Olewaler	
ECO502A	3-0-0-0-9		**Course Contents:** Introduction: Optimal contracts under uncertainty, hidden information (adverse selection), or hidden action (moral hazard); Bilateral contracting: Hiddeninformation screening and signaling, hidden action moral hazard; Optimal contracting with multilateral asymmetric information: Auctions and trade under multilateral private information; moral hazard in teams, tournaments and organizations; Incomplete contracts: Institution design, implementation theory, bilateral and multilateral contracts **References/Text Books:** 1. Patrick Bolton and Mathias Dewatripont, Contract Theory (2005), The MIT Press.2. T.V. S. Rammohan Rao, Contract Economics (2004), New Age International.	APPLIED GAME THEORY
ECO514	3-1-0-0-4		**Course Contents:** Basic inputoutput system; Projection of inputoutput coefficients; Non surveyand partial survey methods; Input demand functions; Capital coefficients anddynamic considerations in inputoutput analysis; Application of inputoutputtechniques in the economic planning; Inputoutput tables for the Indian economy;Application of IO models in the field of energy and environment **References/Text Books:**	INPUT-OUTPUT TECHNIQUES
ECO522A	3-0-0-0-9	ECO221A	**Course Contents:** Monetary Policy in the Basic Macro Model, Demand for Money, Targets versus Instruments, Role of Expectations and Monetary Policy, Time versus Discretionary Policy, Credibility of the Central Bank, Theories of Monetary Aggregate, Money in a Growth Model, and Money in an Overlapping Generations Model. **References/Text Books:** I. Monetary Economics by J Handa2. Handbook of Monetary Economics, edited by Benjamin Friedman and F H Hahn, Vols 1&23. Journal articles to be suggested in class.	MONETARY ECONOMICS
ECO524A	3-0-0-0-9		**Course Contents:** Static representative agent model, Dynamic representative model, Bellmao equation!Pontryagin's Maximum Principle, Asset pricing, Dynamic endowment economy, Overlapping generations model, Real business cycle models. **References/Text Books:** 1. Cooley, T. 1995. Frontiers of Business Cycle Research, Princeton University Press.2. Krueger, Dirk, Lecture Notes (available on his website).3. Ljungqvist, L. and Sargent, Thomas J. 2004. Recursive Macroeconomic Theory, SecondEdition, MIT Press, Cambridge, MA.4. Romer, David. 2006, Advanced Macroeconomics, Third Edition, New York: McGrawHill.5. Williamson, Stephen D., Lectures in Macroeconomics (available on his website).	HETEROGENOUS FIRMS AND INTERNATIONAL TRADE
ECO527	3-1-0-0-4		**Course Contents:** Introduction; Foreign direct versus portfolio investment; Global and regionaltrends in direct investment; Horizontal and vertical integration; Ownershiplocationinternalization framework; Endogenous market structures in internationaltrade; General equilibrium approaches to the multinational firm; Determinantsof	MULTINATIONAL ENTERPRISES

			FDI; Overseas investment and firm exports; Vertical multinationals,fragmentation and outsourcing; Licensing versus direct investment: models ofinternalization of the multinational enterprise; Contracts, intellectual propertyrights, and multinational investment in developing countries; Multinational firms,technology diffusion and trade; International taxation and transfer prices; Dodomestic firms benefit from direct foreign investment?; MNEs and host countryrelations **References/Text Books:**	
ECO535A	3-0-0-0-9		**Course Contents:** Scope of public economics; Equity, social welfare and taxation; Taxation, income support and social insurance; Taxation and individuals; Market failure and government intervention; Optimal provision of public goods; Public expenditure and public debt; Modeling government behaviour; Organization of public sector. **References/Text Books:**	PUBLIC ECONOMICS
ECO541	3-0-0-0-4		**Course Contents:** Correlation vs Causality, Omitted Variables, Measurement Error, Randomized Experiments, Introduction to the course; Random Variable, Probability Review2. Observational Studies and Regression, Overview of research design, and examples4. Measurement Error and Omitted Variables Bias, Applications4. Experimental Designs , Applications5. QuasiExperimental Designs, Applications4. Selection on Observables: Matching and Propensity Scores, Applications4. Selection on Observables: Fixed Effects, PrePost Designs and Difference in Differences, Applications6. Regression Discontinuity, Applications4. Instrumental Variables, Applications4. Recent Developments in the field: Discussion of papers on new methods and applications5. **References/Text Books:** Joshua D. Angrist, JornSteffen Pischke, Mostly Harmless Econometrics: An Empiricist's Companion, Princeton University Press, 2008A. Colin Cameron, Pravin K. Trivedi , Microeconometrics: Methods and Applications Papers from various Journals like American Economic Review, Journal of Political Economy, Quarterly Journal of Economics, Journal of Labor Economics, Journal of development Economics etc.	EMPIRICAL METHODS IN APPLIED MICROECONOMICS
ECO541A	3-0-0-0-9		**Course Contents:** Correlation vs Causality, Omitted Variables, Measurement Error, Randomized Experiments, Introduction to the course; Random Variable, Probability Review2. Observational Studies and Regression, Overview of research design, and examples4. Measurement Error and Omitted Variables Bias, Applications4. Experimental Designs , Applications5. QuasiExperimental Designs, Applications4. Selection on Observables: Matching and Propensity Scores, Applications4. Selection on Observables: Fixed Effects, PrePost Designs and Difference in Differences, Applications6. Regression Discontinuity, Applications4. Instrumental Variables, Applications4. Recent Developments in the field: Discussion of papers on new methods and applications5. **References/Text Books:** Joshua D. Angrist, JornSteffen Pischke, Mostly Harmless Econometrics: An Empiricist's Companion, Princeton University Press, 2008A. Colin Cameron, Pravin K. Trivedi , Microeconometrics: Methods and Applications Papers from various Journals like American Economic Review, Journal of Political Economy, Quarterly Journal of Economics, Journal of Labor Economics, Journal of development Economics etc.	EMPIRICAL METHODS IN APPLIED MICROECONOMICS
ECO542	3-0-3-0-4	ECO341	**Course Contents:** 1.Panel Data Basics(06) Fixed, Random effect models(one way and two way models),Pooled OLS, Models with unobservable heterogeneity2.Model Specification(03) Goodnessoffit measures ,FTest, LMTest, HausmanTest, Model extensions 3.Dynamic panel data procedures(07) Instrumental Variable Procedure(IV),GIVE(Generalized Instrumental Variable Estimators (2Stage Least Squares) and	PANEL DATA PROCEDURES AND ANALYSIS

			GMM(Generalized Method of Moments) Estimators, Properties of the GMM estimators, Variances of the IV and 2SLS estimators, Tests for Overidentifying Restrictions, Arellano Bond, Arellano Bover , Blundell Bond Procedures, GMM procedure in a simultaneous equation settings.4.Specification of Dynamic Models(05) SarganHansenTest, Test for autocorrelation, Choice of instruments ,Identification problems5.UnitRootTests for Panel Data(04) Levin/Lin, Im/Peseran/Shin, Maddala/Lin ,PANICAnalysis Taking contemporary correlation into account ,Residual tests by Pedroni and Kao TraceTest by LLL (1999) 6.Estimating Cointegration Relationships(04) Fully Modified(FM)OLS (Pedroni, Phillips/Moon) ,Dynamic Ordinary Least Squares(DOLS)Estimation ,Parametric estimation (Pooled Mean Group, 2Stage Least Squares) ,Estimation of error correction models, Panel VAR(Vector Auto Regression) and Innovation Accounting in a panel framework 7.Limited Dependent variable models with Panel data(06)Tobit, Logit and Probit Models in a panel settings with applications in Labour economics8.Application of Panel data in Trade, Finance, Industrial Economics, Macroeconomics and Microeconomics, among others with hands on experience of doing panel data analysis through standard econometric softwares (07) **References/Text Books:** 1.Angrist,J D and JS Pischke, Mostly Harmless Econometrics: An Empiricist Companion, Princeton University Press, Princeton and Oxford,2009 2.Arellano, M. (2003), Panel Data Econometrics, 1st edition, Oxford University Press, ISBN13: 9780199245291.3.Baltagi, B.H. (2008), Econometric Analysis of Panel Data, 4th edition, Wiley, ISBN13: 9780470518861.4.Baltagi, B.H. (2011), Econometrics, 5th edition, Springer, ISBN13: 9783642200588.5.Cameron, A.C. and Trivedi, P.K. (2010), Microeconometrics Using Stata, 2nd edition, Stata Press, ISBN13: 9781597180733. 6.Greene, W.H. (2011), Econometric Analysis, 7th edition, Prentice Hall, ISBN13: 9780131395381. 7.Verbeek, M. (2012), A Guide to Modern Econometrics, 4th edition, Wiley, ISBN13: 9781119951674.8.Wooldridge, J.M. (2010), Econometric Analysis of Cross Section and Panel Data, 2nd edition, The MIT Press, ISBN13: 9780262232586.9. Christopher Dougherty(2011), Introduction to Econometrics, OUP, Fourth Edition, Oxford, New York	
ECO543	3-0-3-0-4		**Course Contents:** Course Description: This is an introductory level course in Bayesian methods aimed to introduce students to the Bayesian framework (originating from Bayes rule), that formally allows to incorporate nonsample information into the model. The course will equip the students with sufficient tools to analyze data using Bayesian techniques that will be useful in academia as well as industry. The course is targeted for advanced undergraduate students or any individual seeking to learn Bayesian techniques.The course will be heavily dependent on basic knowledge of statistics, elementary calculus, linear algebra, different kind of distributions and linear regression. Consequently, students who have taken the course Econometric Methods (ECO341A) will have an advantage. However, students who are willing to take this course but have not taken econometric methods are required to thoroughly study Ch 1 to Ch 4 from Statistical Inference (by Casella and Berger) and linear regression.Softwares: Bayesian methods are highly computational, hence proficiency in coding is required or one should be willing to put in extra hours to code programs. The official software for this course will be Matlab. **References/Text Books:**	BAYESIAN DATA ANALYSIS
ECO543A	3-0-3-0-9	MSO201A	**Course Contents:** Course Description:This is an introductory level course in Bayesian methods aimed to introduce students to the Bayesian framework (originating from Bayes rule), that formally allows to incorporate nonsample information into the model. The course will equip the students with sufficient tools to analyze data using Bayesian techniques that will be useful in academia as well as industry. The course is targeted for advanced undergraduate students or any individual seeking to learn Bayesian techniques.The course will be heavily dependent on basic knowledge of statistics, elementary calculus, linear algebra, different kind of distributions and linear regression. Consequently, students who have taken the course Econometric Methods (ECO341A) will have an advantage. However, students who are willing to take this course but have not taken econometric methods are required to thoroughly study Ch 1 to ch 4 from Statistical Inference (by Casella and Berger) and linear regression.Softwares: Bayesian methods are highly computational, hence proficiency in coding is	BAYESIAN DATA ANALYSIS

			required or one should be willing to put in extra hours to code programs. The official software for this course will be Matlab. **References/Text Books:**	
ECO572	3-0-0-0-4	ECO201 ECO341	**Course Contents:** This course is designed for students who wish to learn about production economics and benchmarking analysis. Benchmarking is used to measure performance of a producer using a specific indicator (production/ cost/profit) resulting in a metric of performance that is then compared to other producers. Students will learn to estimate production and cost functions and compute measures of absolute and relative economic performance using dataenvelopment analysis (DEA), deterministic frontier analysis (DFA), and stochastic frontier analysis (SFA) methods. Students analyse different types of datasets using software packages such as DEAP, Excel solver, FRONTIER, and Stata. **References/Text Books:**	PRODUCTIVITY AND EFFICIENCY ANALYSIS
ECO572A	3-0-0-0-9	ECO201A/ECO101A ECO341A	**Course Contents:** This course is designed for students who wish to learn about production economics and benchmarking analysis. Benchmarking is used to measure performance of a producer using a specific indicator (production/ cost/profit) resulting in a metric of performance that is then compared to other producers. Students will learn to estimate production and cost functions and compute measures of absolute and relative economic performance using dataenvelopment analysis (DEA), deterministic frontier analysis (DFA), and stochastic frontier analysis (SFA) methods. Students analyse different types of datasets using software packages such as DEAP, Excel solver, FRONTIER, and Stata. **References/Text Books:**	PRODUCTIVITY AND EFFICIENCY ANALYSIS
ECO598	0-0-4-0-4		**Course Contents:** PROJECTI **References/Text Books:**	PROJECT-I
ECO599	0-0-4-0-4		**Course Contents:** PROJECTII **References/Text Books:**	PROJECT-II
ECO731	3-0-0-0-4		**Course Contents:** Unbounded Operators, Matrix representation, Selfadjointness Criterion, Quadratic Forms, Differential Operators, Selfadjoint Extensions, Functional Calculus, Spectra of Selfadjoint Operators, Semianalytic vectors, Theorems of Nelson and Nussbaum, States and Observables, Superselection Rules, Position and Momentum, An Uncertainty Principle of Bargmann, Canonical Commutation Relations, Schrodinger representations, Schrodinger Operators, Selfadjointness, A Theorem of Kato, Spectral Theory for Schrodinger Operators, Discrete Spectrum, Essential Spectrum **References/Text Books:** * N. Akhiezer, I. Glazman, Theory of Linear Operators in Hilbert Space II, Dover, 1961.* J. Blank, P. Exner, M. Havlivcek, Hilbert Space Operators in Quantum Physics, Springer, 2008.* T. Kato, Perturbation Theory, Springer, 1976.* M. Miklavcic, Applied Functional Analysis and Partial Differential Equations, World Scientific, 1998.* M. Reed and B. Simon, Methods of Modern Mathematical Physics II, Academic Press, 1975.	PUBLIC ECONOMICS AND PUBLIC POLICY
ECO731A	3-0-0-0-9		**Course Contents:**	PUBLIC ECONOMICS AND

			Unbounded Operators, Matrix representation, Selfadjointness Criterion, Quadratic Forms, Differential Operators, Selfadjoint Extensions, Functional Calculus, Spectra of Selfadjoint Operators, Semianalytic vectors, Theorems of Nelson and Nussbaum, States and Observables, Superselection Rules, Position and Momentum, An Uncertainty Principle of Bargmann, Canonical Commutation Relations, Schrodinger representations, Schrodinger Operators, Selfadjointness, A Theorem of Kato, Spectral Theory for Schrodinger Operators, Discrete Spectrum, Essential Spectrum **References/Text Books:** Course Reference : * N. Akhiezer, I. Glazman, Theory of Linear Operators in Hilbert Space II, Dover, 1961.* J. Blank, P. Exner, M. Havlivcek, Hilbert Space Operators in Quantum Physics, Springer, 2008.* T. Kato, Perturbation Theory, Springer, 1976.* M. Miklavcic, Applied Functional Analysis and Partial Differential Equations, World Scientific, 1998.* M. Reed and B. Simon, Methods of Modern Mathematical Physics II, Academic Press, 1975.	PUBLIC POLICY
ECO732	3-0-1--4	#	**Course Contents:** Problems of statistical inference in economics constraints on the parameterspace, random coefficient models, distributed lags, decision models, and systemsof equations. New functional forms kernel estimation, neural networks. **References/Text Books:**	ECONOMETRICS
ECO732A	3-0-0-0-9		**Course Contents:** Problems of statistical inference in economics constraints on the parameterspace, random coefficient models, distributed lags, decision models, and systemsof equations. New functional forms kernel estimation, neural networks. **References/Text Books:**	ECONOMETRICS
ECO734	3-0-0--4	#	**Course Contents:** Scope of Industrial organization; Industrial Efficiency; Basic Framework forthe Study of Industrial Organization; Recent Approaches to Industrial Organization;Market Structure and Its Elements; Market Conduct, Internal Structure of theFirm. Critical Appraisal of Industrial Development policies in India; Case Studiesfrom Heavy Industries, Consumer Goods Industries and Public Utilities. **References/Text Books:**	INDUSTRIAL ORGANISATION AND POLICY
ECO734A	3-0-0-0-9		**Course Contents:** Scope of Industrial organization; Industrial Efficiency; Basic Framework forthe Study of Industrial Organization; Recent Approaches to Industrial Organization;Market Structure and Its Elements; Market Conduct, Internal Structure of theFirm. Critical Appraisal of Industrial Development policies in India; Case Studiesfrom Heavy Industries, Consumer Goods Industries and Public Utilities. **References/Text Books:**	INDUSTRIAL ORGANISATION AND POLICY
ECO735	3-0-0--4	#	**Course Contents:** The international trends in economic development, various development theoriesand operational strategies towards capital formation, international capital flows,foreign trade, agriculture, industry, HRD, technology transfer and environmentwill constitute the broad contents of this course. Further, focus will be on neweconomic policies and emerging new international structures. Besides, theshidents will undertake some empirical project as group assign many. **References/Text Books:**	DEVELOPMENT ECONOMICS

ECO735A	3-0-0-0-9		**Course Contents:** The international trends in economic development, various development theories and operational strategies towards capital formation, international capital flows, foreign trade, agriculture, industry, HRD, technology transfer and environment will constitute the broad contents of this course. Further, focus will be on new economic policies and emerging new international structures. Besides, the shidents will undertake some empirical project as group assign many. **References/Text Books:**	DEVELOPMENT ECONOMICS
ECO736	3-0-0--4	#	**Course Contents:** This course provides a methodology of emprical research in applying econometrictools for policy oriented research in social sciences. Emphasis will be given tovarious ways of handling problems faced in doing empirical research in India. **References/Text Books:**	APPLIED ECONOMETRICS
ECO737	3-0-0--4	#	**Course Contents:** Developments in monopolistic competition (nonprice decisions in particular), themicroeconomic theory of modern organiszations (discretionary managerialbehaviour, the organizational dimension) as envisaged by Williamson and Coase,and their implications for industrial policy. **References/Text Books:**	ADVANCES IN MICROECONOMIC THEORY
ECO737A	3-0-0-0-9		**Course Contents:** Developments in monopolistic competition (nonprice decisions in particular), the microeconomic theory of modern organizations (discretionary managerial behaviour, the organizational dimension) as envisaged by Williamson and Coase, and their implications for industrial policy. **References/Text Books:**	ADVANCES IN MICROECONOMIC THEORY
ECO738	3-0-0--4	#	**Course Contents:** The course will highlight the basic inputoutput models and their extensions.Various examples would be drawn from the empirical analysis of the inputoutputframework in India and abroad. **References/Text Books:**	INTER-INDUSTRY ECONOMICS
ECO738A	3-0-0-0-9		**Course Contents:** The course will highlight the basic inputoutput models and their extensions.Various examples would be drawn from the empirical analysis of the inputoutputframework in India and abroad. **References/Text Books:**	INTER-INDUSTRY ECONOMICS
ECO740	3-0-0--4	#	**Course Contents:** The course will cover some frontier topics in advanced economic analysis fora detailed discussion in seminars. **References/Text Books:**	SEMINAR ON SELECTED TOPICS IN ADVANCED ECONOMIC ANALYSIS
ECO745	3-0-0--4	#	**Course Contents:** The course begins with the role of money in static macroeconomic models,neoclassical growth models and consumption loan models, then focusses uponsupply of money and monetary aggregate demand for money, and the role ofthe central bank.	ADVANCED MONETARY THEORY

			References/Text Books:	
ECO745A	3-0-0-0-9		**Course Contents:** The course begins with the role of money in static macroeconomic models,neoclassical growth models and consumption loan models, then focusses uponsupply of money and monetary aggregate demand for money, and the role ofthe central bank. **References/Text Books:**	ADVANCED MONETARY THEORY
ECO747	3-1-0--4		**Course Contents:** With a view to establish sustainable development and to overcome the dilemmaof development, the course proposes to focus on the broad aspects ofenvironmental economics, environmental legislations and the environmentalimpact assessment. The consequent changes in the approaches and policies ofvarious Government under the leadership of U.N. and World Bank will be discussedalong with a number of case studies. The legel aspects of various enviromentalprojects will be discussed. Besides the students will undertake an empericalexcercise through project assignment. **References/Text Books:**	ENVIRONMENTAL ECONOMICS LEGISLATION AND SOCIAL IMPACT
ECO747A	3-0-0-0-9		**Course Contents:** With a view to establish sustainable development and to overcome the dilemma of development, the course proposes to focus on the aspects of environtal economics, environmental legislations and the environmental impact assessment. The consequent chanes in the approaches and policies of various Government under the leadership of U.N. and World Bank will be discussed along with a number of case studies. The legal aspects of various environmental excercise through project assignment. **References/Text Books:**	ENVIRONMENTAL ECONOMICS LEGISLATION AND SOCIAL IMPACT
ECO750	3-0-0--4	#	**Course Contents:** Discussions on macroeconomic theory within the ISLM framework, add the supplyconsiderations, and then review some of the new clasical and new keynesiancontributions; budget financing, interactions with the rest of the world andcommon empirical issues in macroeconomics. **References/Text Books:**	ADVANCED MICROECONOMICS
ECO750A	3-0-0-0-9		**Course Contents:** Discussions on macroeconomic theory within the ISLM frame work, and the supply considerations, and then review some of the new classical and new keynesian contributions; budget financing, interactions with the rest of the world and common empirical issues in macroeconomics. **References/Text Books:**	ADVANCED MACROECONOMICS
ECO756	3-0-0-0-4		**Course Contents:** Experimental Design, Measurement Error, Omitted Vairables Bias, Quasi_Experimental Designs, Selection on Observables: Matching and Propensity Scores, Difference in Differences, Instrumental Variables, Regression Discontinuity. **References/Text Books:** 1. Wooldridge, J.M. (2010), Econometric Analysis of Cross Section and Panel Data, 2nd edition. 2. Cameron, A.C. and Trivedi, P.K. (2005), Microeconometric: Methods and Applications. 3. Cameron A.C. and Trivedi, P.K.(2010), Microeconometrics Using Stata, 2nd edition, Stata Press. 4. Angrist, J.D. and J.S. Pischke (2009), "Mostly Harmless Exonometrics: An Empiricist Companion". 5. Journal Papers to becrecommended by the Instrucor.	PROGRAMME EVALUATION: METHODS AND APPLICATIONS

ECO756A	3-0-0-0-9		**Course Contents:** Experimental Design, Measurement Error, Omitted Vairables Bias, Quasi_Experimental Designs, Selection on Observables: Matching and Propensity Scores, Difference in Differences, Instrumental Variables, Regression Discontinuity. **References/Text Books:** 1. Wooldridge, J.M. (2010), Econometric Analysis of Cross Section and Panel Data, 2nd edition. 2. Cameron, A.C. and Trivedi, P.K. (2005), Microeconometric: Methods and Applications. 3. Cameron A.C. and Trivedi, P.K.(2010), Microeconometrics Using Stata, 2nd edition, Stata Press. 4. Angrist, J.D. and J.S. Pischke (2009), "Mostly Harmless Exonometrics: An Empiricist Companion". 5. Journal Papers to becrecommended by the Instrucor.	PROGRAMME EVALUATION: METHODS AND APPLICATIONS
ECO799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
ENG112	4-2-0-0-4		**Course Contents:** This course imparts training in the use of English language for communicativepurposes, and aims to develop reading comprehension, writing, listening, andspoken language skills of the student. The Language Lab component seeks toprovide training in pronunciation and listening skills. Instruction is carried outin small tutorial groups for effective individual attention. **References/Text Books:**	ENGLISH LANGUAGE AND COMMUNICATION SKILLS
ENG112C	3-1-0-0-11		**Course Contents:** Reading Comprehension SkillsDiscovering structure; identifying themes and subthemes; understanding and interpretingfacts; distinguishing facts from opinions and specific from general statements; searchingfor information; drawing information and making generalizations (14 Hrs). }Writing SkillsProcess of Writing from prewriting activities through drafting and revision; Developinga composition using techniques such as definition, classification, analogy, etc;Descriptive, narrative, and argumentative techniques in writing (14 Hrs).Language Skills(a). Identifying, understanding and applying grammatical structures of English withspecial emphasis on Sentence structure, Diction, Agreement, Tense, and Point of view.(b). Strategies: Economy, emphasis, clarity, concreteness, unity and coherence (7 Hrs).Spoken Language SkillsDescriptive, narrative, and argumentative techniques in spoken language use (7 Hrs). **References/Text Books:**	ENGLISH LANGUAGE AND COMMUNICATION SKILLS
ENG112N	3-1-0--4		**Course Contents:** This course imparts training in the use of English language for communicativepurposes, and aims to develop reading comprehension, writing, listening, andspoken language skills of the student. The Language Lab component seeks toprovide training in pronunciation and listening skills. Instruction iscarried out in small tutorial groups for effective individual attention. **References/Text Books:**	ENGLISH LANGUAGE AND COMPOSITION
ENG122	3-1-0-0-4		**Course Contents:** Introducing Language; Natural Language and Artificial Languages; NaturalLanguage and Animal Communication Systems; Evolution of Language; Acquisition ofLanguage; Ancient Indian Linguistics; Modern Linguistics; Applied Linguistics. **References/Text Books:** I. Hirschberg, S. and T. Hirschberg, Reflections on language, OUP, 1999.2. Radford, R., Linguistics: An	INTRODUCTION TO LINGUISTICS

			Introduction, CUP, 1999.3. Jackendoff, Ray, Foundations of Language, OUP, 2000.*4. Bergmann, Anouschka; Katleen Currie Hall & Sharon Mariam Ross, Language Files.Ohio State University Press, 2007.5. Selected papers on various topics	
ENG122A	3-1-0-0-11		**Course Contents:** Introducing Language; Natural Language and Artificial Languages; NaturalLanguage and Animal Communication Systems; Evolution of Language; Acquisition ofLanguage; Ancient Indian Linguistics; Modern Linguistics; Applied Linguistics. **References/Text Books:** I. Hirschberg, S. and T. Hirschberg, Reflections on language, OUP, 1999.2. Radford, R., Linguistics: An Introduction, CUP, 1999.3. Jackendoff, Ray, Foundations of Language, OUP, 2000.*4. Bergmann, Anouschka; Katleen Currie Hall & Sharon Mariam Ross, Language Files.Ohio State University Press, 2007.5. Selected papers on various topics	INTRODUCTION TO LINGUISTICS
ENG123	3-1-0--4		**Course Contents:** The course will introduce students to literature through exposure to differentliterary genres within the three main categories of prose, poetry, and drama. The focus of thecourse will be on how to read a literary text in terms of its use of language and style as well itsthematic content. In the process, students will learn about the different approaches to literaryanalysis as a way of understanding, interpreting, and evaluating specific literary texts. **References/Text Books:**	INTRODUCTION TO LITERATURE
ENG123A	3-1-0-0-11		**Course Contents:** The course will introduce students to literature through exposure to differentliterary genres within the three main categories of prose, poetry, and drama. The focus of thecourse will be on how to read a literary text in terms of its use of language and style as well itsthematic content. In the process, students will learn about the different approaches to literaryanalysis as a way of understanding, interpreting, and evaluating specific literary texts. **References/Text Books:**	INTRODUCTION TO LITERATURE
ENG124	3-1-0-0-4		**Course Contents:** Problems of definition; Multilingual communities; Language variation; Language andidentity; Standardization; Language, culture and cognition; Language and social control; Methodologicalissues. **References/Text Books:** Clyne, Michael, 2003. Dynamics of Language Contact, Cambridge University Press.Downes, William, 1998. Language and Society, Cambridge University Press.Romaine, S., 2000. Language in Society: An Introduction to Sociolinguistics, OUP.	LANGUAGE AND SOCIETY
ENG124A	3-1-0-0-11		**Course Contents:** Problems of definition; Multilingual communities; Language variation; Language andidentity; Standardization; Language, culture and cognition; Language and social control; Methodologicalissues. **References/Text Books:** Clyne, Michael, 2003. Dynamics of Language Contact, Cambridge University Press.Downes, William, 1998. Language and Society, Cambridge University Press.Romaine, S., 2000. Language in Society: An Introduction to Sociolinguistics, OUP.	LANGUAGE AND SOCIETY
ENG408A	3-0-0-0-9		**Course Contents:** 1. The foundations of SLA First language and Second language, acquiring L1 and L2, diversity in learning and learners, logical problem of language acquisition, differentframeworks of SLA. 2. Interlanguage Nature	SECOND LANGUAGE ACQUISITION

			of language, contrastive analysis, error analysis, monitor model, UG and SLA, learnability, critical period hypothesis, functional approaches, functiontoform mapping. 3. Psycholinguistic aspectsLanguage and brain, learning processes, competition models, connectionistapproaches, differences in learners, learning strategies, effects of multilingualism. 4. Social contexts Communicative competence, microsocial and macro social factors, role ofinput and interaction, role of output. 5. Acquiring knowledge for L2 use Linguistic competence, linguistic performance, academic vs interpersonal competence, receptive activities, productive activities, discourse rules. 6. Teaching and second language learning Classroom language, processing instruction, teachability/ learnability, input manipulation, input enhancement. **References/Text Books:**	
ENG431	3-1-0--4		**Course Contents:** The genre of the novel is seen as a colonial legacy as it developed in Indiasince the arrival of the British. The Indian English novel bears the colonial imprint more as it iswritten in the coloniser' s language. The course attempts to understand this geme that isconsidered foreign in India, in terms of both geme as well as language. However, the IndianEnglish novel has acquired quite a reputation in world literature today and has writers who haveremarkable felicity of style and catholicity of subject matter. The course will trace thedevelopment of the Indian English novel from its origin to the present day, focusing on criticaljunctures that mark this progress. Novels that have made a mark nationally and internationallywill be used to exemplifY this. **References/Text Books:** Mehrotra, Arvind Krishna. History of Indian literature in English. New York: ColumbiaUniversity Press, 2003.Mukherjee, Meenakshi. The Twice Born Fiction: Themes and Techniques of the Indian Novel inEnglish. 1971. Delhi: Pencraft International, 2009.	THE INDO-ANGLIAN NOVEL
ENG432	3-1-0--4		**Course Contents:** This course will engage with the concept of Ideology, and itsrelationship with literature. Beginning with a definition of Ideology and its various subcategories,the course will go on to examine how ideology impacts both the creation andthe reception of literary texts, both explicitly and implicitly. In the process, we willanalyse the many different kinds of relationships that a literary text may have withideology, ranging from propagation and elaboration, to refutation and critique. We willalso attempt to understand how ideology creates and impacts different schools of literarycriticism, and its relationship with aesthetic modes ofliterary reception. **References/Text Books:** Eagleton, Terry. Criticism and Ideology. New York: Verso, 1978.Hawkes, David. Ideology. London: Routledge, 2003.Williams, Raymond. Keywords: A Vocabulary of Culture and Society. New York:Oxford University Press, 1983.	LITERATURE AND IDEOLOGY
ENG432A	3-0-0--9		**Course Contents:** This course will engage with the concept of Ideology, and itsrelationship with literature. Beginning with a definition of Ideology and its various subcategories,the course will go on to examine how ideology impacts both the creation andthe reception of literary texts, both explicitly and implicitly. In the process, we willanalyse the many different kinds of relationships that a literary text may have withideology, ranging from propagation and elaboration, to refutation and critique. We willalso attempt to understand how ideology creates and impacts different schools of literarycriticism, and its relationship with aesthetic modes ofliterary reception. **References/Text Books:** Eagleton, Terry. Criticism and Ideology. New York: Verso, 1978.Hawkes, David. Ideology. London: Routledge, 2003.Williams, Raymond. Keywords: A Vocabulary of Culture and Society. New York:Oxford University Press, 1983.	LITERATURE AND IDEOLOGY

ENG433	3-1-0--4		**Course Contents:** 1. Introduction to Drama2. An Overview of the Theatre:3. European Drama & EuropeanSociety4. Ibsen's The Wild Duck5. Strindberg's The Father6. Russian Society in the 191h Century7. Chekov's The Cherry Orchard8. Pirandello's Six Characters9. Absurd Drama: An Overview10. Beckett's Waiting/or Godot 11. An Overview of American Drama 12. Miller's Death of a Salesman 13. Williams's A Streetcar Named Desire **References/Text Books:** 1. Weiss. Drama in the Modern World.2. Gassner, J. Treasury of the Theatre.	MODERN DRAMA
ENG433A	3-0-0-0-9		**Course Contents:** 1. Introduction to Drama2. An Overview of the Theatre:3. European Drama & EuropeanSociety4. Ibsen's The Wild Duck5. Strindberg's The Father6. Russian Society in the 191h Century7. Chekov's The Cherry Orchard8. Pirandello's Six Characters9. Absurd Drama: An Overview10. Beckett's Waiting/or Godot 11. An Overview of American Drama 12. Miller's Death of a Salesman 13. Williams's A Streetcar Named Desire **References/Text Books:** 1. Weiss. Drama in the Modern World.2. Gassner, J. Treasury of the Theatre.	MODERN DRAMA
ENG434	3-1-0--4		**Course Contents:** 1. Introduction to the Novel2. Novel in the Anglo Americanliterary tradition3. Major concerns in 19th & 20thcentury British, American Novel4. Romance & the Novel in America5. Hawthorne's The Scarlet Letter6. Modernism & the English Novel7. Art & the Artist in Modernist Novel8. Joyce's A Portrait of the Artist9. Feminism and Woolf.10. Woolrs To the Lighthouse11. Forster's A Passage to India12. American Modernism13. Fitzgerald's Tender is the Night14. Hemingway's A Farewell to Arms15 Summing Up **References/Text Books:** 1. Margaret Drabble. The Oxford Companion to English Literature.2. The Cambridge Companion to American Literature.	MODERN BRITISH AND AMERICAN NOVEL
ENG434A	3-0-0-0-9		**Course Contents:** 1. Introduction to the Novel2. Novel in the Anglo Americanliterary tradition3. Major concerns in 19th & 20thcentury British, American Novel4. Romance & the Novel in America5. Hawthorne's The Scarlet Letter6. Modernism & the English Novel7. Art & the Artist in Modernist Novel8. Joyce's A Portrait of the Artist9. Feminism and Woolf.10. Woolrs To the Lighthouse11. Forster's A Passage to India12. American Modernism13. Fitzgerald's Tender is the Night14. Hemingway's A Farewell to Arms15 Summing Up **References/Text Books:** 1. Margaret Drabble. The Oxford Companion to English Literature.2. The Cambridge Companion to American Literature.	MODERN BRITISH AND AMERICAN NOVEL
ENG435	3-1-0--4		**Course Contents:** The literature of any language is usually categorized in terms ofmovements, or discernible trends in style and theme at a particular point in the course ofits development. These trends in literature constitute a literary movement. The majormovements in AngloAmerican literature are Romanticism, Neoclassicism, Realism,Naturalism, Modernism and Postmodernism. These are but generalized categories thatactually include a wide variety of topics which have been dealt with in diverse ways bydifferent writers. The course includes a study of literary movements in general, and moredetailed examination of the topics that are subsumed under particular movements. It will .also take into account the changing perspectives on writing and writers that usuallychange according to the movements. Each topic will be illustrated using a seminal textand writer. **References/Text Books:** Peck, John and Martin Coyle. A Brief History of English Literature. New York: PalgraveMacmillan,	TOPICS IN LITERARY MOVEMENTS

			2002.Sanders, Andrew. Short Oxford History of English Literature. Oxford: Oxford UniversityPress, 2004.	
ENG435A	3-0-0-0-9		**Course Contents:** The literature of any language is usually categorized in terms of movements, or discernible trends in style and theme at a particular point in the course of its development. These trends in literature constitute a literary movement. The major movements in Anglo American literature are Romanticism, Neoclassicism, Realism, Naturalism, Modernism and Postmodernism. These are but generalized categories that actually include a wide variety of topics which have been dealt with in diverse ways by different writers. The course includes a study of literary movements in general, and more detailed examination of the topics that are subsumed under particular movements. It will .also take into account the changing perspectives on writing and writers that usually change according to the movements. Each topic will be illustrated using a seminal textand writer. **References/Text Books:** Peck, John and Martin Coyle. A Brief History of English Literature. New York: PalgraveMacmillan, 2002.Sanders, Andrew. Short Oxford History of English Literature. Oxford: Oxford UniversityPress, 2004.	TOPICS IN LITERARY MOVEMENTS
ENG436	3-0-0--4		**Course Contents:** This course identifies and defines visionary literature through a broadrange of disciplines and/or literary genres. Open to engaging with texts from differentdomains, from philosophy to economics to science fiction and fantasy, the courseanalyses the relationship between visionary writing and the concepts of utopia as well asprophecy. In the process, the course examines the ways in which the visions articulatedby such texts intersect with their and our realities, their purpose and effectiveness, as well as their relevance for social change. **References/Text Books:** No specific textbook or reference material. Thespecific texts chosen for the course in a particular semester will determine the appropriatereference materials.	THE WRITER'S VISION OF THE FUTURE
ENG436A	3-0-0-0-9		**Course Contents:** This course identifies and defines visionary literature through a broadrange of disciplines and/or literary genres. Open to engaging with texts from differentdomains, from philosophy to economics to science fiction and fantasy, the courseanalyses the relationship between visionary writing and the concepts of utopia as well asprophecy. In the process, the course examines the ways in which the visions articulatedby such texts intersect with their and our realities, their purpose and effectiveness, as well as their relevance for social change. **References/Text Books:** No specific textbook or reference material. Thespecific texts chosen for the course in a particular semester will determine the appropriatereference materials.	THE WRITER'S VISION OF THE FUTURE
ENG437	3-1-0--4		**Course Contents:** The course attempts to g1ve a crosssection of Indian literature which isdiverse, multilingual, and spans a vast period of time. The broad areas that will be covered arethe origin and development of genres like drama and poetry in ancient India, Bhakti poetry, therise of the novel, and the themes and issues in contemporary literature written in the variousIndian languages. These will be exemplified with the help of relevant literary texts from differentages and different parts of the country. It will also critically examine the attempt to homogenizethe diverse strands that go into the making of the literature of India. The focus will be on Indianlanguage texts, including fiction, poems and plays in English translation. **References/Text Books:** No specific textbook. Selections can include Sangampoetry, Bhakti poetry, and works of writers like Premchand, Rabindranath Tagore, IsmatChugtai, Dilip Chitre, M. T. Vasudevan Nair, and Mahasweta Devi.	INDIAN LITERATURE

ENG437A	3-0-0-0-9		**Course Contents:** The course attempts to g1ve a crosssection of Indian literature which isdiverse, multilingual, and spans a vast period of time. The broad areas that will be covered arethe origin and development of genres like drama and poetry in ancient India, Bhakti poetry, therise of the novel, and the themes and issues in contemporary literature written in the variousIndian languages. These will be exemplified with the help of relevant literary texts from differentages and different parts of the country. It will also critically examine the attempt to homogenizethe diverse strands that go into the making of the literature of India. The focus will be on Indianlanguage texts, including fiction, poems and plays in English translation. **References/Text Books:** No specific textbook. Selections can include Sangampoetry, Bhakti poetry, and works of writers like Premchand, Rabindranath Tagore, IsmatChugtai, Dilip Chitre, M. T. Vasudevan Nair, and Mahasweta Devi.	INDIAN LITERATURE
ENG438	3-0-0-0-4		**Course Contents:** This course will unpack the many meanings of the term 'postcolonial' through a study of literature that has emerged from the colonial encounter in various parts of the world.Focused mainly on literature written in English (and hence on the British empire within ahistorical context), the course will examine works from Africa, the Caribbean, and India, in addition to British literature itself, to understand how such literature deals with and/or resists the experience and legacy of colonialsim. In addition, the course will engage with contemporary literature, primarily from the US and India, to understand the relevance of postcolonialism within current global relations between the North and the South. **References/Text Books:** I) Loomba, Ania. Colonialism/Postcolonialism. New York: Routledge, 1998. 2) The Empire Writes Back: Theory and Practice in PostColonial Literatures. Edited byBill Ashcroft, Gareth Griffiths, Helen Tiffin. New York: Routledge, 2002.	POSTCOLONIAL LITERATURE
ENG438A	3-0-0-0-9		**Course Contents:** This course will unpack the many meanings of the term 'postcolonial' through a study of literature that has emerged from the colonial encounter in various parts of the world.Focused mainly on literature written in English (and hence on the British empire within ahistorical context), the course will examine works from Africa, the Caribbean, and India, in addition to British literature itself, to understand how such literature deals with and/or resists the experience and legacy of colonialsim. In addition, the course will engage with contemporary literature, primarily from the US and India, to understand the relevance of postcolonialism within current global relations between the North and the South. **References/Text Books:** I) Loomba, Ania. Colonialism/Postcolonialism. New York: Routledge, 1998.2) The Empire Writes Back: Theory and Practice in PostColonial Literatures. Edited byBill Ashcroft, Gareth Griffiths, Helen Tiffin. New York: Routledge, 2002.	POSTCOLONIAL LITERATURE
ENG439	3-0-0--4		**Course Contents:** Censorship is defined as the restrictions that are imposed on the writerand writings by centres of power like the state, religious institutions or other socialorganizations. These external restrictions can lead to selfimposed censorship, in the formof inhibitions which prevent the writer from expressing his I her views and thoughtsopenly. The course attempts to understand why writing is perceived as a threat toestablished institutions like the state or organized religion, and the impact of suchrestrictions on writing. Besides, it also analyzes the process of censorship as it has beenpracticed, and still is practiced, in various parts of the world. The efficacy of thisrestrictive measure will be evaluated with the help oftexts that have created controversiesfor going against accepted notions of morality or religious beliefs. **References/Text Books:** Green, Jonathon and Nicholas Karolides. The Encyclopedia on Censorship. New York:Info base Publishers,	LITERATURE AND CENSORSHIP

			2005.Jansen, Sue Curry. Censorship: The Knot that binds Power and Knowledge. Oxford:Oxford University Press, 1991.Nadaff, Ramona A. Exiling the Poets: The Production of Censorship in Plato's Republic.Chicago: University of Chicago Press, 2003.	
ENG439A	3-0-0-0-9		**Course Contents:** Censorship is defined as the restrictions that are imposed on the writerand writings by centres of power like the state, religious institutions or other socialorganizations. These external restrictions can lead to selfimposed censorship, in the formof inhibitions which prevent the writer from expressing his I her views and thoughtsopenly. The course attempts to understand why writing is perceived as a threat toestablished institutions like the state or organized religion, and the impact of suchrestrictions on writing. Besides, it also analyzes the process of censorship as it has beenpracticed, and still is practiced, in various parts of the world. The efficacy of thisrestrictive measure will be evaluated with the help oftexts that have created controversiesfor going against accepted notions of morality or religious beliefs. **References/Text Books:** Green, Jonathon and Nicholas Karolides. The Encyclopedia on Censorship. New York:Info base Publishers, 2005.Jansen, Sue Curry. Censorship: The Knot that binds Power and Knowledge. Oxford:Oxford University Press, 1991.Nadaff, Ramona A. Exiling the Poets: The Production of Censorship in Plato's Republic.Chicago: University of Chicago Press, 2003.	LITERATURE AND CENSORSHIP
ENG440	3-1-0--4		**Course Contents:** This course will explore the concept of literary genre and itsimplications for both the production and reception of literary works. Delving beyond thebroad divisions of poetry, prose, and drama, this course will investigate the formand content of specific interrelated genres such as crime fiction/rogue fiction/detectivefiction/Nair or romance/gothic/science fiction/fantasy, etc. It will situate these genreswithin a historical context and explore their regional variations by studying Western textsalongside nonWestern ones from the same genre. In the process, the course will examinethe ways in which various social categories influence the contours of various literarygenres and the extent to which genres are contained within culturaltemporal boundaries. **References/Text Books:** No specific textbook. Reference material willbe decided on the basis of the specific group of genres under study during a particularsemester, and may include the following:I) Frow, John. Genre. New York: Routledge, 2005.2) Todorov, Tzvetan. Genres in Discourse. New York: Cambridge UniversityPress, 1990.	TOPICS IN LITERARY GENRES
ENG440A	3-0-0-0-9		**Course Contents:** This course will explore the concept of literary genre and itsimplications for both the production and reception of literary works. Delving beyond thebroad divisions of poetry, prose, and drama, this course will investigate the formand content of specific interrelated genres such as crime fiction/rogue fiction/detectivefiction/Nair or romance/gothic/science fiction/fantasy, etc. It will situate these genreswithin a historical context and explore their regional variations by studying Western textsalongside nonWestern ones from the same genre. In the process, the course will examinethe ways in which various social categories influence the contours of various literarygenres and the extent to which genres are contained within culturaltemporal boundaries. **References/Text Books:** No specific textbook. Reference material willbe decided on the basis of the specific group of genres under study during a particularsemester, and may include the following:I) Frow, John. Genre. New York: Routledge, 2005.2) Todorov, Tzvetan. Genres in Discourse. New York: Cambridge UniversityPress, 1990.	TOPICS IN LITERARY GENRES
ENG443	3-1-0--4		**Course Contents:** Philosophical and linguistic approaches to semantics; Semanticstructure and its computational modeling; Lexical semantics; Logical form of naturallanguage; Anaphoric dependencies; Pragmatic structure; Cognitive	NATURAL LANGUAGE SEMANTICS

			grammar andcognitive semanticsSemantics: Philosophical and Linguistic approaches to Semantics 5Semantic Structure and its Computational Modelling: Semantics 6Pragmatics Distinction, SyntaxSemantics Interface: Syntactic andSemantic Parsing, HPSG, FrameNet SemanticsLexical Semantics: Lexical Underdetermination, Interlexical Relations, 6Lexical Conceptual Structures, Generative Lexicons, Argument Structure,Event Structure and Qualia Structure, WordNet and Generative LexiconsLogical Form of Natural Language, . Propositional Structure, 6Quantification, QuasiquantificationAnaphoric Dependencies: Pronouns and Reflexives, Ellipsis and other 6Lexical GapsPragmatic Structure: Implicature and Nonliteralness, Modelling Pragmatic 6Knowledge, Discourse Representation Theory/Situation SemanticsCognitive Grammar and Cognitive Semantics 5 **References/Text Books:**	
ENG445	3-1-0-0-4		**Course Contents:** The precarious role of an individual in a dynamic societytotalitarian, democratic,technological, globalized, etchas been an intense and perennial subject of concern in literature.Many literary works deal with such problems of humanity as the constraints of individualfreedom, loss of identity, search for self, struggle for individual survival, pangs of isolation andalienation, and attempts for salvaging sanity from a maddeningly disordered world. Theseworks, through fables, fantasies, realistic as well as futuristic representations, interrogate, probeinto the prevalent values, and affect changes in the lives of individuals, and by extension, theirsocieties. Apart from a utopian prophecy of deferred but ultimate triumph of humanity, theseliterary works often inspire, and instill in the readers enduring ideas, ideals, and values. Theworks for study in the course include the classics of world literature from George Orwell, ErnestHemingway, Herman Hesse, R. K. Narayan, Saul Bellow, Somerset Maugham and UpamanyuChatterjee to semiphilosophical and popular texts of Ayn Rand, Khalil Gibran, Paulo Coelho,Richard Bach and Robert Pirsig. **References/Text Books:**	LITERATURE & THE INDIVIDUAL
ENG445A	3-0-0-0-9		**Course Contents:** The precarious role of an individual in a dynamic societytotalitarian, democratic,technological, globalized, etchas been an intense and perennial subject of concern in literature.Many literary works deal with such problems of humanity as the constraints of individualfreedom, loss of identity, search for self, struggle for individual survival, pangs of isolation andalienation, and attempts for salvaging sanity from a maddeningly disordered world. Theseworks, through fables, fantasies, realistic as well as futuristic representations, interrogate, probeinto the prevalent values, and affect changes in the lives of individuals, and by extension, theirsocieties. Apart from a utopian prophecy of deferred but ultimate triumph of humanity, theseliterary works often inspire, and instill in the readers enduring ideas, ideals, and values. Theworks for study in the course include the classics of world literature from George Orwell, ErnestHemingway, Herman Hesse, R. K. Narayan, Saul Bellow, Somerset Maugham and UpamanyuChatterjee to semiphilosophical and popular texts of Ayn Rand, Khalil Gibran, Paulo Coelho,Richard Bach and Robert Pirsig. **References/Text Books:**	LITERATURE & THE INDIVIDUAL
ENG446	3-1-0-0-4		**Course Contents:** This course will examine the processes and politics of adaptation as textstravel across genres, media, and cultures. Focusing primarily on literary texts, graphic narrativesand films, it will investigate the different vocabularies of each media and see how meaning istransformed as it travels across different languages. In the process, it will delve into topics suchas the semiotics of translation, the 'fidelity' debate, the relationship between adaptation andappropriation, ideology and intention in the creation of adaptations etc. **References/Text Books:** 1) Hutcheon, Linda. A Theory of Adaptation. New York: Routledge, 2006.2) Sanders, Julie. Adaptation and Appropriation. New York: Routledge, 2006.	LITERATURE & ADAPTATION

ENG446A	3-0-0-0-9		**Course Contents:** This course will examine the processes and politics of adaptation as texts travel across genres, media, and cultures. Focusing primarily on literary texts, graphic narrativesand films, it will investigate the different vocabularies of each media and see how meaning is transformed as it travels across different languages. In the process, it will delve into topics such as the semiotics of translation, the 'fidelity' debate, the relationship between adaptation and appropriation, ideology and intention in the creation of adaptations etc. **References/Text Books:** 1) Hutcheon, Linda. A Theory of Adaptation. New York: Routledge, 2006.2) Sanders, Julie. Adaptation and Appropriation. New York: Routledge, 2006.	LITERATURE & ADAPTATION
ENG448	3-0-0-0-4		**Course Contents:** South Asia as a linguistic region 5Indo Aryan languages 5Dravidian languages 4TibetoBurman languages 3Munda languages 3Languages of the Andamans 2Convergence features 4Language contact . 4The role of English 2Orality, literacy and writing systems 3Language and Discourse 2Languages in Diaspora 2 .Language Conflicts 2. **References/Text Books:** Abbi, An vita. 1997. Languages of Tribal and Indigenous Peoples of India: TheEthnic Space. MLBDAbbi, Anvita. 2006. Endangered Languages of the Andaman Islands. Lin comEuropa.	LANGAUGES OF SOUTH ASIA
ENG448A	3-0-0-0-9		**Course Contents:** South Asia as a linguistic region 5Indo Aryan languages 5Dravidian languages 4TibetoBurman languages 3Munda languages 3Languages of the Andamans 2Convergence features 4Language contact . 4The role of English 2Orality, literacy and writing systems 3Language and Discourse 2Languages in Diaspora 2 .Language Conflicts 2. **References/Text Books:** Abbi, An vita. 1997. Languages of Tribal and Indigenous Peoples of India: TheEthnic Space. MLBDAbbi, Anvita. 2006. Endangered Languages of the Andaman Islands. Lin comEuropa.	LANGAUGES OF SOUTH ASIA
ENG451	3-0-1-0-4		**Course Contents:** The focus of the course is on the use of English language in national/multinational corporations andcommunication mediated through mobile, telephone, email, internet and other advanced technologies.Significant topics for discussion include: 1. Communication, Culture, Power 2. Current World Trends in MediaCommunication 3. Ethnographic Perceptions 4. Global Imbalances in Informational and Cultural Exchange 5.Benefits of Intercultural Communication 6. Intercultural Competence 7. Interpersonal Communication 8.Environments and Information Load 9. CrossCultural Communication Styles I 0. Etiquettes for the Net 11.Qualities of Effective Report Writing 12. Writing Effective Emails 13. Communication Information ThroughVisuals 14. Channels of Nonverbal Communication 15. Competence in Interviewing Contexts 16. Confidencein Use of Body Language. **References/Text Books:**	GLOBAL COMMUNICATION
ENG452A	3-0-0-0-5		**Course Contents:** METHODOLOGY AND UNIVERSAL. PHONOLOGYCAL TYPOLOGY. MORPHOLOGICAL TYPOLOGY. CONSTITUENT ORDER TYPOLOGY. GRAMMATICAL RELATION AND ALIGMENT. HIERARCHIES AND SEMANTIC MAPS. TYPOLOGY OF WORD CLASSES. TYPOLOGY OF VALENCE. TYPOLOGY OF NEGATION. TYPOLOGY OF RELATIOVE CLAUSES. **References/Text Books:**	LINGUISTIC TYPOLOGY
ENG453A	3-0-0-0-5		**Course Contents:**	LINGUISTIC UNIVERSALS

			THEORETICAL AND EMPIRICAL APPROACHES TO LINGUISTIC UNIVERSALS. ARGUMENT FROM LINGUISTIC TYPOLOGY AND EPISTEMOLOGY. ABSOLUTE STATISTICAL AND IMPLICATIONAL UNIVERSALS. EXPLANATORY ADEQUACY AND THE UNIVERSA GRAMMER, FORMAL AND SUBSTANTIVE UNIVERSALS. FACULTY OF LANGUAGE,PRINCIPAL AND PARAMETERS, THE MINIMALIST PROGRAMME. **References/Text Books:**	
ENG456	3-0-0-0-4		**Course Contents:** I.Introduction to Climate Change. II. Geological Causes of Climate Change. III. Anthropogenic Causes of Climate Change. IV. Climate Skepticism; Threat Perception and Underlying Politics. V. Effects of Climate Change. VI. Cocepts of Ecohorror. VII. Dystopian Doom: The Irreversible Damage. VIII. Fictional Representations of Climate Change: Ecofiction/Ecofabulism. IX. Film Representations of Climate Change: Enviropocalypse, Postapocalypse. X. Concepts, Themes and Issues in Climate Fiction. XI. What is Wrong with Cliflicks? XII. Impact of Climate Change on Species Survival: Scarcity of Resources and Hunger Games. XIII. Future Possibilities: Gaia and Geoengineering. XIV. Sustainability and Climate Responsibility. XV. Reality Check: Climate Politics that Avert Possible Solutions. **References/Text Books:** Atwood, Margaret. Oryx and Crake. TOronto: McClelland & Stewart Limited, 2003._______. Maddaddam. Toronto: McClelland & Stewart Limited, 2013. Budyko, M.I. and Yu. A. Izrael, Eds. Anthropogenic Climatic Change. Tucson: The Univ. of Arizona Press, 1991. ______, et al. Global Climatic Catastrophes. Trans. V.G. Yanuta. New York: SpringerVerlag, 1986.Bacigalupi, Paolo. The Windup Girl. San Francisco, CA: Night Shade Books, 2009. Clark, Timothy, The Cambridge Introduction to Literature and the Environment. Cambridge: Cambridge Univ. Press, 2011. Crichton, Michael. State of Fear. New York: Harper Collins, 2004. Fleming, James ROdger. Fixing the Sky. New York: Columbia Univ. Press 2010.Fraser, Evan D.G. #foodcrisis: A Graphic Novel about Global Food Security. Guelph, Ontrario: Evan Fraser, 2014. Glass, Matthew. Ultimatum. New York: Atlantic Monthly Press, 2009. McNeil, Jean. The Ice Lovers. Toronto: MacArthur & Co., 2009.	CLIMATE FICTION AND FILMS
ENG456A	3-0-0-0-9		**Course Contents:** I.Introduction to Climate Change. II. Geological Causes of Climate Change. III. Anthropogenic Causes of Climate Change. IV. Climate Skepticism; Threat Perception and Underlying Politics. V. Effects of Climate Change. VI. Cocepts of Ecohorror. VII. Dystopian Doom: The Irreversible Damage. VIII. Fictional Representations of Climate Change: Ecofiction/Ecofabulism. IX. Film Representations of Climate Change: Enviropocalypse, Postapocalypse. X. Concepts, Themes and Issues in Climate Fiction. XI. What is Wrong with Cliflicks? XII. Impact of Climate Change on Species Survival: Scarcity of Resources and Hunger Games. XIII. Future Possibilities: Gaia and Geoengineering. XIV. Sustainability and Climate Responsibility. XV. Reality Check: Climate Politics that Avert Possible Solutions. **References/Text Books:** Atwood, Margaret. Oryx and Crake. TOronto: McClelland & Stewart Limited, 2003._______. Maddaddam. Toronto: McClelland & Stewart Limited, 2013. Budyko, M.I. and Yu. A. Izrael, Eds. Anthropogenic Climatic Change. Tucson: The Univ. of Arizona Press, 1991. ______, et al. Global Climatic Catastrophes. Trans. V.G. Yanuta. New York: SpringerVerlag, 1986.Bacigalupi, Paolo. The Windup Girl. San Francisco, CA: Night Shade Books, 2009. Clark, Timothy, The Cambridge Introduction to Literature and the Environment. Cambridge: Cambridge Univ. Press, 2011. Crichton, Michael. State of Fear. New York: Harper Collins, 2004. Fleming, James ROdger. Fixing the Sky. New York: Columbia Univ. Press 2010.Fraser, Evan D.G. #foodcrisis: A Graphic Novel about Global Food Security. Guelph, Ontrario: Evan Fraser, 2014. Glass, Matthew. Ultimatum. New York: Atlantic Monthly Press, 2009. McNeil, Jean. The Ice Lovers. Toronto: MacArthur & Co., 2009.	CLIMATE FICTION AND FILMS
ENG457	3-0-0-0-4		**Course Contents:**	FILM AND THEORY

			"The Uncanny": omnipotence of thought; the doppelganger, the evil eye, Freud's theory of the Oedipus complex, Mulvey's concept of scopophia. Analysis of "Vertigo" and "Rear Window". "Melodrama and Tears": Eyeline gaze, the unabandoned wish, "undermotivated events," function of fate, determinism. The use of events happening "too late." Analysis of Douglas Sirks's "All That Heaven Allows" and "Written on the Wind." Discussion of "Freud's Masterplot" on repetition (and the repetition compulsion), precedence and consequence in the creationof "linkage." Movement toward closed and legible wholes under "the mandate of desire." Analysis of "Picnic" and "Splendor in the Grass". Krips and Zizek on Lacan: Discussion of unrealistic anxiety, the other and the Big Other, lack in the visual field, internalization, the ego ideal. Analysis of "Strangers on a Train" **References/Text Books:** Brooks, Peter. "Freud's masterplot." Yale French Studies (1977): 280300. Cook, Pam. "Duplicity in Mildred Pierce." Women in film noir (1978): 6882. Creed, Barbara. The monstrousfeminine; Film, feminism, psychoanalysis. Psychology Press, 1993. Creed, Barbara. "Film and psychoanalysis." The Oxford Guide to Film Studies (1998): 7790. De Lauretis, Teresa. Technologies of gender: Essays on theory, film, and fiction. Vol. 441. Indiana University Press, 1987. Heung, Marina. "What's the Matter with Sara Jane?": Daughters and Mothers in Douglas Sirk's" Imitation of Life." Cinema journal (1987): 2143. Krips, Henry. "The politics of the gaze: Foucault, Lacan and Zizek." Culture Unbound 2 (2010): 91102. Loren, Scott. "Selffashioning, Freedom, and the Problem of History: the return of noir." European journal of American studies3.1 (2008).	
ENG457A	3-0-0-0-9		**Course Contents:** "The Uncanny": omnipotence of thought; the doppelganger, the evil eye, Freud's theory of the Oedipus complex, Mulvey's concept of scopophia. Analysis of "Vertigo" and "Rear Window". "Melodrama and Tears": Eyeline gaze, the unabandoned wish, "undermotivated events," function of fate, determinism. The use of events happening "too late." Analysis of Douglas Sirks's "All That Heaven Allows" and "Written on the Wind." Discussion of "Freud's Masterplot" on repetition (and the repetition compulsion), precedence and consequence in the creationof "linkage." Movement toward closed and legible wholes under "the mandate of desire." Analysis of "Picnic" and "Splendor in the Grass". Krips and Zizek on Lacan: Discussion of unrealistic anxiety, the other and the Big Other, lack in the visual field, internalization, the ego ideal. Analysis of "Strangers on a Train" **References/Text Books:** Brooks, Peter. "Freud's masterplot." Yale French Studies (1977): 280300. Cook, Pam. "Duplicity in Mildred Pierce." Women in film noir (1978): 6882. Creed, Barbara. The monstrousfeminine; Film, feminism, psychoanalysis. Psychology Press, 1993. Creed, Barbara. "Film and psychoanalysis." The Oxford Guide to Film Studies (1998): 7790. De Lauretis, Teresa. Technologies of gender: Essays on theory, film, and fiction. Vol. 441. Indiana University Press, 1987. Heung, Marina. "What's the Matter with Sara Jane?": Daughters and Mothers in Douglas Sirk's" Imitation of Life." Cinema journal (1987): 2143. Krips, Henry. "The politics of the gaze: Foucault, Lacan and Zizek." Culture Unbound 2 (2010): 91102. Loren, Scott. "Selffashioning, Freedom, and the Problem of History: the return of noir." European journal of American studies3.1 (2008).	FILM AND THEORY
ENG701	3-0-0-0-4		**Course Contents:** Structure of language; statistical structure and information theory; phonetics,phonemics and the distinctive feature theory; grammatical structure; ICanalysis; phrase structure and transformational grammars; grammatical categoriesand functions; semantics. **References/Text Books:**	FUNDAMENTALS OF MODERN LINGUISTICS
ENG701A	3-0-0-0-9		**Course Contents:** Structure of language; statistical structure and information theory; phonetics,phonemics and the distinctive feature theory; grammatical structure; ICanalysis; phrase structure and transformational grammars; grammatical categoriesand functions; semantics.	FUNDAMENTALS OF MODERN LINGUISTICS

			References/Text Books:	
ENG703	3-0-0--4	#	**Course Contents:** Varieties of English; registers and dialects; phonetics of English; phonetictranscription; grammar of English; morphology and syntax; the transformationalgenerative approach to the phonology and syntax of English. **References/Text Books:**	STRUCTURE OF MODERN ENGLISH
ENG708A	3-0-0-0-9		**Course Contents:** Modern developments in applied linguistics particularly in the fields of language learning and teaching; psychological, sociological, lingustic, and pedagogical aspects of language learning, second language learning; teaching and learning of English as a second language in India; coursedesign, teaching of language skills; contrastive analysis, erroranalysis, programmed instruction, audiovisual aids, language testing etc. **References/Text Books:**	APPLIED LINGUISTICS
ENG709	3-0-0--4		**Course Contents:** This course attempts to apply the principles of linguistic analysis to real languagedata. It covers phonological, lexical, syntactic and semantic analysis and involvessome amount of fieldwork. **References/Text Books:**	LINGUISTIC ANALYSIS
ENG709A	3-0-0-0-9		**Course Contents:** This course attempts to apply the principles of lingustic analysis to real language data. It covers phonologica, lexical, syntactic and semantic analysis and involves some amount of fieldwork. **References/Text Books:**	LINGUISTIC ANALYSIS
ENG711A	3-0-0-0-9		**Course Contents:** Selected Indian writings in English or translated from Indian Languages will be used for an extensive examination of some significant themes, e.g., rejection of old taboos, industrialization and its attendant problems, growth of secularism, social changes, bureaucracy and its role, generation gap, etc. **References/Text Books:**	INDIAN WRITING IN ENGLISH
ENG712	3-0-0--4		**Course Contents:** This course will study in depth and detail the various modes of interactionbetween literature and society. The primary emphasis will be on some of themajor themes and social concerns (such as individual and society, alienation,technological progress and its human consequences, free will and determinism)which have preoccupied creative writers. **References/Text Books:**	LITERATURE AND SOCIETY
ENG715	3-0-0--4		**Course Contents:** This course will study selected pedagogical material on the teaching of literaturewith a view to acquainting the student with the major theories and techniquesof literary study as an academic discipline. It will also seek to familiarise thestudent with the basic tools and materials of literary research. **References/Text Books:**	METHODOLOGY OF TEACHING AND RESEARCH IN LITERATURE
ENG715A	3-0-0-0-9		**Course Contents:** This course will study selected pedagogical material on the teaching of literaturewith a view to acquainting the student with the major theories and techniquesof literary study as an academic discipline. It will also seek	METHODOLOGY OF TEACHING AND RESEARCH IN LITERATURE

			to familiarise thestudent with the basic tools and materials of literary research. **References/Text Books:**	
ENG716	3-0-0--4	#	**Course Contents:** This course is intended to provide the students an opportunity to take up ontheir own a shortterm fieldwork or library project, with constant guidancefrom the Instructor. Evaluation will depend on the final product and interimreports. **References/Text Books:**	INDIVIDUAL PROJECTS
ENG716A	3-0-0-0-9		**Course Contents:** This course is intended to provide the students an opportunity to take up ontheir own a shortterm fieldwork or library project, with constant guidancefrom the Instructor. Evaluation will depend on the final product and interimreports. **References/Text Books:**	INDIVIDUAL PROJECTS
ENG719	3-0-0--4		**Course Contents:** The course will study the major themes and techniques in the literature of theAmerican Renaissance, with special attention to the writings of Melville,Hawthorne, Emerson, Thoreau and Poe. **References/Text Books:**	AMERICAN RENAISSANCE
ENG733	3-0-0--4		**Course Contents:** The course deals with major trends and developments in Indian literaturefrom ancient to modern times. The course will focus primarily on the followingtopics: the problem of definition;the growth of nationalism; elements of unityin a multilingual situation; ancient religious and secular liteature; impact ofWestern literatures; modern regional literatures. **References/Text Books:**	INDIAN LITERATURE
ENG735	3-0-0--4		**Course Contents:** The course covers literature in English in the Commonwealth countries of Africa,Australia, Canada, India, New Zealand, and the West Indies. An attempt willbe made to show that commonwealth writers, while contributing to the literatureof their own country, find their particular artistic understanding inescapablyinformed by what William Walsh calls other silent but active aims. **References/Text Books:**	COMMONWEALTH LITERATURE
ENG735A	3-0-0-0-9		**Course Contents:** The course covers literature in English in the Commonwealth countries of Africa,Australia, Canada, India, New Zealand, and the West Indies. An attempt willbe made to show that commonwealth writers, while contributing to the literatureof their own country, find their particular artistic understanding inescapablyinformed by what William Walsh calls other silent but active aims. **References/Text Books:**	COMMONWEALTH LITERATURE
ENG742A	3-0-0-0-9		**Course Contents:** Concept and practice of responsible dissent in various sociopolitical contexts: Notions of dissent and responsible dissent, ethical roots of dissent, contexts and forms of dissent, profiles of dissenties (Chomsky, Russell, early Gandhi, Ram Mohan Roy, King, etc.), role and responsibility of the inttellectual, role of media in supression of facts and dissemination of misinformation, strategies of manufacture of consent in	RESPONSBILE DISSENT

			totalitarian and democratic structures. **References/Text Books:**	
ENG743	3-1-0--4		**Course Contents:** Definitions: the Sex/Gender debate, Masculinity and femininity, patriarchy, thefeminism/gender studies debate.Gender and Identity: Processes of Identity formation, gender roles in differentsocial contexts, gendered lifescripts and their historical transformations.Gender and Representation: The politics of representation, external vs internalselfrepresentations, the media and representation.The Politics of Feminism: The reasons and implications of focusing on genderas a subject of inquiry, the relationship between theory and practice, thelocational specificity of "feminism," the role of feminism in India. **References/Text Books:**	FEMINIST THEORY AND LITERATURE
ENG743A	3-0-0-0-9		**Course Contents:** Definitins: the Sex / Gender debaate, Masculinity and femininity, patriarchy, the feminism/ gender studies debate.Gender and Identity: Processes of Identity formation, gender roles ain different social contexts, gendered lifescripts and their historical transformations.Gender and Representation: The politics of representation, external vs internal selfrepresentations, the media and representation.The Politics of Feminism: The reasons and implications of focusing on gender as a subject of inquirey, the relationship between theory and practice, the locational specificity of "feminism," the role of feminism in India. **References/Text Books:**	FEMINIST THEORY AND LITERATURE
ENG748	3-0-0-0-4		**Course Contents:** The course explores languagecognition mappings in varied contexts such asunilingual, billingual and sign language use, Crosslinguistic variations in basicconceptual domains such as time and apace and lexicalization patterns will beexamined. Other topics include nature of linguistic representations open classsemantics and semantics of grammar type hierarchies and continuums,compositional structures and cocompositionality, noncompositional structures,constrains on possible grammars, perceptual processes and grounding. **References/Text Books:**	COGNITIVE LINGUISTICS
ENG749	3-0-0--4	#	**Course Contents:** Any postgraduate course in Modern LiteratureAcquainting the students with the major critical concepts, selfreflexive textsand amorphous themes of Postmodernism, the course aims to explore theusefulness of the term postmodernism as a means of approaching contemporaryliterature. The course will offer an advanced introduction to the central conceptsof postmodernism by providing an approach to contemporary American, LatinAmerican, European and Indian (Writing in English) literature. Major topics fordiscussion are: The relevance of Postmodernism, differences between Modernismand Postmodernism, Deconstuction, the Death of the Author, Rhizome, Knowledgeand Power, Entropy, the Literature of Exhaustion, the Hyperreal and theSimulacrum, Cyberspace and Cyberpunk, Postmodern Ethics, Postmodernism andPopular Culture, Postmodernism in an Indian context, Postmodern Films,Postmodernism and its Limitations. **References/Text Books:**	POSTMODERN THEORY AND LITERATURE
ENG750	3-0-0--4	#	**Course Contents:** Postwar American fiction is characterized by a complex sensibility that is oftenpervasive in the novels of the period from 1945 through the Cold War of theseventies and eighties to the present. With America coming into unexampledprosperity following WWII, this sensibility manifests itself as a sense oftriumphalism only to give way to introspection and selfdebate concerning theproblematic of defining American identity and nationhood against a distinctmulticultural presence, and the unviability of "American Dream" in a transnationaland globalized world in the creation of which, curiously, America itself hasenormous	POSTWAR AMERICAN FICTION

			investments. Interestingly, fiction of this period frames war both asa trope and a realistic concern. The protracted cultural wars which began withthe Civil Rights era of the 1960s infused new life into the literature of theUnited States in that the traditionally oppressed voices of minorities, be theyAfrican Americans, women or the immigrants, began to be heard. And thevariegated literary movements (postmodernism, humanism, and feminism toname a few) and fictional strategies (such as protest, fantasy, black humor)employed in the genre bring in to one's reading a nuanced and engagingperspective of how these writers have negotiated reality into their imaginativeartistic vision. The fiction of this period is marked by thematic concerns suchas politics, paranoia, race, money, technology, sex, suburbia, urban decay,immigration, and spirituality, among others. The course strives to closereadselect texts, in the light of rigorous theoretical interventions. **References/Text Books:**	
ENG750A	3-0-0-0-9		**Course Contents:** Postwar American fiction is characterized by a complex sensibility that is oftenpervasive in the novels of the period from 1945 through the Cold War of the seventies and eighties to the present. With America coming into unexampled prosperity following WWII, this sensibility manifests itself as a sense of triumphalism only to give way to introspection and selfdebate concerning the problematic of defining American identity and nationhood against a distinct multicultural presence, and the unviability of "American Dream" in a transnational and globalized world in the creation of which, curiously, America itself has enormous investments. Interestingly, fiction of this period frames war both as a trope and a realistic concern. The protracted cultural wars which began with the Civil Rights era of the 1960s infused new life into the literature of the United States in that the traditionally oppressed voices of minorities, be they African Americans, women or the immigrants, began to be heard. And the variegated literary movements (postmodernism, humanism, and feminism to name a few) and fictional strategies (such as protest, fantasy, black humor) employed in the genre bring in to one's reading a nuanced and engaging perspective of how these writers have negotiated reality into their imaginative artistic vision. The fiction of this period is marked by thematic concerns such as politics, paranoia, race, money, technology, sex, suburbia, urban decay, immigration, and spirituality, among others. The course strives to closeread select texts, in the light of rigorous theoretical interventions. **References/Text Books:**	POSTWAR AMERICAN FICTION
ENG751	3-0-0-0-4		**Course Contents:** Any postgraduate course in English Literature is desirableContemporary critical theories particularly those of the post1960s, haveproblematised the writing, reading and receiving of literature. This courseexamines complex aspects of recent critical theories associated with gender,race, subjectivity, sexuality, textuality, narratology, ecology, and notions ofculture and history. It aims to expose students to contemporary theories thatwould enhance their research into chosen areas of literature. Delving on relevantissues and debates, the course acquaints students with various strategies ofreading, interpretation and analysis of literary/nonliterary texts and theacquistion of current critical vocabulary. Important topics of discussion includesemiotics, deconstruction, interextuality, reader response theory, autobiographicaltheory, postLacanian psychoanalytic criticism, postcolonialism, postmodernism,third wave feminism, cultural materialism, new historicism, posthumanism,ecocriticism, hypertext theory, and cyber criticism. Siginficant contributions bythe following and other such representative figures will be incorporated in thediscussions: Edward Said, Frantz Fanon Fredric Jameson, Gilles Deleuze andFelix Guattari, Jacques Derrida, Mikhail Bakhtin, Michel Foucault, Roland Barthes,Stephen Greenblatt and Umberto Eco. **References/Text Books:**	CONTEMPORARY CRITICAL THEORIES & LITERARY PRAXES
ENG751A	3-0-0-0-9		**Course Contents:** Contemporary critical theories particularly those of the post1960s, have problematised the writing, rading and receiving of leterature. This course examines complex aspects of recent critical theories associated with gender, race, subjectivity, sexuality, textuality, narratology, ecology, and notions of culture and history. It	CONTEMPORARY CRITICAL THEORIES & LITERARY PRAXES

			aims to expose students to contemporary theories that would enhance their research into chosen areas of literature. Delving on relevant issues and debates, the course acquaints students with various strategies of reading, interpretation and analysis of literary/nonliterary texts and the acquisition of current critical vocabulary. Important topics of discussion include semiotics, deconstruction, interextuality, reader response theory, autobiographical theory, postLacanian psychoanalytic criticism, postcolonialism, postmodernism, third wave feminism, cultural materialism, new histricism, posthumanism, **References/Text Books:**	
ENG752	3-0-0-0-4		**Course Contents:** The course explores the convergence and divergence of eastern and westernaesthetic practices, in an attempt to two. Its scope includes classical Greekand Sanskrit texts like Bharata s Natyasastra and Aristotles Poetics which areextensive treatises on dramaturgy, Longinus s concept of the sublime,Anandavardhanas concept of dhvani and postulates of New Criticism. **References/Text Books:**	COMPARATIVE AESTHETICS
ENG752A	3-0-0-0-9		**Course Contents:** The course explores the convergence and divergence of eastern and westernaesthetic practices, in an attempt to two. Its scope includes classical Greekand Sanskrit texts like Bharata s Natyasastra and Aristotles Poetics which areextensive treatises on dramaturgy, Longinus s concept of the sublime,Anandavardhanas concept of dhvani and postulates of New Criticism. **References/Text Books:**	COMPARATIVE AESTHETICS
ENG753	3-0-0-0-4		**Course Contents:** The course covers the theoretical aspect of the practice of translation in the west and in India. It includes the history of translation and various forms of translation like retellings and intersemiotic adaptations. The course also explores the cultural turn in translation including aspects like the politics implicit in the practice of translation between unequal languages in a globalized world. **References/Text Books:**	TRANSLATION STUDIES
ENG754	3-0-0-0-4		**Course Contents:** This subject is an introduction to historical linguistics, the study oflanguage change and linguistic relationships. We will explore the kinds ofchanges that languages undergo throughout their history, drawing onmaterial from a wide range of languages. The comparative method oflinguistic reconstruction will be introduced and demonstrated, togetherwith methods of language classification and subgrouping. We will alsoinvestigate language change in progress and relations between language andcultural history.Topics to be discussedIntroduction what is historical linguistics?Lexical and semantic change, borrowingPhonological changeMorphological changeSyntactic changeLanguage classification, subgrouping and regroupingLinguistic reconstruction: comparative and other methodsModels of language changeLanguage change in progressLanguage and cultural historyLanguage and prehistory, longdistance comparisonsTextsCampbell, Lyle 1998. Historical Linguistics: An Introduction. EdinburghUniversity PressMillar, Robert McColl (ed.) 2007. Trasks Historical Linguistics. HodderArnold **References/Text Books:** Bhat, D.N.S. 2001. Sound Change. MLBD.Croft, William 2000. Explaining Language Change: An Evolutionary Approach.Longman.Crowley, Terry 2010. An Introduction to Historical Linguistics. OxfordUniversity Press.Crystal, David 2002. The English Language. PenguinDurie, Mark and Malcolm Ross 1996 The Comparative Method Reviewed:Regularity and Irregularity in Language Change. Oxford University Press[D&R below]Fortson, Benjamin W. 2004. IndoEuropean Language and Culture. Blackwell.Hock, Hans Henrich 1991. Principles of Historical Linguistics. Mouton deGruyterJoseph, Brian D.	HISTORICAL LINGUISTICS

			and Richard D. Janda 2003. The Handbook of HistoricalLinguistics. BlackwellLightfoot, D.W. 1979. Principles of Diachronic Syntax. CUPMcMahon, April S. 1994. Understanding Language Change. CUPSchendl, Herbert 2001. Historical Linguistics. Oxford University Press	
ENG799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
HSS401A	3-0-0-0-9		**Course Contents:** Personal Skills: SelfAssessment; Identifying Strength & Limitations; Habits, WillPower and Drives; Developing SelfEsteem and Building SelfConfidence, Significance of SelfDiscipline. Understanding Perceptions, Attitudes, and Personality Types. MindSet: Growth and Fixed; Values and Beliefs. Motivation and Achieving Excellence; SelfActualisation Need. Goal Setting, Life and Career Planning; Constructive Thinking. Professional Skills: Communicating Clearly: Understanding and Overcoming barriers; Cross gender/Cross Cultural communication, Strategic Communication. Active Listening. Persuasive Speaking and Presentation Skills. Conducting Meetings, Writing Minutes, Sending Memos and Notices. Netiquette: Effective Email Communication; Telephone Etiquette. Body Language in Group Discussion and Interview. Interpersonal Skills: Enhancing Empathy, Showing Sympathy and Dealing with Antipathy; Gaining Trust and Developing Emotional Bonding. Ethics and Etiquettes (Social and Official Settings); Respecting Privacy; Civic Sense and Care for the Environment. Negotiating, DecisionMaking, ConflictResolution, Five Styles. Emotional Literacy; Assertiveness versus Aggressiveness; Learning to Say No.; Learning to Appreciate and Give Praise; Presenting Bad News. Humour, Jokes and Anecdotes in Effective Communication. Management Skills: Managing Time and Beating Procrastination. Managing People: Leading and Working with Team (Coordination and Cooperation); Developing Accountability, Commitment and Responsibility; Behaving Conscientiously. Managing Stress and Maintaining Positive Outlook. Managing Health, Boosting Memory, Enhancing Study Skills. Managing Money and Love; Balancing Personal and Professional Life. **References/Text Books:** Dorch, Patricia. What Are Soft Skills? New York: Execu Dress Publisher, 2013.Kamin, Maxine. Soft Skills Revolution: A Guide for Connecting with Compassion for Trainers, Teams, and Leaders. Washington, DC: Pfeiffer & Company, 2013. Klaus, Peggy, Jane Rohman & Molly Hamaker. The Hard Truth about Soft Skills. London: HarperCollins Ebooks, 2007.Petes S. J., Francis.Soft Skills and Professional Communication. New Delhi: Tata McGrawHill Education, 2011. Stein, Steven J. & Howard E. Book. The EQ Edge: Emotional Intelligence and Your Success. Canada: Wiley & Sons, 2006.	SOFT SKILLS AND PERSONALITY DEVELOPMENT
HSS403	3-1-0-0-4		**Course Contents:** From biomedical model of health to sociopsychological model of health;Illness cognition; Social processes, illness and coping; Methodological issues in study of health;Stigma aod testing and treatment seeking behavior; Health policy in India; Preventive, curativeand palliative health care; Role of NGOs aod CBOs. **References/Text Books:**	SOCIAL AND BEHAVIOURAL ASPECTS OF HEALTH
HSS403A	3-0-0-0-9		**Course Contents:** From biomedical model of health to sociopsychological model of health; Illness cognition; Social processes, illness and coping; Methodological issues in study of health; Stigma aod testing and treatment seeking behavior; Health policy in India; Preventive, curative and palliative health care; Role ofNGOs aod CBOs. **References/Text Books:**	SOCIAL AND BEHAVIOURAL ASPECTS OF HEALTH
HSS701	3-0-0--4		**Course Contents:** The aim of the course is to understand the origins of the notions in theclassical period, its rejuvenation in the medieval and early modern periods,and contemporary debates surrounding different theories of rights with	THEORIES OF RIGHTS

			specialemphasis on examining debates on human rights. Some specific domains ofrights will be taken up for intensive study in the light of various theoriticalpositions. Themes include: Stoicism, Republicanism, Natural Law Discourse,Liberalism, Utilitiarianism, Legal Positivism, Marxism, and Communitarianism. **References/Text Books:**	
HSS702	3-0-0-0-4		**Course Contents:** 1.Health and illness: biomedical and sociopsychological models2.Social cognitive models of health3.Culture and health; cross cultural and comparative research in mental health4.Illness, distress and self5.Self regulation of health and illness; illness cognition6.Positivist, feminist and materialist approaches to health7.Stress and coping8.Personal and social meanings of illness; Illness narratives and cultural construction of illness9.Postmodernity, health policy and its impact on peoples health10.Major national, regional and ethnographic studies on physical and mental health in India11.Positivist, qualitative, and ethnographic approaches12.National health policy in India and issues for research; Caregiving in the Indian context **References/Text Books:** The main readings are various journal articles and survey reports and policy documents that are available online. Reference books include (i) Margaret Konz Snooks, Health Psychology: Biological, Psychological, and Sociocultural Perspectives. (ii) Bernice A. Pescosolido et al. (eds.), Handbook of the Sociology of Health, Illness, and Healing: A Blueprint for the 21st Century. (iii) K. Charmaz and D. A. Paterniti, Health. Illness and Healing Social Context and Self. (iv) David Wainwright (ed.), A Sociology of Health. (v) Poul Rohleder, Critical Issues in Clinical & Health Psychology. (vi) John Germov (ed.), Second Opinion. (vii) Sarah Nettleton, The Sociology of Health and Illness. (viii) L. D. Cameron and H. Leventhal, The Selfregulation of Health and Illness Behaviour. (ix) A. Kleinman, The illness narratives: Suffering, healing and the human condition	HEALTH AND ILLNES: PSYCHO-SOCIAL PERSPECTIVES
HSS702A	3-0-0-0-9		**Course Contents:** 1.Health and illness: biomedical and sociopsychological models2.Social cognitive models of health3.Culture and health; cross cultural and comparative research in mental health4.Illness, distress and self5.Self regulation of health and illness; illness cognition6.Positivist, feminist and materialist approaches to health7.Stress and coping8.Personal and social meanings of illness; Illness narratives and cultural construction of illness9.Postmodernity, health policy and its impact on peoples health10.Major national, regional and ethnographic studies on physical and mental health in India11.Positivist, qualitative, and ethnographic approaches12.National health policy in India and issues for research; Caregiving in the Indian context **References/Text Books:** The main readings are various journal articles and survey reports and policy documents that are available online. Reference books include (i) Margaret Konz Snooks, Health Psychology: Biological, Psychological, and Sociocultural Perspectives. (ii) Bernice A. Pescosolido et al. (eds.), Handbook of the Sociology of Health, Illness, and Healing: A Blueprint for the 21st Century. (iii) K. Charmaz and D. A. Paterniti, Health. Illness and Healing Social Context and Self. (iv) David Wainwright (ed.), A Sociology of Health. (v) Poul Rohleder, Critical Issues in Clinical & Health Psychology. (vi) John Germov (ed.), Second Opinion. (vii) Sarah Nettleton, The Sociology of Health and Illness. (viii) L. D. Cameron and H. Leventhal, The Selfregulation of Health and Illness Behaviour. (ix) A. Kleinman, The illness narratives: Suffering, healing and the human condition	HEALTH AND ILLNES: PSYCHO-SOCIAL PERSPECTIVES
PHI140	3-0-0-0-4		**Course Contents:** 1. Introduction: The Dialectical Style oflndian Philosophy TheKhandanaMandana style. Stating the real and imaginary objections.Refutation of Objections. Establishing the position.2. Historical Sketch: The AstikaNastika division and its logic. TheCriteria of Categorization.3. Valid Cognition (prama): Its definition in different schools (at leastin Nyaya, Bauddha, Mimamsa and Advaita). Genesis and categorization ofvalid	INTRODUCTION TO INDIAN PHILOSOPHY

			cognition in different schools.4. Content of Valid cognition (prameya): That which is thereIndianMetaphysics. Indian Realism (Nyaya). Indian Idealism (Buddhism andAdvaita)5. Causality: Causal theories in different schools (Adhityasamutpada,Arambhavada, Parinamavada, Vivartavada and Pratityasamutpada)6. Logic: Inference (anumana) and its features in Nyaya. Logical Blockersor Hetvabhasas in Nyaya7. Ethics: Theory of karman as an extension oflndian causal theory.Purushartha. **References/Text Books:** * Six Ways of Knowing, D M Datta, Calcutta University, 1972.* An Introduction to Indian Philosophy, S Chatterjee and D Datta, Rupa & Co., 2007(paperback)* Outlines oflndian Philosophy, M Hiriyanna, Motilal Banarasidass, 1999 (paperback)* A Critical Survey oflndian Philosophy, C D Sharma, Motilal Banarasidass, 1987.* The Philosophical Traditions oflndia, P T Raju, Motilal Banarasidass, 1992.* A History of Indian Philosophy, S N Dasgupta, Cambridge University Press, 1922.* Encyclopedia oflndian Philosophy,Voll 12, ed. Karl Potter, Motilal Banarasidass,	
PHI140A	3-1-0-0-11		**Course Contents:** 1. Introduction: The Dialectical Style oflndian Philosophy TheKhandanaMandana style. Stating the real and imaginary objections.Refutation of Objections. Establishing the position.2. Historical Sketch: The AstikaNastika division and its logic. TheCriteria of Categorization.3. Valid Cognition (prama): Its definition in different schools (at leastin Nyaya, Bauddha, Mimamsa and Advaita). Genesis and categorization ofvalid cognition in different schools.4. Content of Valid cognition (prameya): That which is thereIndianMetaphysics. Indian Realism (Nyaya). Indian Idealism (Buddhism andAdvaita)5. Causality: Causal theories in different schools (Adhityasamutpada,Arambhavada, Parinamavada, Vivartavada and Pratityasamutpada)6. Logic: Inference (anumana) and its features in Nyaya. Logical Blockersor Hetvabhasas in Nyaya7. Ethics: Theory of karman as an extension oflndian causal theory.Purushartha. **References/Text Books:** * Six Ways of Knowing, D M Datta, Calcutta University, 1972.* An Introduction to Indian Philosophy, S Chatterjee and D Datta, Rupa & Co., 2007(paperback)* Outlines oflndian Philosophy, M Hiriyanna, Motilal Banarasidass, 1999 (paperback)* A Critical Survey oflndian Philosophy, C D Sharma, Motilal Banarasidass, 1987.* The Philosophical Traditions oflndia, P T Raju, Motilal Banarasidass, 1992.* A History of Indian Philosophy, S N Dasgupta, Cambridge University Press, 1922.* Encyclopedia oflndian Philosophy,Voll 12, ed. Karl Potter, Motilal Banarasidass,	INTRODUCTION TO INDIAN PHILOSOPHY
PHI141	3-1-0--4		**Course Contents:** General introduction to philosophy: Nature of philosophy; its relations with, and differencesfrom, science, religion, art, and culture. Metaphysics: Causality; determinism and free wilLMaterialism and Idealism. Personal Identity_ Critique of Metaphysics.Logic: Truth, validity, and arguments.Epistemology: Scepticism; Defining knowledge; The Gettier problem. Theories of perception.Descartes and foundationalism. Coherentism. Naturalized epistemology.Ethics: Utilitarianism. Kant. Virtue ethics.Applied Ethics: Some problems of applied ethics. **References/Text Books:** Chisholm, Roderick. Theory of Knowledge. Prentice Hall, Englewood Cliffs NJ, 1989.Horner, Chris and Emrys Westacott. Thinking through Philosophy. Cambridge University Press,Cambridge, 2000.Russell, Bertrand. Problems of Philosophy. Oxford University Press, 1912, Reprint 1972.Singer, Peter. Practical Ethics. 2nd edn. Cambridge University Press, Cambridge, 1993.	INTRODUCTION TO PHILOSOPHY
PHI141A	3-1-0-0-11		**Course Contents:** General introduction to philosophy: Nature of philosophy; its relations with, and differencesfrom, science, religion, art, and culture. Metaphysics: Causality; determinism and free wilLMaterialism and Idealism. Personal Identity_ Critique of Metaphysics.Logic: Truth, validity, and arguments.Epistemology: Scepticism; Defining knowledge; The Gettier problem. Theories of perception.Descartes and foundationalism. Coherentism. Naturalized epistemology.Ethics: Utilitarianism. Kant. Virtue ethics.Applied Ethics: Some	INTRODUCTION TO PHILOSOPHY

			problems of applied ethics. **References/Text Books:** Chisholm, Roderick. Theory of Knowledge. Prentice Hall, Englewood Cliffs NJ, 1989.Horner, Chris and Emrys Westacott. Thinking through Philosophy. Cambridge University Press,Cambridge, 2000.Russell, Bertrand. Problems of Philosophy. Oxford University Press, 1912, Reprint 1972.Singer, Peter. Practical Ethics. 2nd edn. Cambridge University Press, Cambridge, 1993.	
PHI141B	3-1-0-0-11		**Course Contents:** General Introduction to the Course; Nature of Knowledge; Sources of Knowledge;The Problem of Perception; Skepticism; Kinds of Metaphysics; MetaphysicalSystems; MindBody Dualism; Proofs for the Existence of God; PositivisticCritique of Metaphysics; Normative Ethics; MetaEthics; Free will and Moralresponsibility. **References/Text Books:**	INTRODUCTION TO PHILOSOPHY
PHI142	3-1-0--4		**Course Contents:** Introduction: Logic as the science of distinguishing valid arguments from invalid ones. Fallacies.Aristotelian Logic and its limitationsPropositional Logic: Propositional Calculus. Logical Operators. Translation from NaturalLanguage Arguments. Relations between Logical Connectives. Rules of Deduction. TruthTables. Test ofInvalidity. Semantic Tableaux MethodPredicate Logic: Predicate Calculus. Quantifiers and Properties. Translations. Bondage andFreedom. Rules of Deduction (Generalization and Instantiation) and Constraints. TestingInvalidity in Nonrelational Predicate Calculus using the Truth Table Method. SemanticTableaux MethodAxiomatic System: Introduction to the System of Principia Mathematica. Godel'sIncompleteness Theorem **References/Text Books:** Texts:Copi, Irvin and Carl Cohen, Introduction to Logic, Prentice Hall, New Jeresy, 101h edn., 1998Hausman, Alan, Howard Kahane, and Paul Tidman, Logic and Philosophy: A ModernIntroduction, Wadsworth Publishing, Boston, 2010Hurley, Patrick, Concise Introduction to Logic, Wadsworth Publishing, Boston, 2007Kalish, Donais and Richard Montague, Logic: Techniques of Formal Reasoning, Harcourt, Brace& World, Inc., 1964References:Crossley, John, et al, What is Mathematical Logic, Oxford University Press, Oxford, 1972Gardner, Martin, Aha! Insight, Aha! Gotcha, The Mathematical Association of America, 2002Hedman, Shawn, First course in Mathematical Logic, Oxford University Press, Oxford, 2004, pp1115	INTRODUCTION TO LOGIC
PHI142A	3-1-0-0-11		**Course Contents:** Introduction: Logic as the science of distinguishing valid arguments from invalid ones. Fallacies.Aristotelian Logic and its limitationsPropositional Logic: Propositional Calculus. Logical Operators. Translation from NaturalLanguage Arguments. Relations between Logical Connectives. Rules of Deduction. TruthTables. Test ofInvalidity. Semantic Tableaux MethodPredicate Logic: Predicate Calculus. Quantifiers and Properties. Translations. Bondage andFreedom. Rules of Deduction (Generalization and Instantiation) and Constraints. TestingInvalidity in Nonrelational Predicate Calculus using the Truth Table Method. SemanticTableaux MethodAxiomatic System: Introduction to the System of Principia Mathematica. Godel'sIncompleteness Theorem **References/Text Books:** Texts:Copi, Irvin and Carl Cohen, Introduction to Logic, Prentice Hall, New Jeresy, 101h edn., 1998Hausman, Alan, Howard Kahane, and Paul Tidman, Logic and Philosophy: A ModernIntroduction, Wadsworth Publishing, Boston, 2010Hurley, Patrick, Concise Introduction to Logic, Wadsworth Publishing, Boston, 2007Kalish, Donais and Richard Montague, Logic: Techniques of Formal Reasoning, Harcourt, Brace& World, Inc., 1964References:Crossley, John, et al, What is Mathematical Logic, Oxford University Press, Oxford, 1972Gardner, Martin, Aha! Insight, Aha! Gotcha, The Mathematical Association of America, 2002Hedman, Shawn, First course in Mathematical Logic, Oxford University Press, Oxford, 2004, pp1115	INTRODUCTION TO LOGIC

PHI442	3-1-0--4		**Course Contents:** This course deals with the philosophical ideas of Karl Marx, Gandhi and someof the important existentialist thinkers, especially JeanPaul Sartre and MatrinHeideggar. Major emphasis is laid on the moral issues raised by these thinkers. **References/Text Books:**	MARXISM, GANDHI AND EXISTENTIALISM
PHI442A	3-0-0-0-9		**Course Contents:** This course deals with the philosophical ideas of Karl Marx, Gandhi and someof the important existentialist thinkers, especially JeanPaul Sartre and MatrinHeideggar. Major emphasis is laid on the moral issues raised by these thinkers. **References/Text Books:**	MARXISM, GANDHI AND EXISTENTIALISM
PHI446	3-0-0-0-4		**Course Contents:** On what Philosophy of Science is; Logic and Empiricism; Theory and Observation; Evidence,Confirmation and Falsificationism; Induction and Probability; Scientific Revolution versus NormalScience; Scientific Explanation I : Theoretical Entities; Scientific Explanation II : Naturalism,Realism and Antirealism; Laws of Nature, dispositions and causes and Conditionals,Causality and Indeterminism, Bayesian and Modern theories of Evidence; Science and Values **References/Text Books:** * Peter GodfreySmith(2003), Theory and Reality: An Introduction to Philosophy of Science,University of Chicago Press. [Standard Text for this course] James Ladyman(2002), Understanding Philosophy of Science, ,Routledge, London. Hacking, I. (1983). Representing and Intervening, Cambridge University Press, Cambridge. Chalmers, A. F. (1982). What Is This Thing Called Science? Open University Press,Milton Keynes, second edition. Thomas Kuhn(! 996) The Structure of Scientific Revolutions, University of Chicago Press. Okasha Samir (2002), Short introduction to philosophy of science, Oxford: Oxford U niversityPress. Hempel, Carl (I 966),Philosophy of natural science, PrenticeHall foundations of philosophyseries. Englewood Cliffs, N.J.,: PrenticeHall. Gillies, D. A.(1993), Philosophy of Science in the Twentieth Century: Four CentralThemes, Blackwell Publishers. Rom Harre (1972), The philosophies of Science: An introductory survey, Oxford Universitypress, USA.	PHILOSOPHY OF SCIENCE
PHI446A	3-0-0-0-9		**Course Contents:** On what Philosophy of Science is; Logic and Empiricism; Theory and Observation; Evidence,Confirmation and Falsificationism; Induction and Probability; Scientific Revolution versus NormalScience; Scientific Explanation I : Theoretical Entities; Scientific Explanation II : Naturalism,Realism and Antirealism; Laws of Nature, dispositions and causes and Conditionals,Causality and Indeterminism, Bayesian and Modern theories of Evidence; Science and Values **References/Text Books:** * Peter GodfreySmith(2003), Theory and Reality: An Introduction to Philosophy of Science,University of Chicago Press. [Standard Text for this course] James Ladyman(2002), Understanding Philosophy of Science, ,Routledge, London. Hacking, I. (1983). Representing and Intervening, Cambridge University Press, Cambridge. Chalmers, A. F. (1982). What Is This Thing Called Science? Open University Press,Milton Keynes, second edition. Thomas Kuhn(! 996) The Structure of Scientific Revolutions, University of Chicago Press. Okasha Samir (2002), Short introduction to philosophy of science, Oxford: Oxford U niversityPress. Hempel, Carl (I 966),Philosophy of natural science, PrenticeHall foundations of philosophyseries. Englewood Cliffs, N.J.,: PrenticeHall. Gillies, D. A.(1993), Philosophy of Science in the Twentieth Century: Four CentralThemes, Blackwell Publishers. Rom Harre (1972), The philosophies of Science: An introductory survey, Oxford Universitypress, USA.	PHILOSOPHY OF SCIENCE
PHI447	3-1-0--4		**Course Contents:**	MORAL THINKING

			Introduction to Ethical Theories(Consequentialist and Nonconsequentialist theories, Hedonism,Utilitarianism, Deontological theories, Ethical Rules, Situation Ethics, Virtue Ethics).MetaethicalTheories (Ethical Relativism: Is Anything Wrong at all? Ethical Naturalism, Nonnaturalism,Noncognitive Theories, Intuitionism, Approach to an Adequate Theory; the Moralpoint of view; Why be Moral?). Ethics in the Indian tradition. Applied Ethics: Issues andDilemmas. **References/Text Books:** 1. Frankena, W.K. Ethics. New Delhi: Prentice Hall ofindia,19992. Hospers, John. An Introduction to Philosophical Analysis. New Delhi: Allied Publishers,19673. LaFollette, Hugh, ed. Ethics in Practice: An Anthology. Cambridge: Blackwell,19974. Radhakrishnan,S. Indian Philosophy. 2 Vols. New Delhi: Oxford University Press, 19405. Pojman, Louis (Ed.) Ethical Theory: Classical and Contemporary Readings, Belmont:Wadsworth, 19986. Cahn, Steven M. & Peter Markie (Eds.) Ethics: History. Theory and ContemporaryIssues, Issues, New York: OUP, 1998	
PHI447A	3-0-0-0-9		**Course Contents:** Introduction to Ethical Theories(Consequentialist and Nonconsequentialist theories, Hedonism, Utilitarianism, Deontological theories, Ethical Rules, Situation Ethics, Virtue Ethics).Metaethical Theories (Ethical Relativism: Is Anything Wrong at all? Ethical Naturalism, Nonnaturalism, Noncognitive Theories, Intuitionism, Approach to an Adequate Theory; the Moral point of view; Why be Moral?). Ethics in the Indian tradition. Applied Ethics: Issues and Dilemmas. **References/Text Books:** Text (excerpts):1. Frankena, W.K. Ethics. New Delhi: Prentice Hall ofindia,19992. Hospers, John. An Introduction to Philosophical Analysis. New Delhi: Allied Publishers,19673. LaFollette, Hugh, ed. Ethics in Practice: An Anthology. Cambridge: Blackwell,19974. Radhakrishnan,S. Indian Philosophy. 2 Vols. New Delhi: Oxford University Press, 19405. Pojman, Louis (Ed.) Ethical Theory: Classical and Contemporary Readings, Belmont:Wadsworth, 19986. Cahn, Steven M. & Peter Markie (Eds.) Ethics: History. Theory and ContemporaryIssues, Issues, New York: OUP, 1998	MORAL THINKING
PHI448	3-0-0-0-4		**Course Contents:** The distinction between Authority, Power and Sovereignty; Political forms ofAuthority; The individuals Rights and his Legitimate Autonomy; Encroachmenton the Individuals Legtimate Sphere: its Sources and their Disguised Forms;Misuse of Power and Safeguards against it. **References/Text Books:**	INDIVIDUAL VS AUTHORITY
PHI448A	3-0-0-0-9		**Course Contents:** The distinction between Authority, Power and Sovereignty; Political forms ofAuthority; The individuals Rights and his Legitimate Autonomy; Encroachmenton the Individuals Legtimate Sphere: its Sources and their Disguised Forms;Misuse of Power and Safeguards against it. **References/Text Books:**	INDIVIDUAL VS AUTHORITY
PHI450	3-0-0--4		**Course Contents:** The Aesthetic attitude; Aesthetic Experience; Art and Aesthetic; Defining Artand its Problems; Art and Emotion; Literary Aesthetics; Art, Society and Morality;Philosophy of Literature. **References/Text Books:**	PHILOSOPHICAL AESTHETICS
PHI450A	3-0-0-0-9		**Course Contents:** The Aesthetic attitude; Aesthetic Experience; Art and Aesthetic; Defining Artand its Problems; Art and Emotion; Literary Aesthetics; Art, Society and Morality;Philosophy of Literature.	PHILOSOPHICAL AESTHETICS

			References/Text Books:	
PHI451	3-1-0--4		**Course Contents:** Introduction and Historical Sketch; Comparative Ontology: Object of knowledge (prameya);Irreducible ontological categories (padarthas) in different schools; Different theories of error(khyativada); Theories on Causation (karanata); Comparative Epistemology: Cognition;Definitions of valid cognition (prama); Means of valid cognitions: Definition and number (indifferent schools); Logic: Nyaya Logic and theory of Inference; Logical fallacies; Nyayadoctrine on formal representation of cognitions. **References/Text Books:** Datta, D. M. Six Ways of Knowing. Calcutta: Calcutta University. 1972Chatterjee, S. and D. Datta. An Introduction to Indian Philosophy. Calcutta: Rupa & Co. 2007'Chatterjee, S. C. Nyaya theory of knowledge. Bharatiya Kala Prakashan. 2008Bhattacharya, G. Tarkasamgrahadipika on Tarkasamgraha. Progressive Publishers. 2008Dasgupta, S. N. A History of Indian Philosophy. Cambridge University Press. 1922Potter, K. (ed). Encyclopedia of Indian Philosophy. New Delhi: Motilal Banarasidass	TOPICS IN INDIAN PHILOSOPHY
PHI451A	3-0-0-0-9		**Course Contents:** Introduction and Historical Sketch; Comparative Ontology: Object of knowledge (prameya);Irreducible ontological categories (padarthas) in different schools; Different theories of error(khyativada); Theories on Causation (karanata); Comparative Epistemology: Cognition;Definitions of valid cognition (prama); Means of valid cognitions: Definition and number (indifferent schools); Logic: Nyaya Logic and theory of Inference; Logical fallacies; Nyayadoctrine on formal representation of cognitions. **References/Text Books:** Datta, D. M. Six Ways of Knowing. Calcutta: Calcutta University. 1972Chatterjee, S. and D. Datta. An Introduction to Indian Philosophy. Calcutta: Rupa & Co. 2007'Chatterjee, S. C. Nyaya theory of knowledge. Bharatiya Kala Prakashan. 2008Bhattacharya, G. Tarkasamgrahadipika on Tarkasamgraha. Progressive Publishers. 2008Dasgupta, S. N. A History of Indian Philosophy. Cambridge University Press. 1922Potter, K. (ed). Encyclopedia of Indian Philosophy. New Delhi: Motilal Banarasidass	TOPICS IN INDIAN PHILOSOPHY
PHI455	3-0-0-0-4		**Course Contents:** Brief overview of first order logic, Problem of Logical Consequence, Deviant Logics: ManyvaluedLogic I: Three valued Logics, Many Valued Logic2: Many valued logic and Degrees oftruth, Para consistent Logic, Basic concepts of Fuzzy Logic; Extensions of First order Logic:Basic concepts of Normal Modal Logic, Epistemic Logic, Problem of Counterfactuals; LogicalPluralism **References/Text Books:** 1. James Graham Priest, An Introduction to NonClassical Logic, Cambridge: CambridgeUniversity Press 2001 (standard Text for the course),22. Colin Mcginn, Logical Properties, Oxford University Press, 2000.3. John P. Burgess, Philosophical Logic, Princeton University Press, 20094. Quine, W. V. 0, Philosophy of Logic, Prentice Hall, 1970.5. Haack, Susan, Deviant Logic, Cambridge University Press, 1974.6. Jacquette, Dale. Philosophy of Logic. Amsterdam, The Netherlands: Elsevier/NorthHolland, 2007.7. Rescher, Nicholas. Topics In Philosophical Logic. Dordrecht: D. Reidel, 1968.8. Blackburn, Patrick, Maarten de Rijke, and Y de Venema. Modal Logic. Cambridge [England]:Cambridge University Press, 2001.9. Lewis, David K. Counterfactuals. Cambridge, Harvard University Press, 1973.10. S. Read, Thinking about Logic, Oxford University Press, 199511. J. C. Beall, Greg Restall, Logical Pluralism, Clarendon Press, 2006.	PHILOSOPHICAL LOGIC
PHI455A	3-0-0-0-9		**Course Contents:** Brief overview of first order logic, Problem of Logical Consequence, Deviant Logics: ManyvaluedLogic I: Three valued Logics, Many Valued Logic2: Many valued logic and Degrees oftruth, Para consistent Logic, Basic concepts of Fuzzy Logic; Extensions of First order Logic:Basic concepts of Normal Modal Logic, Epistemic Logic, Problem of Counterfactuals; LogicalPluralism	PHILOSOPHICAL LOGIC

			References/Text Books: 1. James Graham Priest, An Introduction to NonClassical Logic, Cambridge: CambridgeUniversity Press 2001 (standard Text for the course),22. Colin Mcginn, Logical Properties, Oxford University Press, 2000.3. John P. Burgess, Philosophical Logic, Princeton University Press, 20094. Quine, W. V. 0, Philosophy of Logic, Prentice Hall, 1970.5. Haack, Susan, Deviant Logic, Cambridge University Press, 1974.6. Jacquette, Dale. Philosophy of Logic. Amsterdam, The Netherlands: Elsevier/NorthHolland, 2007.7. Rescher, Nicholas. Topics In Philosophical Logic. Dordrecht: D. Reidel, 1968.8. Blackburn, Patrick, Maarten de Rijke, and Y de Venema. Modal Logic. Cambridge [England]:Cambridge University Press, 2001.9. Lewis, David K. Counterfactuals. Cambridge, Harvard University Press, 1973.10. S. Read, Thinking about Logic, Oxford University Press, 199511. J. C. Beall, Greg Restall, Logical Pluralism, Clarendon Press, 2006.	
PHI751	3-0-0-0-4		**Course Contents:** An analytical study of Russells The Philosophy of Logical Atomism andWittgensteins Tractatus LogicoPhilosophicus: Facts and Propositions; Namesand Objects; Definite Description; Picture Theory of Meaning; Limits ofLanguage, Thought and The World; Silence and the Transcendental. **References/Text Books:**	TWENTIETH CENTURY PHILOSOPHY-I
PHI751A	3-0-0-0-9		**Course Contents:** An analytical study of Russells The Philosophy of Logical Atomism andWittgensteins Tractatus LogicoPhilosophicus: Facts and Propositions; Namesand Objects; Definite Description; Picture Theory of Meaning; Limits ofLanguage, Thought and The World; Silence and the Transcendental. **References/Text Books:**	TWENTIETH CENTURY PHILOSOPHY-I
PHI752	3-0-0--4		**Course Contents:** Theories of Art as Mimesis, Expression and Form; Aesthetic Experience; Artas a Cultural System; Art and Morality; the Philosophy of Literature: Truth,Meaning, Interpretation and Evaluation; Literature and Cultural Studies. **References/Text Books:**	PROBLEMS IN PHILOSOPHICAL AESTHETICS
PHI753	3-0-0--4		**Course Contents:** Propositional Logic; Decision Procedures; Quantification Theory; AxiomaticMethod; Philosophical Problems. **References/Text Books:**	MODERN LOGIC
PHI757	3-0-0--4		**Course Contents:** The details of the studies in this course will be designed for advanced studentsdepending on their fields of research. **References/Text Books:**	MORAL JUDGEMENT
PHI757A	3-0-0-0-9		**Course Contents:** The details of the studies in this course will be designed for advanced studentsdepending on their fields of research. **References/Text Books:**	MORAL JUDGEMENT
PHI765	3-0-0--4		**Course Contents:** An Analytical Study of the Logic of Ordinary Language; Problems of Meaning,Reference and Truth; the AnalyticSynthetic Distinction; the SchemeContentDistinction; Antifoundationalism and Neopragmatism. Special reference to theviews of Wittgenstein, Austin, Strawson, Quine, Davidson, Kripke, Putnam	TWENTIETH CENTURY PHILOSOPHY II

			andThomas Nagel. **References/Text Books:**	
PHI765A	3-0-0-0-9		**Course Contents:** An Analytical Study of the Logic of Ordinary Language; Problems of Meaning, Reference and Truth; the AnalyticSynthetic Distinction; the SchemeContent Distinction; Antifoundationalism and Neopragmatism. Special reference to the views of Wittgenstein, Austin, Strawson, Quine, Davidson, Kripke, Putnam and Thomas Nagel. **References/Text Books:**	TWENTIETH CENTURY PHILOSOPHY II
PHI768	4-0-0--4		**Course Contents:** The History of Modal notions; The Lewis systems; Strict Implication andEntaliment; The System E and Relevance Logic; Philosophical Problems. **References/Text Books:**	MODAL LOGIC
PHI768A	3-0-0-0-9		**Course Contents:** The History of Modal notions; The Lewis systems; Strict Implication andEntaliment; The System E and Relevance Logic; Philosophical Problems. **References/Text Books:**	MODAL LOGIC
PHI769	4-0-1--4		**Course Contents:** A discussion of Epistemological, Metaphysical and Value problems raised in theClassical Systems of Indian Philosophy. Depending on the students interest,aptitude and progress, either some texts will be studied in details or one setof problems will be studied through relevant texts. **References/Text Books:**	INDIAN PHILOSOPHY I
PHI774	3-0-0--4		**Course Contents:** Nature and Method of Social Philosophy; Nature of Society; Theories of Originsof Society; Place and Role of Social Institutions; Social Values and Ends ofPolitical Authority; Sources of Justification and Legitimacy of Political Authority;Individual and Society; Individual and State. **References/Text Books:**	SOCIAL AND POLITICAL PHILOSPHY
PHI774A	3-0-0-0-9		**Course Contents:** Nature and Method of Social Philosophy; Nature of Society; Theories of Origins of Society; Place and Role of Social Institutions; Social Values and Ends of Political Authority; Sources of Justification and Legitimacy of Political Authority; Individual and Society; Individual and State. **References/Text Books:**	SOCIAL AND POLITICAL PHILOSPHY
PHI782	3-0-0--4		**Course Contents:** The course seeks to go into the sources of modern existentialist movementin the thoughts of Hegel, Husserl and Kierkegaard. A detailed study of Sartresphilosophy will be undertaken in the light of his early and later writings. **References/Text Books:**	EXISTENTIALISM
PHI782A	3-0-0-0-9		**Course Contents:** The course seeks to go into the sources of modern existentialist movement in the thoughts of Hegel, Husserl	EXISTENTIALISM

			and Kierkegaard. A detailed study of Sartre's phiilosophy will be undertaken in the lisght of his early and later writings. **References/Text Books:**	
PHI799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
PSY151	3-1-0--4		**Course Contents:** Psychological Perspectives and Approaches; Perception; Learning; Memory;Higher Cognitive Processes; Motivation and Emotion; Intelligence; Personality;Individual Differences. **References/Text Books:**	INTRODUCTION TO PSYCHOLOGY
PSY151A	3-1-0-0-11		**Course Contents:** Psychological Perspectives and Approaches; Perception; Learning; Memory;Higher Cognitive Processes; Motivation and Emotion; Intelligence; Personality;Individual Differences. **References/Text Books:**	INTRODUCTION TO PSYCHOLOGY
PSY151B	3-1-0-0-11		**Course Contents:** Psychological Perspectives and Approaches; Perception; Learning; Memory;Higher Cognitive Processes; Motivation and Emotion; Intelligence; Personality;Individual Differences. **References/Text Books:**	INTRODUCTION TO PSYCHOLOGY
PSY152	3-1-0-0-4	#	**Course Contents:** Nature and Scope of Applied Psychology, Historical Perspective, Areas ofApplied Psychology, Roles and Skills of Applied Psychologists, Ethical Issues, Clinical andCounseling Psychology, Community Psychology and Mental Health, Educational Psychology,Ecological Psychology, Industrial and Organizational Psychology, Legal Psychology **References/Text Books:**	APPLICATION OF PSYCHOLOGY TO LIFE
PSY152A	3-1-0-0-11		**Course Contents:** Nature and Scope of Applied Psychology, Historical Perspective, Areas ofApplied Psychology, Roles and Skills of Applied Psychologists, Ethical Issues, Clinical andCounseling Psychology, Community Psychology and Mental Health, Educational Psychology,Ecological Psychology, Industrial and Organizational Psychology, Legal Psychology **References/Text Books:**	APPLICATION OF PSYCHOLOGY TO LIFE
PSY451	3-1-0--4	#	**Course Contents:** The course content, along with lecture wise breakup, is given below.Examinations: Choice of format of the examinations is left to the instructor.Laboratory content: As of now, the time table does not provide an option of introducingthe students to laboratory practices. Hence, some demos might be used to enrich theunderstanding of the course content. **References/Text Books:** I. Wayne Weiten, Dana S Dunn, and Elizabeth Yost Hammer (201 1). PsychologyApplied to Modem Life: Adjustment in the 21st Century. Wadsworth publishing(I oth edition).2. Robert C. Carson, James Neal	PSYCHOLOGY OF ADJUSTMENT

			Butcher, Susan Mineka (2000). Abnormalpsychology and modem life. Allyn & Bacon (I I th edition).3. W.S. Paine (Ed.) (1984). Job stress and burnout. Sage.	
PSY451A	3-0-0-0-9		**Course Contents:** The course content, along with lecture wise breakup, is given below.Examinations: Choice of format of the examinations is left to the instructor.Laboratory content: As of now, the time table does not provide an option of introducingthe students to laboratory practices. Hence, some demos might be used to enrich theunderstanding of the course content. **References/Text Books:** I. Wayne Weiten, Dana S Dunn, and Elizabeth Yost Hammer (201 1). PsychologyApplied to Modem Life: Adjustment in the 21st Century. Wadsworth publishing(I oth edition).2. Robert C. Carson, James Neal Butcher, Susan Mineka (2000). Abnormalpsychology and modem life. Allyn & Bacon (I I th edition).3. W.S. Paine (Ed.) (1984). Job stress and burnout. Sage.	PSYCHOLOGY OF ADJUSTMENT
PSY454	3-1-0--4	#	**Course Contents:** Social psychology as a branch of psychology its historical background, Majorparadigms of contemporary social psychology, Methods adopted in social psychology,Aggression and violence, Person perception, Social motivation, Attitude and its change, Socialfacilitation, Social loafing, Social power, Conformity and Compliance, Obedience to authority,Distributive and procedural justice, Group dynamics and intergroup relations, Issues of gender,poverty and marginalization **References/Text Books:** Baron, R. A., Branscombe, N. R., & Byrne, D. (2009). Social Psychology (12th ed.). Boston,MA: Pearson/Allyn and Bacon.Gergen, Kenneth J. (1999). An invitation to social construction. Thousand Oaks, CA: Sage.McGarty, C. & Haslam, S. A. (Eds.) (1997). The message of social psychology: Perspectives onmind in society. Oxford, UK and Cambridge, MT: Blackwell.Misra, G. & Dalal, A. K. (Eds.) (2006). New directions in Indian psychology (Vol. 1): SocialPsychology. New Delhi: Sage.Strickland, L. H., Aboud, F. E., & Gergen, K. J. (Eds) (1976). Social psychology in transition.Plenum: New York.	SOCIAL PSYCHOLOGY
PSY454A	3-0-0-0-9		**Course Contents:** Social psychology as a branch of psychology its historical background, Majorparadigms of contemporary social psychology, Methods adopted in social psychology,Aggression and violence, Person perception, Social motivation, Attitude and its change, Socialfacilitation, Social loafing, Social power, Conformity and Compliance, Obedience to authority,Distributive and procedural justice, Group dynamics and intergroup relations, Issues of gender,poverty and marginalization **References/Text Books:** Baron, R. A., Branscombe, N. R., & Byrne, D. (2009). Social Psychology (12th ed.). Boston,MA: Pearson/Allyn and Bacon.Gergen, Kenneth J. (1999). An invitation to social construction. Thousand Oaks, CA: Sage.McGarty, C. & Haslam, S. A. (Eds.) (1997). The message of social psychology: Perspectives onmind in society. Oxford, UK and Cambridge, MT: Blackwell.Misra, G. & Dalal, A. K. (Eds.) (2006). New directions in Indian psychology (Vol. 1): SocialPsychology. New Delhi: Sage.Strickland, L. H., Aboud, F. E., & Gergen, K. J. (Eds) (1976). Social psychology in transition.Plenum: New York.	SOCIAL PSYCHOLOGY
PSY457	3-1-0--4	#	**Course Contents:** General introduction to the scope of interpersonal dynamics, and themethods used. Major theoretical approaches (Social exchange theory, FIR08, InterpersonalCircumplex). Interpersonal judgment and impression formation (the major models).Interpersonal communication (sending and receiving messages, listening skills, communicatorstyle, Transactional Analysis). Interpersonal influence and power. Interpersonal conflict and itsmanagement. The social self (selfmonitoring and selfdisclosure). Shyness and loneliness asproblems in interpersonal relationships. Promoting positive interpersonal dynamics (the role ofempathy and	INTERPERSONAL DYNAMICS

			emotional intelligence). **References/Text Books:** Hinde: Towards Understanding Relationships.Berne : Games People Play.Duck & Gilmour : Personal Relationships.No single textbook is available that covers all the topics included in the course. Therefore,students will be assigned compulsory readings Uournal articles and book chapters), and will beencouraged to read from books that deal with topics relevant to the course.	
PSY458	3-1-0--4		**Course Contents:** Organizations and the systems concept, Chronological sequence ofdevelopment of thought in Organizational Behavior area, A road map for understandingorganizatiomil behavior: The elementary aspects of function and structure, their contributions toorganizational existence, Organizational models, Attitudes, Job Satisfaction, Motivation andperformance, Communication, Conflict and Negotiation, Leadership, Power, Control,Organizational Citizenship, and Antiorganization behaviors, Organizational Change andOrganizational Development: Individual and group approaches, Culture and OrganizationalBehavior, Work Groups, and Significance of individual and group effectiveness throughawareness of self and others. This last portion requires experiential learning. **References/Text Books:** I. Katz, D., & Kahn, R.L. (1978). The social psychology of organizations. (2nd ed.). NewYork: John Wiley & Sons.2. Robbins, S.P. Organizational behavior. New Delhi: PrenticeHall of!ndia PrivateLimited. (13th edition/ Most Recent Edition/).3. Sinha, J B P (2008). Culture and organizational behavior. New Delhi: SAGEPublications India Pvt Ltd.	ORGANIZATIONAL AND ADMINISTRATIVE PSYCHOLOGY
PSY458A	3-0-0-0-9		**Course Contents:** Organizations and the systems concept, Chronological sequence ofdevelopment of thought in Organizational Behavior area, A road map for understandingorganizatiomil behavior: The elementary aspects of function and structure, their contributions toorganizational existence, Organizational models, Attitudes, Job Satisfaction, Motivation andperformance, Communication, Conflict and Negotiation, Leadership, Power, Control,Organizational Citizenship, and Antiorganization behaviors, Organizational Change andOrganizational Development: Individual and group approaches, Culture and OrganizationalBehavior, Work Groups, and Significance of individual and group effectiveness throughawareness of self and others. This last portion requires experiential learning. **References/Text Books:** I. Katz, D., & Kahn, R.L. (1978). The social psychology of organizations. (2nd ed.). NewYork: John Wiley & Sons.2. Robbins, S.P. Organizational behavior. New Delhi: PrenticeHall of!ndia PrivateLimited. (13th edition/ Most Recent Edition/).3. Sinha, J B P (2008). Culture and organizational behavior. New Delhi: SAGEPublications India Pvt Ltd.	ORGANIZATIONAL AND ADMINISTRATIVE PSYCHOLOGY
PSY468	3-1-0--4		**Course Contents:** The major emphasis of the course will be to provide an overview of theindividual level social cognitive processes. In addition to this, students will also be exposed toconcepts pertaining to collective and shared sense making and social representations. An analysisbased on discursive processes will also be provided in order to understand the culturalunderpinning of human social cognition. Overall, the course will foster an understanding ofcognitive and social processes of human sense making in the social world. Both, individual levelinformation processing, and collective and symbolic processes of human social life will becovered in the course. **References/Text Books:** Augoustinos, M. and Walker, I. Social Cognition: An Integrated Introduction. London: SagePublications. 1995.Brewer, M. B. and Hewstone, M (eds.). Social Cognition. Blackwell Publishing: Cornwall, U.K.2004.Fiske, S.T. and Taylor, S.E. Social Cognition. Singapore: McGrawHill. 1991.Kunda, Z. Social	SOCIAL COGNITION

			Cognition: Making sense of people. MIT Press: Cambridge. !999.Postmes, T. and Jetten, J (eds.). Individuality and the Group: Advances in Social Identity. SagePublications: London. 2006.In addition to above texts, reading assignments (journal articles and book chapters) will beincluded from other sources.	
PSY468A	3-0-0-0-9		**Course Contents:** The major emphasis of the course will be to provide an overview of theindividual level social cognitive processes. In addition to this, students will also be exposed toconcepts pertaining to collective and shared sense making and social representations. An analysisbased on discursive processes will also be provided in order to understand the culturalunderpinning of human social cognition. Overall, the course will foster an understanding ofcognitive and social processes of human sense making in the social world. Both, individual levelinformation processing, and collective and symbolic processes of human social life will becovered in the course. **References/Text Books:** Augoustinos, M. and Walker, I. Social Cognition: An Integrated Introduction. London: SagePublications. 1995.Brewer, M. B. and Hewstone, M (eds.). Social Cognition. Blackwell Publishing: Cornwall, U.K.2004.Fiske, S.T. and Taylor, S.E. Social Cognition. Singapore: McGrawHill. 1991.Kunda, Z. Social Cognition: Making sense of people. MIT Press: Cambridge. !999.Postmes, T. and Jetten, J (eds.). Individuality and the Group: Advances in Social Identity. SagePublications: London. 2006.In addition to above texts, reading assignments (journal articles and book chapters) will beincluded from other sources.	SOCIAL COGNITION
PSY470A	3-0-0-0-9		**Course Contents:** Conceptualizing Wellbeing : (a) Nature, definitione and lived experience of wellbeing, (b) Methods in the studey of wellbeing: Quantitative and qualitative approaches.2) Types of Wellbeing: a) Objective wellbeing, b) Psychological wellbeing, c) Subjective wellbeing and happiness, d) Quality of Life. 3) Indigenous Approaches to Wellbeing: Experiences and Constructions within the Socio]Cultural Contexts 4) Wellbeing among Specific Groups: Youth, Elderly, Women, Disadvantaged Groups and Disaster Survivors 5) Indian Psychology of Wellbeing: Perspectives from Samkhya, AdvaitaVedanta and Yoga Systems **References/Text Books:** 1. Denzin, N. (1985). Emotions as lived experiences. Symbolic Interaction, 8, 223]240.2. Diener, E., & Suh, E.M. (2000). Culture and subjective well]being (pp. 185]218). Cambridge, MA: MIT Press. 3. Diener, E., Oishi, S., & Lucas, R. E. (2003). Personality, culture, and subjective well]being: Emotional and cognitive evaluations of life. Annual Review of Psychology, 2003, 54, 403]425. 4. Kahneman, D., Diener, E., & Schwarz, N. (Eds.). (1999). Well]being: The foundations of hedonic psychology. New York: Russell Sage Foundation. 5. Keyes, Corey L. M. & Haidt, Jonathan (Ed). (2003). Flourishing: Positive psychology and the life well]lived. Washington, DC, US: American Psychological Association.6. Kitayama, S., Markus, H.R. & Kurokawa, M. (2000). Culture, emotion, and wellbeing: Good feelings in Japan and the United States, Cognition and Emotion, 14, 93124. 7.Paranjpe, A.C. (1998). Self and identity in modern psychology and Indian thought. New York: Plenum Press.	PSYCHOLOGY OF WELLBEING
PSY774	3-0-0-0-4		**Course Contents:** In the last few years, research in psychology has witnessed a remarkable shiftto a post positivist paradigm. A large number of qualitative methods haveemerged in consonance with this shift. For a researcher in psychology. theknowledge of reseach methods and methodological issues is now incompletewithout an in depth understanding of the qualitative methods. This course isaimed at providing an extensive overview of qualitative research methods,methodological roots, major theoretical principles and issues in qualitativeresearch. Various methods would be discussed along with examples ofrepresentations cultural psychology developmental psychology discursive psychology,counseling and psychotherapy. **References/Text Books:**	QUALITATIVE RESEARCH : THEORY AND PRACTICE
PSY774A	3-0-0-0-9		**Course Contents:**	QUALITATIVE RESEARCH :

			In the last few years, research in psychology has witnessed a remarkable shiftto a post positivist paradigm. A large number of qualitative methods haveemerged in consonance with this shift. For a researcher in psychology. theknowledge of reseach methods and methodological issues is now incompletewithout an in depth understanding of the qualitative methods. This course isaimed at providing an extensive overview of qualitative research methods,methodological roots, major theoretical principles and issues in qualitativeresearch. Various methods would be discussed along with examples ofrepresentations cultural psychology developmental psychology discursive psychology,counseling and psychotherapy. **References/Text Books:**	THEORY AND PRACTICE
PSY775	3-0-0-0-4		**Course Contents:** Development and evolution of brain : Brain organization and function; Cerebralasymmetry; Neuropsychology of higher order functions memory language,emotional processes, spatial behaviour ; Applied human neuropsychology.Selected Readings:1. Barrett, L., Dunbar, R., & Lycett, J. (2002). Human evolutionary psychology,Palgrave Publishers Ltd.2. Kolb, B. & Whishaw, I.Q. (1990) Fundamentals of human neuropsychology,W.H. Freeman & Company.3. Mandal, M.K., BulmanFleming , M.B., & Tiwari, G.(2000). Side Bias: ANeuropsychological Perspective, Kluwer Academic Publishers. **References/Text Books:**	FUNDAMENTAL OF NEUROPSYCHOLOGY
PSY775A	3-0-0-0-9		**Course Contents:** Development and evolution of brain : Brain organization and function; Cerebralasymmetry; Neuropsychology of higher order functions memory language,emotional processes, spatial behaviour ; Applied human neuropsychology.Selected Readings:1. Barrett, L., Dunbar, R., & Lycett, J. (2002). Human evolutionary psychology,Palgrave Publishers Ltd.2. Kolb, B. & Whishaw, I.Q. (1990) Fundamentals of human neuropsychology,W.H. Freeman & Company.3. Mandal, M.K., BulmanFleming , M.B., & Tiwari, G.(2000). Side Bias: ANeuropsychological Perspective, Kluwer Academic Publishers. **References/Text Books:**	FUNDAMENTAL OF NEUROPSYCHOLOGY
PSY776	----4		**Course Contents:** Seminar Course in Psychology **References/Text Books:**	SEMINAR COURSE IN PSYCHOLOGY
PSY776A	3-0-0-0-9		**Course Contents:** Seminar Course in Psychology **References/Text Books:**	SEMINAR COURSE IN PSYCHOLOGY
PSY780	3-0-0--4	#	**Course Contents:** Introduction to the field of personality. Trait and situational approaches topersonality are covered, along with a critical assessment of the major theoriesof personality. **References/Text Books:**	PSYCHOLOGY OF PERSONALITY
PSY783	3-0-0--4	#	**Course Contents:** The course includes experimental paradigms in contemporary social psychologycovering areas such as attitude and attitude change, group processes, socialpower, reward allocation, prosocial behavior, social cognition, social influenceprocesses, aggression and violence; and the important theories in socialpsychology. **References/Text Books:**	ADVANCED EXPERIMENTAL SOCIAL PSYCHOLOGY

PSY784	3-0-0-0-4		**Course Contents:** This course will explain how social psycological theories can be applied to reallife. The prime objective is to disseminate findings from behavioural scienceresearch which have relevance for problems of society. **References/Text Books:**	APPLIED SOCIAL PSYCHOLOGY
PSY786	3-0-0-0-4		**Course Contents:** A coherent introduction to organizational psychology, historically takingoff from industrial psychology and human relations movement. The coursetakes a look at manin organizations in a social environment andconcentrates on the theoretically significant empirical research. **References/Text Books:**	UNDERSTANDING ORGANIZATIONAL BEHAVIOUR
PSY786A	3-0-0-0-9		**Course Contents:** A coherent introduction to organizational psychology, historically takingoff from industrial psychology and human relations movement. The coursetakes a look at manin organizations in a social environment andconcentrates on the theoretically significant empirical research. **References/Text Books:**	UNDERSTANDING ORGANIZATIONAL BEHAVIOUR
PSY787	3-0-0-0-4		**Course Contents:** The course focuses on a practical training to understand the human behaviour at workin order to predict the effectiveness and wellbeing in various types of organizations,and to enhance the understanding of change processes in these organizations. **References/Text Books:**	MANAGEMENT OF ORGANIZATIONAL BEHAVIOUR
PSY787A	3-0-0-0-9		**Course Contents:** The course focuses on a practical training to understand the human behaviour at workin order to predict the effectiveness and wellbeing in various types of organizations,and to enhance the understanding of change processes in these organizations. **References/Text Books:**	MANAGEMENT OF ORGANIZATIONAL BEHAVIOUR
PSY790	3-0-0--4	#	**Course Contents:** The course deals with scientific study of human mind and explores cognitiveprocesses involved in perception, memory, pattern recognition, psycholinguistics,and bilingualism. Recent research techniques, issues and stands in these areasare critically examined. **References/Text Books:**	HUMAN COGNITIVE PROCESSES
PSY790A	3-0-0-0-9		**Course Contents:** The course deals with scientific study of human mind and explores cognitive processes involved in perception, memory, pattern recognition, psycholinguistics, and bilingualism. Recent research techniques, issues and stands in these areas are critically examined. **References/Text Books:**	HUMAN COGNITIVE PROCESSES
PSY798	3-0-0-0-4		**Course Contents:** The course aims at providing an understanding of the concepts and issues insocial cognition research. The course contents include historical roots of socialcongnition; social congnitive principles a costbenefit analysis; representationof social knowledge; social schemas; heuristics and biases; contribution of socialrepresentations; rituals and rhetoric; knowledge and social process; socialcognition and the study of	ADVANCED COURSE IN SOCIAL COGNITION

			stereotyping, prejudice and discrimination, socialcognition and discourse; social sensibility and neural function. **References/Text Books:**	
PSY798A	3-0-0-0-9		**Course Contents:** The course aims at providing an understanding of the concepts and issues insocial cognition research. The course contents include historical roots of socialcongnition; social congnitive principles a costbenefit analysis; representationof social knowledge; social schemas; heuristics and biases; contribution of socialrepresentations; rituals and rhetoric; knowledge and social process; socialcognition and the study of stereotyping, prejudice and discrimination, socialcognition and discourse; social sensibility and neural function. **References/Text Books:**	ADVANCED COURSE IN SOCIAL COGNITION
PSY799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
SOC171	3-1-0--4		**Course Contents:** What is Sociology? Explain how the new science of societycame about in the nineteenth century inWestern Europe and how it wasdifferent from earlier social thought. Discuss the intellectual and socialconditions which gave rise tosociology. The Intellectual rootsPhilosophy ofhistory, political philosophy and theEnlightenment. The socioeconomic roots: the TwinRevolutions The Industrial Revolution The French RevolutionTheoretical thinking in sociology(A) Classical sociological theorists: Karl Marx Max Weber Emile Durkheim(B) Modern sociological theories 1 Functionalism and StructuralFunctionalism Conflict theory Symbolic InteractionismSociety, Community and Self 21ecturesNorms, values, roles, custom, statusDeviance Theories of subcultureThe concept of anomieSociology of Organizations Different sociological theories oforganization Formal and informal organizationsSocial Stratification and Inequality 41ectures Class Race and Ethnicity Gender Caste DisabilityPoverty Definition and measurement Extent of poverty Theories of povertyPower and Politics Debating basic concepts in politicalsociology Authoritarianism and democracySociology of Work and Economy Work, nonwork and leisure Taylorsim, Fordism and PostFordism Sociology of Religion Sociological theories of religion Religious organizations Secularization debates **References/Text Books:**	INTRODUCTORY SOCIOLOGY
SOC171A	3-1-0-0-11		**Course Contents:** What is Sociology? Explain how the new science of societycame about in the nineteenth century inWestern Europe and how it wasdifferent from earlier social thought. Discuss the intellectual and socialconditions which gave rise tosociology. The Intellectual rootsPhilosophy ofhistory, political philosophy and theEnlightenment. The socioeconomic roots: the TwinRevolutions The Industrial Revolution The French RevolutionTheoretical thinking in sociology(A) Classical sociological theorists: Karl Marx Max Weber Emile Durkheim(B) Modern sociological theories 1 Functionalism and StructuralFunctionalism Conflict theory Symbolic InteractionismSociety, Community and Self 21ecturesNorms, values, roles, custom, statusDeviance Theories of subcultureThe concept of anomieSociology of Organizations Different sociological theories oforganization Formal and informal organizationsSocial Stratification and Inequality 41ectures Class Race and Ethnicity Gender Caste DisabilityPoverty Definition and measurement Extent of poverty Theories of povertyPower and Politics Debating basic concepts in politicalsociology Authoritarianism and democracySociology of Work and Economy Work, nonwork and leisure Taylorsim, Fordism and PostFordism Sociology of Religion Sociological theories of religion Religious organizations	INTRODUCTORY SOCIOLOGY

			Secularization debates **References/Text Books:**	
SOC171B	3-1-0-0-11		**Course Contents:** What is Sociology? Explain how the new science of societycame about in the nineteenth century inWestern Europe and how it wasdifferent from earlier social thought. Discuss the intellectual and socialconditions which gave rise tosociology. The Intellectual rootsPhilosophy ofhistory, political philosophy and theEnlightenment. The socioeconomic roots: the TwinRevolutions The Industrial Revolution The French RevolutionTheoretical thinking in sociology(A) Classical sociological theorists: Karl Marx Max Weber Emile Durkheim(B) Modern sociological theories 1 Functionalism and StructuralFunctionalism Conflict theory Symbolic InteractionismSociety, Community and Self 21ecturesNorms, values, roles, custom, statusDeviance Theories of subcultureThe concept of anomieSociology of Organizations Different sociological theories oforganization Formal and informal organizationsSocial Stratification and Inequality 41ectures Class Race and Ethnicity Gender Caste DisabilityPoverty Definition and measurement Extent of poverty Theories of povertyPower and Politics Debating basic concepts in politicalsociology Authoritarianism and democracySociology of Work and Economy Work, nonwork and leisure Taylorsim, Fordism and PostFordism Sociology of Religion Sociological theories of religion Religious organizations Secularization debates **References/Text Books:**	INTRODUCTORY SOCIOLOGY
SOC173	3-1-0--11		**Course Contents:** Indian Sociology: An Introduction, Social Roots of Indian Society:Vedic heritage,Brahminic, Islamic, British, Indian Social Structure:Rural Context, Urban Context,Indian Social Institutions and OrganisationsFamily, Marriage, Jajmani Relation,Caste and Tribe, Religion and education, Social Movements in India:Reformist,Nationalist, Agrarian, Backward Caste, Processes of Social Change in India,Westernization, Sanskritisation, Contemporary Social Problems. Secularism,Common civil code, Reservation policy, Demographic transition, etc. **References/Text Books:**	INTRODUCTION TO INDIAN SOCIETY
SOC173A	3-1-0-0-11		**Course Contents:** The question of identificationPostive Discrimination:Features, Legal provisionsFamily and Kinship:Family as a functional unit; Types of family; Kinship usaqeHindu marriage:Aims, Age, Preference and restrictions; Polyandry; Polygyny;Sati; Widow remarriage, DowryMarriage among Muslims:Historical background ; Types of marriage; Mahr; Divorce;RecentchanqesMarriage among Christians:Historical background and chanqesReligious Traditions:Hinduism, Buddhism, Jainism, Sikhism, IslamSecularism; Reliqious violenceSocial Movements:Revivalist, Reformist, Peasant, Trade Union movements **References/Text Books:**	INTRODUCTION TO INDIAN SOCIETY
SOC470	3-1-0--4		**Course Contents:** Objectives of the course is to portray the process of development and underdevelopment from asociological perspective. Being essentially a theory based course, it would analyse the process ofdevelopment from various theoretical perspectives that have been dominant at different periods oftime in intellectual traditions of sociology.1 Defining the concept of Development: Sociocultural factors, 2 The modernization perspective of development (the Structural Functional view): Its intellectual heritage classical modernisationstudies (Sociological aspects, political aspects, economic aspects,Psychological aspects), its assumptions, its methodology and itslimitations,3 The Modernisation perspective: New modernization studies. 4 The Dependence perspective of development (the NeeMarxist view): Its intellectual heritage, the classical dependence studies (theories ofunderdevelopment), Dependence perspective: Its assumptions, itsmethodology and its limitations.5 The Dependence Perspective of development: New dependence studies.6	SOCIOLOGY OF DEVELOPMENT

			The World System Perspective: Its intellectual heritage, Contributions of Immanuel Wallerstein, the theory of world capitalist system, itsassumptions, its methodology and its limitations.7 World system studies at Global level, Powers of world system perspective.8 Global System Interdependence, New Structural analysis, agent centered analyses, a newsubstantive focusDynamics of complexchange.9 Globalization (neo Liberalism), Development reconsideredvoices of Dissent and alternatives. **References/Text Books:** * Alvin Y So, 2005, Social Change and Development,, Sage publications, Thousand Oaks* P W Preston, 2001, Development Theory and Introduction, Blackwell Publishers.* David Lehmann, 1989, Development Theory, Frank Cass.* Eisenstadt 5 N, 1979, Modernization Protest and Change, Prentice Hall, EEE.	
SOC470A	3-0-0-0-9		**Course Contents:** Objectives of the course is to portray the process of development and underdevelopment from asociological perspective. Being essentially a theory based course, it would analyse the process ofdevelopment from various theoretical perspectives that have been dominant at different periods oftime in intellectual traditions of sociology.1 Defining the concept of Development: Sociocultural factors, 2 The modernization perspective of development (the Structural Functional view): Its intellectual heritage classical modernisationstudies (Sociological aspects, political aspects, economic aspects,Psychological aspects), its assumptions, its methodology and itslimitations,3 The Modernisation perspective: New modernization studies. 4 The Dependence perspective of development (the NeeMarxist view): Its intellectual heritage, the classical dependence studies (theories ofunderdevelopment), Dependence perspective: Its assumptions, itsmethodology and its limitations.5 The Dependence Perspective of development: New dependence studies.6 The World System Perspective: Its intellectual heritage, Contributions of Immanuel Wallerstein, the theory of world capitalist system, itsassumptions, its methodology and its limitations.7 World system studies at Global level, Powers of world system perspective.8 Global System Interdependence, New Structural analysis, agent centered analyses, a newsubstantive focusDynamics of complexchange.9 Globalization (neo Liberalism), Development reconsideredvoices of Dissent and alternatives. **References/Text Books:** * Alvin Y So, 2005, Social Change and Development,, Sage publications, Thousand Oaks* P W Preston, 2001, Development Theory and Introduction, Blackwell Publishers.* David Lehmann, 1989, Development Theory, Frank Cass.* Eisenstadt 5 N, 1979, Modernization Protest and Change, Prentice Hall, EEE.	SOCIOLOGY OF DEVELOPMENT
SOC473	3-1-0--4		**Course Contents:** Approaches to study Indian Society. Social stratification: caste, jati and varna among Hindus, nonHindus. Marriage and Family among Hindus, Muslims and Christians; polyandry and polygyny; regulations of marriage, separation and divorce. Kinship organization in India. Concepts and approaches to social change in India: Sanskritization and Westernization; parochialization and universalization; structural, dialectical, cognitive historical,and indological approaches. Ortilogenelic processes of cultural change in culture traditions and modernization. Heterogenetic processes of cultural change in culture traditions and modernization. Recent processes of change: peasant religious and sectarian movements; dalit and backward caste movements; tribal, labour movements. New Social Movement: Ecological Movement **References/Text Books:** Dumont, Louis. Homo Hierarchius: The Caste System and its ImplicationsLondon: Weidenfeld and Nicholson, 1970.Ghurye, G. S. Caste and Race in India. Mumbai: Popular Prakashan, 1969, 5thedition.Gupta, Dipankar, editor. Social Stratification. New Delhi: Oxford University Press,1991.Kapadia, K. M. Marriage and Family in India. Calcutta: Oxford University Press,1966.Rao, M. S. A. Social Movements and Social Transformation: A Study of TwoBackward Classes Movements in India. New Delhi: Macmillan, 1979.Shah, Ghanshyam. Social Movements in India: A Review of the Literature. NewDelhi: Sage, 1990.Singh, Yogendra. Modernization of Indian Tradition. Jaipur: Rawat Publications,1986 (reprint).Srinivas, M. N. Social Change in Modern India. New Delhi: Orient Longman,1995 (reprint 2002).	INDIAN SOCIETY AND CULTURE

SOC473A	3-0-0-0-9		**Course Contents:** Approaches to study Indian Society. Social stratification: caste, jati and varna among Hindus, nonHindus. Marriage and Family among Hindus, Muslims and Christians; polyandry and polygyny; regulations of marriage, separation and divorce. Kinship organization in India. Concepts and approaches to social change in India: Sanskritization and Westernization; parochialization and universalization; structural, dialectical, cognitive historical,and indological approaches. Ortilogenelic processes of cultural change in culture traditions and modernization. Heterogenetic processes of cultural change in culture traditions and modernization. Recent processes of change: peasant religious and sectarian movements; dalit and backward caste movements; tribal, labour movements. New Social Movement: Ecological Movement **References/Text Books:** Dumont, Louis. Homo Hierarchius: The Caste System and its Weidenfeld and Nicholson, 1970.Ghurye, G. S. Caste and Race in India. Mumbai: Popular Prakashan, 1969, 5thedition.Gupta, Dipankar, editor. Social Stratification. New Delhi: Oxford University Press,1991.Kapadia, K. M. Marriage and Family in India. Calcutta: Oxford University Press,1966.Rao, M. S. A. Social Movements and Social Transformation: A Study of TwoBackward Classes Movements in India. New Delhi: Macmillan, 1979.Shah, Ghanshyam. Social Movements in India: A Review of the Literature. NewDelhi: Sage, 1990.Singh, Yogendra. Modernization of Indian Tradition. Jaipur: Rawat Publications,1986 (reprint).Srinivas, M. N. Social Change in Modern India. New Delhi: Orient Longman,1995 (reprint 2002).	INDIAN SOCIETY AND CULTURE
SOC474	3-1-0--4		**Course Contents:** 01 Industrial Sociology nature and scope, Evolution of Industry as a productive system,02 Formal organization: Bureaucracy and its functions, 03 Roles of Executives in bureaucratic organizations, Functions of Executives,04 Informal Organizations: importance of human relations at work, Patterns of communications in Informal organizations, Importanceof informal organizations, Group dynamics,OS Industrial Relations: Trifold role: management (Employers Associations/ Federations), labour (national/ Internationalorganizations) and government (Labour legislations/ labour courtsand adjudications) global experiences.06 Role of labour and work in industry, Labour problems, Social structure of Trade unions, Trade Unionism (in India) and labourpolicies in India (through five year plans),07 Industrial conflicts, and conflict resolution mechanisms: Collective bargaining and Grievance procedures, and Changing nature ofoccupations, Embourgeoisement, unionism vrs. professionalism08 Participatory Management Issues (Indian as well as Global experiences), **References/Text Books:** 1. Monappa Arun,2006, Industrial Relations, Tata McGrawhill publishing Co.(Reprint)2. Stephen Edgell, 2006, The Sociology of work, Sage publications.3. Schnieder E V, 1972, Industrial Sociology, The social relations of Industry and the community,Tata McGrawhill Publishing co.4. Shils Edward, 1963, Automation and Industrial relations, Holt Rinehart and Winston5. lvar E Berg, 1981, Sociological Perspectives on La pour markets, Academic Press.6. Forsyth, D.R. 2010. Group Dynamics, 5th Edition. Belmont, CA: Thomson Wadsworth.7. Watson Tony J, 2004, Sociology, Work and Industry, New York: Routledge reprint.8. Miller DC and W H Form,1968, Industrial Sociology, London: Harper & Row,9. Parker Stanley Robert, 1981,The Sociology of Industry, Allen and Unwin	INDUSTRIAL SOCIOLOGY
SOC477	3-1-0--4		**Course Contents:** From rural to urban: debates around the concepts of gemeinschaftand gesellschaft; Origin of city in history; Theories of urban sociology (Classical andContemporary); Technology and urban life; Poetics and politics of urban spaces;Urban planning and design; Rural, urban, 'rururban' and suburban: the future ofurban sociology. **References/Text Books:** Rao, M. S. A., ed. (1974) Urban Sociology in India: Reader and Source Book. NewDelhi: Orient Longman.Gottdiener, Mark and Ray Hutchison (2006) The New Urban Sociology. Boulder: WestView Press.Gottdiener, Mark and Leslie Budd (2005) Key Concepts in Urban Studies. London: SagePublications.Karp David eta! (1977) Being Urban: A Sociology of City Life. Lexington, Mass: D.	URBAN HABITAT AND SOCIAL INTERACTION

			C.Heatb and Company.Lin Jan and Mele Christopher, ed. (2005) The Urban Sociology Reader. London:Routledge.Palen, J. John. (2008) The Urban World. Boulder: Paradigm Publishers.David Pinder. (2005) Visions of the City; Utopianism, Power and Politics in TwentiethCenturyUrbanism. New York: Routledge.	
SOC477A	3-0-0-0-9		**Course Contents:** From rural to urban: debates around the concepts of gemeinschaftand gesellschaft; Origin of city in history; Theories of urban sociology (Classical andContemporary); Technology and urban life; Poetics and politics of urban spaces;Urban planning and design; Rural, urban, 'rururban' and suburban: the future ofurban sociology. **References/Text Books:** Course Reference : Rao, M. S. A., ed. (1974) Urban Sociology in India: Reader and Source Book. NewDelhi: Orient Longman.Gottdiener, Mark and Ray Hutchison (2006) The New Urban Sociology. Boulder: WestView Press.Gottdiener, Mark and Leslie Budd (2005) Key Concepts in Urban Studies. London: SagePublications.Karp David eta! (1977) Being Urban: A Sociology of City Life. Lexington, Mass: D. C.Heatb and Company.Lin Jan and Mele Christopher, ed. (2005) The Urban Sociology Reader. London:Routledge.Palen, J. John. (2008) The Urban World. Boulder: Paradigm Publishers.David Pinder. (2005) Visions of the City; Utopianism, Power and Politics in TwentiethCenturyUrbanism. New York: Routledge.	URBAN HABITAT AND SOCIAL INTERACTION
SOC479	3-0-0--4		**Course Contents:** Relationship between demographic trends and the socioeconomic context;Demography and population studies; World population growth; Population of India; Populationtheories; Data and methods in population studies; Population policies; Population policy in India;HIV I AIDS and reproductive health. **References/Text Books:** Davis, Kingsley (1968) The Population of India and Pakistan. New York: Russell and Russell.Sharma, A. K. (2011) Population and Society. New Delhi: Concept Publishing Company Pvt.Ltd.Shryock, Hemy S., Siegel, JacobS., and associates (1971) The Methods and Materials ofDemography. New York: U.S. Bureau of Census.Smith David, and Keyfitz, Nathan (1977) Mathematical Demography. Berlin: SpringerVerlag.Smith, David P. (1992) Formal Demography. New York: Plenum Press.Sorokin, Pitirim (1978) Contemporary Sociological Theories. Ludhiana: Kalyani Publishers.United Nations (1973) The Determinants and Consequences of Population Trends. Vol. 1 NewYork: United Nations.United Nations (1974) Methods of Projections of Urban and Rural Population. New York:United Nations.United Nations (1983) Indirect Techniques for Demographic Estimation. New York: UnitedNations.	POPULATION, ECONOMY AND SOCIETY
SOC479A	3-0-0-0-9		**Course Contents:** Relationship between demographic trends and the socioeconomic context;Demography and population studies; World population growth; Population of India; Populationtheories; Data and methods in population studies; Population policies; Population policy in India;HIV I AIDS and reproductive health. **References/Text Books:** Course Reference : Davis, Kingsley (1968) The Population of India and Pakistan. New York: Russell and Russell.Sharma, A. K. (2011) Population and Society. New Delhi: Concept Publishing Company Pvt.Ltd.Shryock, Hemy S., Siegel, JacobS., and associates (1971) The Methods and Materials ofDemography. New York: U.S. Bureau of Census.Smith David, and Keyfitz, Nathan (1977) Mathematical Demography. Berlin: SpringerVerlag.Smith, David P. (1992) Formal Demography. New York: Plenum Press.Sorokin, Pitirim (1978) Contemporary Sociological Theories. Ludhiana: Kalyani Publishers.United Nations (1973) The Determinants and Consequences of Population Trends. Vol. 1 NewYork: United Nations.United Nations (1974) Methods of Projections of Urban and Rural Population. New York:United Nations.United Nations (1983) Indirect Techniques for Demographic Estimation. New York: UnitedNations.	POPULATION, ECONOMY AND SOCIETY
SOC481	3-0-0-0-4		**Course Contents:**	SOCIETY AND SOCIAL

			Sociological perspectives on social problems; Social change; Interactionbetween structural and cultural components in the process of social change; Major socialproblems of India such as social and economic inequality, unemployment, illiteracy, high dropoutrate in schools, gender gap, population problem, bad governance, communalism andterrorism; The concept of inclusive growth . **References/Text Books:** Beteille, Andre (2000) Antinomies of Society: Essays on Ideologies & Institutions. New Delhi:Oxford University Press.Dumont, Louis (1970) Homo Hierachicus. London: Paladin, Granada Publishing Ltd.English, Richard (2009) Terrorism: How to Respond Oxford: Oxford University Press.Planning Commssion (2008) Eleventh Five Year Plan, 200712. New Delhi: Oxford UniversityPress.Srinivas, M.N. (1966) Social Change in Modern India. Berkeley: California University Press.	PROBLEMS OF INDIA
SOC481A	3-0-0-0-9		**Course Contents:** Sociological perspectives on social problems; Social change; Interactionbetween structural and cultural components in the process of social change; Major socialproblems of India such as social and economic inequality, unemployment, illiteracy, high dropoutrate in schools, gender gap, population problem, bad governance, communalism andterrorism; The concept of inclusive growth . **References/Text Books:** Beteille, Andre (2000) Antinomies of Society: Essays on Ideologies & Institutions. New Delhi:Oxford University Press.Dumont, Louis (1970) Homo Hierachicus. London: Paladin, Granada Publishing Ltd.English, Richard (2009) Terrorism: How to Respond Oxford: Oxford University Press.Planning Commssion (2008) Eleventh Five Year Plan, 200712. New Delhi: Oxford UniversityPress.Srinivas, M.N. (1966) Social Change in Modern India. Berkeley: California University Press.	SOCIETY AND SOCIAL PROBLEMS OF INDIA
SOC482A	3-0-0-0-9		**Course Contents:** Defining Globalization : a. Flows and Structures, b. Key Debates, c. Related Processes. SocioEconomic Aspects of Globalization : a. Neoliberalism, b. Global Economic Structuresc. c. Global Economic Flows. Globalization and political structures and processes : Culture and Globalization. Hightech flows and structures. Flows of people. Environmental Flows. Globalization and Social Stratification : a. UrbanRural, b. Gender and Sexuality, c. Class, d. Race, Ethnicity and Caste. **References/Text Books:** Ritzer, George. 2010. Globalization: A Basic Text. Chichester: Wiley Blackwell.Ritzer, George and Zeynep Atalay, eds. 2010. Readings in Globalization: KeyConcepts and Major Debates. Chichester: Wiley Blackwell. Additional Readings:Journal articles and book excerpts may be assigned periodically to the students.These readings will be assigned to students well in advance.	SOCIOLOGY OF GLOBALIZATION
SOC486	3-1-0--4		**Course Contents:** 1 Introduction: Magna Carta, English Bill of Rights, American/French Declaration, Universal Declaration ofHuman Rights: Background, Content and Relevance2 Theories/Justification/ Perspectives on Human Rights: Natural, Moral and Legal; Natural rights, Positivist,Liberal, Marxist, Feminist, Asian perspectives3 Debates: Universality of Rights; Rights Vs Duties; Individual Vs Group Rights; Civil and Political Rights Vssocial, Economic and cultural rights4 The notion of rights in various religious traditions (Hindu, Muslim, Buddhist traditions)5 Western Influence (especially the impact of the British rule); National Freedom Movement, and the roles ofGandhi, Ambedkar and Nehru)6 Intergovernmental Organization: The United Nations (study of specific UN agencies related to human rights);Regional Instruments7 International NGO Amnesty International its working and impact on India 8 Constitutional Developments in India: Constitutional Provisions (especially Fundamental Rights Vs DirectivePrinciples of State_Policy) and Emergency 9 Case Studies of Selected National NGOs10 Case Studies of Selected Regional NGOs 11 National Human Rights Commission of India:Background, Structure and Functioning .12 The Judiciary, including Public Interest Litigation13 International Humanitarian Law; International Refugee Law14 Some Issues in Human Rights: Violence and Terrorism; Women's Rights, Child Rights, Dalit Rights,Minority	HUMAN RIGHTS THEORY AND PRACTICE

			Rights, Tribal Rights, Capital Punishment,Euthanasia, Rights of the Elderl)l, Gay Rights **References/Text Books:** Basu, D. D. Introduction to the Constitution of India. New Delhi: Prentice Hall,2008, 18th edition.Desai, A. R., editor. Violation of Democratic Rights in India, 3 volumes.Mumbai: Popular Prakashan, 19861991.Donnelly Jack. Universal Human Rights in Theory and Practice. Ithaca:Cornell University Press, 2003.FakudaParr, Sakiko and A. K. Shiva Kumar, editors. Readings in HumanDevelopment: Concepts, Measures and Policies for a DevelopmentParadigm. New Delhi: Oxford University Press, 2003.Mohanty, Manoranjan, Partha Nath Mukherji, with Olle Tornquist, editors.People's Rights: Social Movements and the State in the Third World.New Delhi: Sage Publications, 1998.Nanda, Ved P., James R. Scarritt and George W Shepherd, Jr., editors.Global Human Rights: Public Policies, Comparative Measures andNGO Strategies. Boulder: Westview Press Inc., 1981.	
SOC486A	3-0-0-0-9		**Course Contents:** 1 Introduction: Magna Carta, English Bill of Rights, American/French Declaration, Universal Declaration ofHuman Rights: Background, Content and Relevance2 Theories/Justification/ Perspectives on Human Rights: Natural, Moral and Legal; Natural rights, Positivist,Liberal, Marxist, Feminist, Asian perspectives3 Debates: Universality of Rights; Rights Vs Duties; Individual Vs Group Rights; Civil and Political Rights Vssocial, Economic and cultural rights4 The notion of rights in various religious traditions (Hindu, Muslim, Buddhist traditions)5 Western Influence (especially the impact of the British rule); National Freedom Movement, and the roles ofGandhi, Ambedkar and Nehru)6 Intergovernmental Organization: The United Nations (study of specific UN agencies related to human rights);Regional Instruments7 International NGO Amnesty International its working and impact on India 8 Constitutional Developments in India: Constitutional Provisions (especially Fundamental Rights Vs DirectivePrinciples of State_Policy) and Emergency 9 Case Studies of Selected National NGOs10 Case Studies of Selected Regional NGOs 11 National Human Rights Commission of India:Background, Structure and Functioning .12 The Judiciary, including Public Interest Litigation13 International Humanitarian Law; International Refugee Law14 Some Issues in Human Rights: Violence and Terrorism; Women's Rights, Child Rights, Dalit Rights,Minority Rights, Tribal Rights, Capital Punishment,Euthanasia, Rights of the Elderl)l, Gay Rights **References/Text Books:** Basu, D. D. Introduction to the Constitution of India. New Delhi: Prentice Hall,2008, 18th edition.Desai, A. R., editor. Violation of Democratic Rights in India, 3 volumes.Mumbai: Popular Prakashan, 19861991.Donnelly Jack. Universal Human Rights in Theory and Practice. Ithaca:Cornell University Press, 2003.FakudaParr, Sakiko and A. K. Shiva Kumar, editors. Readings in HumanDevelopment: Concepts, Measures and Policies for a DevelopmentParadigm. New Delhi: Oxford University Press, 2003.Mohanty, Manoranjan, Partha Nath Mukherji, with Olle Tornquist, editors.People's Rights: Social Movements and the State in the Third World.New Delhi: Sage Publications, 1998.Nanda, Ved P., James R. Scarritt and George W Shepherd, Jr., editors.Global Human Rights: Public Policies, Comparative Measures andNGO Strategies. Boulder: Westview Press Inc., 1981.	HUMAN RIGHTS THEORY AND PRACTICE
SOC489	3-1-0-0-4		**Course Contents:** I. The problem Twin goals: happiness and just order; role of value education 2. Paradoxes of happiness Concepts of good life quality of life and subjective wellbeing; happiness, life satisfaction, and positiveaffect; studying quality of life through surveys; andfindings of quality of life surveys.3. The problem of social Moral and institutional approaches; and the inherent conflict transformation between tbe two4. Conceptualizing tbe Man and society; theories of man and society such as relationship between methodological individualism, structuralism, Gidden's theoryman and society of structuration, and structural symbolic interactionism5. Religious and spiritual Vedic, Jain and Buddhist philosophies; Christianity; Islam; approaches to human and Sikhismhappiness6. Economic and utilitarian Utilitarianism; utility and economic theory; capitalism: claims theories of capitalism; internal contradictions; socialism andcommunism; disorganized capitalism; risk7. Political approaches Marxist and neoMarxist thoughts; critical theory; democracy in public and private spheres; manifestos of leading politicaloarties8. An argument for Nehruvian model of industrial socialism;	EXPLORING HUMAN VALUES: VISIONS OF HAPPINESS AND PERFECT SOCIETY

			inclusive growth modernization anddevelopment9. Postmodernization and Modernization and postmodernization; emancipation; emancipation emancipatory practices; dilemmas and paradoxes10. Possibilities of Hope and hopelessness; transforming society; professional transformation ethicsII. Indian social thoughts Attempts to combine spiritual, economic and political theories of values: Rammohan Roy, Aurobindo, Tagore, Gandhi,Ambedkar, Coomarswamv12. Human values and Jeevan Vidya; human values, "I" and "Body" need for humanism: dilemmas harmony in the self; harmony with the body; harmony inand directions family, society, nature and existence; evaluation ofJeevan Vidya.13. Conclusion Summary and conclusion of the course **References/Text Books:** Agrawal, S.P., and J.C. Aggarwal, Educational and Social Uplift of Backward Classes: At WhatCost and How? Manda! Commission and After, New Delhi: Concept Publishing Company,1991.Ahmed, Hila!, "Debating Muslim Political Representation," http://www.indiaseminar.com/2008/586/586 _hila!_ aluned.htm [accessed on 5 October 2009].Ambedkar, B. R., Buddha and his Dhamma, http://www.scribd.com/doc/16634512/BuddhaandHisDhanunabyBRAmbedkarFull [accessed on 21 October, 2010].Beck, Ulrich, Risk Society: Towards a New Modernity, tr. by Ritter, Mark, London: SagePublications, 1992.Beteille, Andre, "Beyond Minority Reports", The Times of India, 12 October, 2009, p. 10.Beteille, Andre, Antinomies of Society: Essays on Ideologies & Institutions. New Delhi: OxfordUniversity Press, 2000.	
SOC720	3-0-0--4		**Course Contents:** Nature and types of scientific explanation, Values and objectivity in social scienceresearch, Various research designs: (i) Descriptive, (ii) Exploratory, (ii)Experimental (two and multigroup designs). Tools and techniques of datacollection, both direct and indirect methods of data collection (projectivetechniques), Various scaling techniques (Differential scales, Summated scalesand Cumulative scales, etc), problems of measurement, Various types ofreliability and validity of measures, Qualitative research. **References/Text Books:**	RESEARCH METHODS
SOC720A	3-0-0-0-9		**Course Contents:** Nature and types of scientific explanation, Values and objectivity in social science research, Various research designs: (i) Descriptive, (ii) Exploratory, (ii) Experimental (two and multigroup designs). Tools and techniques of data collection, both direct and indirect methods of data collection (projective techniques), Various scaling techniques (Differential scales, Summated scales and Cumulative scales, etc), problems of measurement, Various types of reliability and validity of measures, Qualitative research. **References/Text Books:**	RESEARCH METHODS
SOC721	3-0-0--4		**Course Contents:** Relation between theory and research. The nature and use of theory, basic concepts, fundamental perspectives of society, conceptualization of social system social structure and culture, Various perspectives; Structural Functional, conflict Theory Frankfurt school critical theory, Exchange theory, Symbolic Interactionism, Phenomenology, Ethnomethodology & Structuration theory. **References/Text Books:**	SOCIOLOGICAL THEORY
SOC721A	3-0-0-0-9		**Course Contents:** Relation between theory and research. The nature and use of theory, basic concepts, fundamental perspective of society, conceptualization of social system, social structure and culture, Various perspectives; Structural Functional, conflict Theory Frankfurt school critical theory, Exchange theory, Symbolic Interactionism, Phenomenology, Ethnomethodology & Structuration theory. **References/Text Books:**	SOCIOLOGICAL THEORY

SOC723	3-0-0--4	#	**Course Contents:** Basic statistics; correlation and regression analysis; probability and probabilitydistributions; sampling designs; tests of significance; analysis of variance; nonparametric methods; recent developments in applied statistics in social sciences. **References/Text Books:**	INTRODUCTION TO STATISTICAL INFERENCE
SOC732	3-0-0--4	#	**Course Contents:** Sociological perspective on development problems with special reference to India,theories/models of development, Modernization Theory (New modernization studies) Dependence Theory (New dependence studies), World System Theory, Global system Interdependence, Globalization, UNDP definition of Developmentindicators. The sustainable nature of Development, Development reconsideredvoices of Dissent. **References/Text Books:**	SOCIOLOGY OF DEVELOPMENT
SOC734	3-0-0--4		**Course Contents:** Critical evaluation of concepts and theories of social inequality and stratification;aspects of inequality in contemporary societies; methodology of stratification;stratification in India. **References/Text Books:**	SOCIAL INEQUALITY AND STRATIFICATION
SOC742A	3-0-0-0-9		**Course Contents:** The new environmental paradigm in sociology. The relationship between environment and 'social complex'. Environmentalism and Development (issue of socioeconomic equities). The concept of sustainable development in environmental studies. Social response to environmentalimperatives (Role of value structure, normative and attitudinal patterns in communities). Social Institutions in the context of environmentalis, e.g. Roligion, caste, tribe, local communities and voluntary associations. Environmental movements and their impacts. **References/Text Books:**	SOCIOLOGY OF ENVIRONMENT
SOC745	3-0-0-0-4		**Course Contents:** Canons in sociological theory, breaking with modernity, post positivist and poststructural social thought, post modernism in social theory: present images andfuture possibilities, Writings of J Baudrillard, Michel Foucault, J F Lyotard, JDerrida, and F Jameson. **References/Text Books:**	SOCIAL THEORY IN LATE TWENTIETH CENTURY
SOC745A	3-0-0-0-9		**Course Contents:** Canons in sociological theory, breaking with modernity, post positivist and poststructural social thought, post modernism in social theory: present images andfuture possibilities, Writings of J Baudrillard, Michel Foucault, J F Lyotard, JDerrida, and F Jameson. **References/Text Books:**	SOCIAL THEORY IN LATE TWENTIETH CENTURY
SOC746	3-0-0--4		**Course Contents:** The aim of the course is to define the various types of social movements,and understand their role in striving for social change or transformation. Itwill examine theories of social movements in the context of recent debatessurrounding issues of nationalism, ethnicity, and identity. Specific movements,including the role of various actors, will be studied with special reference toIndia. **References/Text Books:**	SOCIAL MOVEMENTS : OLD AND NEW

SOC746A	3-0-0-0-9		**Course Contents:** The aim of the course is to define the various types of social movements,and understand their role in striving for social change or transformation. Itwill examine theories of social movements in the context of recent debatessurrounding issues of nationalism, ethnicity, and identity. Specific movements,including the role of various actors, will be studied with special reference toIndia. **References/Text Books:**	SOCIAL MOVEMENTS : OLD AND NEW
SOC748	----4		**Course Contents:** General introduction to the place of learning in society. Learning, educationand training. Changing meanings of education across time and society. A briefhistorical perspective on education in India. Socialpolitical arithmetic as aspurious way of understanding education and social change. Structural functionalistperspectives and structuralconflict perspectives on education. Class, conflict,legitimation processes, reproduction of society. Anarchist perspectives. NewSociology of Education. Symbolic interactionist perspectives on education.Resistances to schooling. Critical theory and education. NeoWeberian perspectiveson education. Status politics and education. Caste, class, gender andeducation in India. Indian thinkers on education. Current debates on the placeof education in India. **References/Text Books:**	EDUCATION AND SOCIAL CHANGE
SOC749	3-0-0-0-4		**Course Contents:** Theories of risk society, structuration, disorganized capitalism, social and cultural capital, standpoint theory, postmodernism, and complexity theory. Major contributions of Ulrich Beck, Anthony Giddens, Scott Lash, John Urry, Dorothy Smith, Pierre Bourdieu, Zygmunt Bauman, Michel Foucault and Jean Baudrillard. **References/Text Books:**	CONTEMPORARY SOCIAL THEORY
SOC750	3-0-0-0-4		**Course Contents:** Committed to the binary opposition between Reason and religion the evolutionarytheorists believed that religion signified the childhood of human race. TheEnlightenment theories had professed the decline and subsequent disappearance ofreligion. But the events since the secondhalf of the twentieth century have provedthis prediction to be wrong. The resurgence of the religious in contemporary timescalls for a fresh appraisal of the theories of sociology of religion. The coursewill introduce the seminal theories in sociology of religion. It will explore therelation between religion and other areas of social life such as economy and polity.The diachronic processes within religion, i.e., movements, sect formation,institutional forms as well as organizational dynamics will be addressed in thiscourse. Finally, the course will also explore the issues of secularization and civilreligion. **References/Text Books:**	SOCIOLOGY OF RELIGION
SOC751	3-0-0-0-4		**Course Contents:** Relation between theory and method and the concept of paradigmQuantitative Research Methods: Experimental design and surveys; different types of experimental designs; longitudinal studies; sampling techniques. Qualitative Research Methods: Ethnography, casestudies, historical and documentary research. Major data sources and their use in the historical and documentary study of Indian society and culture: Census, Archival material, National Sample Survey, Gazetteers and District Handbooks and other large data sets **References/Text Books:** Brewer, Jonhn and Albert Hunter. Multimethod Research, Sage, 1989.Clifford, James and G. Marcus, Writing Cultures: Poetics and Politics of Ethnography, University of California Press, 1986. Cochran, William. G. Sampling Techniques, Wiley, 1999.Durkheim, Emile. Suicide: Study in Sociology. Free Press, 1968. (Book Two. pp. 145294)Epstein, A. L. (ed) The Craft of Social Anthropology, Tavistock, 1967. Flick,	METHODS OF SOCIOLOGICAL RESEARCH

			Uwe. An Introduction to Qualitative Research, Sage, 2002.Geertz, C. The Interpretation of Cultures. Basic Books, 1963. (Chapter 15).Hammersley, Martyn. The Dilemma of Qualitative Method, Routledge, 1989.Kanji, Gopal K. Statistical Tests, Sage,1993. LeviStrauss, C. Structural Anthropology. Basic Books 1963. (Part 1 pp. 3791)Luckacs, George. History and Class Consciousness. Merlin Press, 1971. (Chapter 1)Margolis, Eric (ed), The Sage Handbook of Visual Research, Sage, 2011.	
SOC751A	3-0-0-0-9		**Course Contents:** Relation between theory and method and the concept of paradigmQuantitative Research Methods: Experimental design and surveys; different types of experimental designs; longitudinal studies; sampling techniques. Qualitative Research Methods: Ethnography, casestudies, historical and documentary research. Major data sources and their use in the historical and documentary study of Indian society and culture: Census, Archival material, National Sample Survey, Gazetteers and District Handbooks and other large data sets. **References/Text Books:** Brewer, Jonhn and Albert Hunter. Multimethod Research, Sage, 1989.Clifford, James and G. Marcus, Writing Cultures: Poetics and Politics of Ethnography, University of California Press, 1986. Cochran, William. G. Sampling Techniques, Wiley, 1999.Durkheim, Emile. Suicide: Study in Sociology. Free Press, 1968. (Book Two. pp. 145294)Epstein, A. L. (ed) The Craft of Social Anthropology, Tavistock, 1967. Flick, Uwe. An Introduction to Qualitative Research, Sage, 2002.Geertz, C. The Interpretation of Cultures. Basic Books, 1963. (Chapter 15).Hammersley, Martyn. The Dilemma of Qualitative Method, Routledge, 1989.Kanji, Gopal K. Statistical Tests, Sage,1993. LeviStrauss, C. Structural Anthropology. Basic Books 1963. (Part 1 pp. 3791)Luckacs, George. History and Class Consciousness. Merlin Press, 1971. (Chapter 1)Margolis, Eric (ed), The Sage Handbook of Visual Research, Sage, 2011.	METHODS OF SOCIOLOGICAL RESEARCH
SOC752A	3-0-0-0-9		**Course Contents:** 1. Styles of causal thought and models of controlled experiment: meaning of statistical inference concepts of relative error and confidence interval; simple bivariate approaches and unmatched differences; one way and factoria analysis of variance. 2. Causal analysis in nonexperimental data; conceptual framework as flowcharts. 3. Models and explanatory fit; modelling social phenomena; measures of life expectancy, disease burden and health inequality. 4. Analysis of frequencies chisquare, odds ratios and relative risk, Cramer's V and Kendall' tau. 5. Multivariate analysis unstandardized and standardized regression coefficients; uses of dummy vaiables; role of proxies; structural equation models; analysing longitudianl and cohort data; tempo effects. 6. Standardized rates and ratios as dependent vairable; ratios of ratios and rates such as ratio of male and female mortality rates; working with indices such as HDI and PCI. **References/Text Books:** Articles from journals : Americal Sociological Review, American Journal of Sociology, British Journal of Sociology, and Population and Development Review. (i) Emile Durkheim, Suicide: Studey in Sociology, The Free Press, New York, 1968 Book II, pp. 145294. (ii) David C. Howell, Fundamental Statistics ofr Behavioral Sciences, Wadsworth, 2011. (iii) Thomas J. Linneman, Social Statistics Routledge, 2011. (iv) Jay Alan Weinstein, Applying Social Statistics: An Introduction to Quantitative Reasoning in Sociology, Rowman & Littlefield Publishers, Inc., 2010. (v) Lorena Madrigal, Statistics for Anthropology, Cambridge Press, 2012.	APPLIED STATISTICS FOR SOCIOLOGISTS AND OTHER SOCIAL SCIENTISTS
SOC799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
***** Department of IME *****				
IME602	3-0-0--4		**Course Contents:**	PROBABILITY AND

			Probability: Sample space, events and probability; Conditional probability and independence; Random variable (RV); Expectation, variance and higher moments; Some standard probability distributions; Functions of RVs; Jointly distributed RVs; Some multivariate distributions; Sum of RVs; Limit theorems.Statistics: Population and sample; Sampling distributions; Properties of point estimators; Maximum likelihood method; Interval estimation; Hypothesis testing; Some standard hypothesis tests; Analysis of variance; Simple linear regression; Multiple linear regression; Goodness of fit tests.Textbooks1)H.J. Larson, Introduction to Probability Theory and Statistical Inference, John Wiley & Sons.2)R.V. Hogg, A.T. Craig, and J.W. McKean, Introduction to Mathematical Statistics, Pearson Education. **References/Text Books:** 1)V.K. Rohatgi and A.K.Md.E. Saleh, An Introduction to Probability and Statistics, Wiley India Private Limited.2)R.J. Larsen and M.L. Marx, An Introduction to Mathematical Statistics and Its Applications, Pearson Education.3)P.G. Hoel, S. Port, and S. Stone, Introduction to Probability Theory, Houghton Mifflin.4)P.G. Hoel, S. Port, and S. Stone, Introduction to Statistical Theory, Houghton Mifflin.5)W. Feller, An Introduction to Probability Theory and its Applications (Vol. 1 & 2), Wiley India Private Limited.6)A.M. Goon, M.K. Gupta, and B. Dasgupta, An Outline of Statistical Theory (Vol. 1 & 2), World Press Private Limited.7)A.M. Goon, M.K. Gupta, and B. Dasgupta, Fundamentals of Statistics (Vol. 1 & 2), World Press Private Limited.8)J.P. Romano and E.L. Lehmann, Testing Statistical Hypotheses, Springer (SIE).9)N.R. Draper and H. Smith, Applied Regression Analysis, Wiley India Private Limited.	STATISTICS
IME602A	3-0-0-0-9		**Course Contents:** Probability: Sample space, events and probability; Conditional probability and independence; Random variable (RV); Expectation, variance and higher moments; Some standard probability distributions; Functions of RVs; Jointly distributed RVs; Some multivariate distributions; Sum of RVs; Limit theorems.Statistics: Population and sample; Sampling distributions; Properties of point estimators; Maximum likelihood method; Interval estimation; Hypothesis testing; Some standard hypothesis tests; Analysis of variance; Simple linear regression; Multiple linear regression; Goodness of fit tests.Textbooks1)H.J. Larson, Introduction to Probability Theory and Statistical Inference, John Wiley & Sons.2)R.V. Hogg, A.T. Craig, and J.W. McKean, Introduction to Mathematical Statistics, Pearson Education. **References/Text Books:** Course Reference : 1)V.K. Rohatgi and A.K.Md.E. Saleh, An Introduction to Probability and Statistics, Wiley India Private Limited.2)R.J. Larsen and M.L. Marx, An Introduction to Mathematical Statistics and Its Applications, Pearson Education.3)P.G. Hoel, S. Port, and S. Stone, Introduction to Probability Theory, Houghton Mifflin.4)P.G. Hoel, S. Port, and S. Stone, Introduction to Statistical Theory, Houghton Mifflin.5)W. Feller, An Introduction to Probability Theory and its Applications (Vol. 1 & 2), Wiley India Private Limited.6)A.M. Goon, M.K. Gupta, and B. Dasgupta, An Outline of Statistical Theory (Vol. 1 & 2), World Press Private Limited.7)A.M. Goon, M.K. Gupta, and B. Dasgupta, Fundamentals of Statistics (Vol. 1 & 2), World Press Private Limited.8)J.P. Romano and E.L. Lehmann, Testing Statistical Hypotheses, Springer (SIE).9)N.R. Draper and H. Smith, Applied Regression Analysis, Wiley India Private Limited.	PROBABILITY AND STATISTICS
IME603	2-0-3--4		**Course Contents:** Computing Computer Organization, Data Representation, Data Structures suchas Arrays, Stacks, Queues and Trees, Algorithms for Searching and Sorting,Complexity, File Processing, Structured Programming, Lab exercises on DataStructure, Algorithms and File Management using any appropriate programminglanguage. **References/Text Books:**	INTRODUCTION TO COMPUTING
IME603A	3-0-0-0-9		**Course Contents:** Computing Computer Organization, Data Representation, Data Structures suchas Arrays, Stacks, Queues and Trees, Algorithms for Searching and Sorting,Complexity, File Processing, Structured Programming, Lab exercises on DataStructure, Algorithms and File Management using any appropriate programminglanguage.	INTRODUCTION TO COMPUTING

			References/Text Books:	
IME605	3-0-0--4	#	**Course Contents:** Introduction, Mathematical Modeling, Linear programming Formulation, solutionprocedures, Duality, Sensitivity, Applications, Network methods Max Flow, Mincost, Shortest path, Dynamic programming Sequential decisions, Principle ofoptimality, Applications Integer Programming Formulation, Nonlinear ProgrammingApplications and solution methods. **References/Text Books:**	OPERATIONS RESEARCH FOR MANAGEMENT
IME605A	3-0-0-0-9		**Course Contents:** Introduction, Mathematical Modeling, Linear programming Formulation, solutionprocedures, Duality, Sensitivity, Applications, Network methods Max Flow, Mincost, Shortest path, Dynamic programming Sequential decisions, Principle ofoptimality, Applications Integer Programming Formulation, Nonlinear ProgrammingApplications and solution methods. **References/Text Books:**	OPERATIONS RESEARCH FOR MANAGEMENT
IME611	3-0-0--4		**Course Contents:** Module 1 : Basic Elements of Financial Systems and Financial Management Fundamentals of Financial Systems and Domain Knowledge of FinacialManagementModule 2 : Mathematical Background Introduction to Stochastic Calculus : Wiener processes and Itos lemma,Stochastic Differential Equations, Martingales and Measures Numerical procedures : Binomial & trinomial trees, Monte Carlo simulation;finite difference methodsModule 3 : Options and Futures Markets Forward and futures contracts : Basic definition, Differences betweenForwards & Futures, Futures & Forwards on Commodities & Currencies,Valuation of Futures, Interest Rate Futures. Swaps : Currency Swaps, Interest Rate Swaps Options : Definitions, Payoff Diagrams, General Arbitrage Relationships,The Binomial Method, Applications to Hedging & Speculating, Delta Hedging,Arbitraging mispriced Options, Pricing of Stock Options on Stock Indices,Currencies, and Futures.Module 4 : Financial Risk Management Introduction : Different types of risk ; approaches to risk management;history of bank regulation. Greek letters : Definitions and how they are used. **References/Text Books:**	FINANCIAL ENGINEERING
IME611A	3-0-0-0-9		**Course Contents:** Module 1 : Basic Elements of Financial Systems and Financial Management Fundamentals of Financial Systems and Domain Knowledge of FinacialManagementModule 2 : Mathematical Background Introduction to Stochastic Calculus : Wiener processes and Itos lemma,Stochastic Differential Equations, Martingales and Measures Numerical procedures : Binomial & trinomial trees, Monte Carlo simulation;finite difference methodsModule 3 : Options and Futures Markets Forward and futures contracts : Basic definition, Differences betweenForwards & Futures, Futures & Forwards on Commodities & Currencies,Valuation of Futures, Interest Rate Futures. Swaps : Currency Swaps, Interest Rate Swaps Options : Definitions, Payoff Diagrams, General Arbitrage Relationships,The Binomial Method, Applications to Hedging & Speculating, Delta Hedging,Arbitraging mispriced Options, Pricing of Stock Options on Stock Indices,Currencies, and Futures.Module 4 : Financial Risk Management Introduction : Different types of risk ; approaches to risk management;history of bank regulation. Greek letters : Definitions and how they are used. **References/Text Books:**	FINANCIAL ENGINEERING
IME624	2-0-3--4		**Course Contents:** System Analysis: Information System Analysis and Design, Decision SupportSystem, Database Management Systems, Query Languages, Emerging Areas likecommunication network distributed systems and knowledge based systems,Simulation; Methodology Approaches Programming Considerations, Languages andData	COMPUTER AIDED DECISION SYSTEMS

			Structures, Statistical Considerations, Validation, Simulation Languages,Applications. **References/Text Books:**	
IME624A	3-0-0-0-9		**Course Contents:** System Analysis: Information System Analysis and Design, Decision SupportSystem, Database Management Systems, Query Languages, Emerging Areas likecommunication network distributed systems and knowledge based systems,Simulation; Methodology Approaches Programming Considerations, Languages andData Structures, Statistical Considerations, Validation, Simulation Languages,Applications. **References/Text Books:**	COMPUTER AIDED DECISION SYSTEMS
IME625	3-0-0-0-4		**Course Contents:** a) Introduction to stochastic process, Random walks, Markov chains, Markovprocesses, poisson processb) Application of Stochastic processes in (i) Queueing Theory, (ii) Scheduling,(iii) Manufacturing (iii) Finace, (vi) Marketing, etc. **References/Text Books:**	INDRODUCTION TO STOCHASTIC PROCESSES AND THEIR APPLICATIONS
IME625A	3-0-0-0-9		**Course Contents:** a) Introduction to stochastic process, Random walks, Markov chains, Markovprocesses, poisson processb) Application of Stochastic processes in (i) Queueing Theory, (ii) Scheduling,(iii) Manufacturing (iii) Finace, (vi) Marketing, etc. **References/Text Books:**	INDRODUCTION TO STOCHASTIC PROCESSES AND THEIR APPLICATIONS
IME634	3-0-0--4		**Course Contents:** Multiobjective decisions, Decisions under uncertainty, Statistical Decision Trees,Applications from Quality Control and Production Control. **References/Text Books:**	MANAGEMENT DECISION ANALYSIS
IME634A	3-0-0-0-9		**Course Contents:** Multiobjective decisions, Decisions under uncertainty, Statistical Decision Trees,Applications from Quality Control and Production Control. **References/Text Books:**	MANAGEMENT DECISION ANALYSIS
IME636	3-0-0-0-4		**Course Contents:** Description of Game Theory, Representation of games in extensive form, Normal form and Coalition form, Concept of preferences and utility, Introduction to solution concepts for normal form games, Description of different solution concepts: Dominance, Nash equilibrium, correlated equilibrium, applications; Static model of oligopoly, extensive form games of perfect and imperfect information, refinements of Nash equilibrium, finite and infinite horizon, alternating bargaining models, games with incomplete information; Bayesian games, Bayes Nash equilibrium as a solution concept, finitely and infinitely repeated game; Trigger strategies, mechanism design, Properties of mechanism and implementation **References/Text Books:**	INTRODUCTION TO GAME THEORY
IME636A	3-0-0-0-9		**Course Contents:** Description of Game Theory, Representation of games in extensive form, Normal form and Coalition form, Concept of preferences and utility, Introduction to solution concepts for normal form games, Description of different solution concepts: Dominance, Nash equilibrium, correlated equilibrium, applications; Static model	INTRODUCTION TO GAME THEORY

			of oligopoly, extensive form games of perfect and imperfect information, refinements of Nash equilibrium, finite and infinite horizon, alternating bargaining models, games with incomplete information; Bayesian games, Bayes Nash equilibrium as a solution concept, finitely and infinitely repeated game; Trigger strategies, mechanism design, Properties of mechanism and implementation **References/Text Books:**	
IME637	3-0-0-0-4	IME605	**Course Contents:** Review of linear and integer linear programming. Multistage decision models: Dynamic programming. Network flow problems: Shortest path, maximum flow and minimum cost flow problems; Network optimization. Multiobjective decision models: Analytic hierarchy and network processes. Nonlinear programming: Uncostrained optimization; Lagrangian relaxation and KKT conditions; Convex optimization; Search, gradient and penalty based methods; Quadratic programming. Metaheauristics and their applications to combinatorial optimization problems such as scheduling and allocation problems. Stochastic decision models: Markov chains; Queues and queuing networks. **References/Text Books:** Course Reference : Katta G. Murty, Linear Programming, Wiley. Laurence A. Wolsey, Integer Programming, Wiley. Richard Bellman, Dynamic Programming, Dover. R.K. Ahuja, T.L. Magnanti, J.B. Orlin, Network Flows, Prentice Hall. A. Ishizaka and P. Nemery, Multicriteria Decision Analysis, Wiley. Rangarajan K. Sundaram, A First Course in Optimization Theory, Cambridge. S. Boyd and L Vandenberghe, Convex Optimization, Cambridge. J. Nocedal, S.J. Wright, Numerical Optimization, Springer. ElGhazali Talbi, Metaheauristics: From design to implementation, Wiley. Kalyanmoy Deb, Multiobjective Optimization Using Evolutionary Algorithms, Wiley. D. Gross, C.M. Harris, Fundamentals of Queueing Theory, Wiley. Wayne L. Whinston, Operations Research: Applications and Algorithms.	ADVANCED DECISION MODELS
IME637A	3-0-0-0-9	IME605A	**Course Contents:** Review of linear and integer linear programming. Multistage decision models: Dynamic programming. Network flow problems: Shortest path, maximum flow and minimum cost flow problems; Network optimization. Multiobjective decision models: Analytic hierarchy and network processes. Nonlinear programming: Uncostrained optimization; Lagrangian relaxation and KKT conditions; Convex optimization; Search, gradient and penalty based methods; Quadratic programming. Metaheauristics and their applications to combinatorial optimization problems such as scheduling and allocation problems. Stochastic decision models: Markov chains; Queues and queuing networks. **References/Text Books:** Katta G. Murty, Linear Programming, Wiley. Laurence A. Wolsey, Integer Programming, Wiley. Richard Bellman, Dynamic Programming, Dover. R.K. Ahuja, T.L. Magnanti, J.B. Orlin, Network Flows, Prentice Hall. A. Ishizaka and P. Nemery, Multicriteria Decision Analysis, Wiley. Rangarajan K. Sundaram, A First Course in Optimization Theory, Cambridge. S. Boyd and L Vandenberghe, Convex Optimization, Cambridge. J. Nocedal, S.J. Wright, Numerical Optimization, Springer. ElGhazali Talbi, Metaheauristics: From design to implementation, Wiley. Kalyanmoy Deb, Multiobjective Optimization Using Evolutionary Algorithms, Wiley. D. Gross, C.M. Harris, Fundamentals of Queueing Theory, Wiley. Wayne L. Whinston, Operations Research: Applications and Algorithms.	ADVANCED DECISION MODELS
IME639	3-0-0-0-4		**Course Contents:** Introduction. Commonality in modeling problems across Transport and TelecomIntroduction to graph TheoryReview of linear and integer linear programming Minimum Spanning Tree Problem Steiner Tree ProblemShortest Path Problem, Dijkstras algorithm, Bellman Ford AlgorithmAll Shortest Paths, Floyds algorithm, ApplicationsIntroduction to complexity theory and NPcompletenessNetwork Flow Models, Max Flow Min Cut Problem, Minimum Cost FlowsKnapsack Problem and applicationsBin Packing and applicationsVehicle Routing ProblemLarge Scale Optimization, Column Generation, Hands on with CPLEXSet Covering/Partitioning/Packing Models and ApplicationsTraveling Salesman Problem with	ANALYTICS IN TRANSPORT AND TELECOM

			applicationsFixed Charge Transportation ProblemTelecom Network Design, Access Networks, Backbone NetworksDesign of Survivable NetworksGraph Coloring Model and applicationsChinese Postman Problem with applications **References/Text Books:** Recommended Books:oR.K. Ahuja, T.L. Magnanti, J.B. Orlin, Network Flows, Prentice HalloE. Lawler, Combinatorial Optimization: Networks and Matroids, DoveroH.M. Salkin, K. Mathur Foundations of Integer Programming, North HollandoW.L. Whinston, Operations Research: Applications and Algorithms, Cengage Learning	
IME639A	3-0-0-0-9		**Course Contents:** Introduction. Commonality in modeling problems across Transport and TelecomIntroduction to graph TheoryReview of linear and integer linear programming Minimum Spanning Tree Problem Steiner Tree ProblemShortest Path Problem, Dijkstras algorithm, Bellman Ford AlgorithmAll Shortest Paths, Floyds algorithm, ApplicationsIntroduction to complexity theory and NPcompletenessNetwork Flow Models, Max Flow Min Cut Problem, Minimum Cost FlowsKnapsack Problem and applicationsBin Packing and applicationsVehicle Routing ProblemLarge Scale Optimization, Column Generation, Hands on with CPLEXSet Covering/Partitioning/Packing Models and ApplicationsTraveling Salesman Problem with applicationsFixed Charge Transportation ProblemTelecom Network Design, Access Networks, Backbone NetworksDesign of Survivable NetworksGraph Coloring Model and applicationsChinese Postman Problem with applications **References/Text Books:** Recommended Books:oR.K. Ahuja, T.L. Magnanti, J.B. Orlin, Network Flows, Prentice HalloE. Lawler, Combinatorial Optimization: Networks and Matroids, DoveroH.M. Salkin, K. Mathur Foundations of Integer Programming, North HollandoW.L. Whinston, Operations Research: Applications and Algorithms, Cengage Learning	ANALYTICS IN TRANSPORT AND TELECOM
IME640A	3-0-0-0-9		**Course Contents:** Introduction: Information and its characteristics including entropy, System and its characteristics. IS Cycle Theories: Delone and McLean's Success Model, Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, User Resistance Theories, Task Technology Fit Theory, Process Virtualization Theory, Theory of Deferred Action. Strategic and Economic Theories: Resource based view, Theory of Slack Resources, Portfolio Theory, Theory of Lemon Markets, Technology Organization Environment Framework, Porter's Competitive Forces Model, Business Value of IT, Diffusion of Innovations, Institutional Theory, A Multilevel Social Network Perspective, Agency Theory. Socio Psychological Theories: Actor network theory, Theory of Planned Behaviour, Structuration Theory. **References/Text Books:** 1. Dwivedi, Y.K.,Wade, M.R., & Schneberger, S.L. (2012) Information Systems Theory: Explaining and Predicting Our Digital Society, Vol 1. Springer	INFORMATION SYSTEMS THEORY
IME641	3-0-0--4		**Course Contents:** Production systems : concepts and integrated view, Policy Decisions, Capacityplanning, Product development, Plant location, Plant layout, Materials handling,Assembly line balancing, Work design, Methods engineering, Human Factorsengineering, Project Management and Network models, Recent trends **References/Text Books:**	DESIGN OF PRODUCTION SYSTEMS
IME641A	3-0-0-0-9		**Course Contents:** Production systems : concepts and integrated view, Policy Decisions, Capacityplanning, Product development, Plant location, Plant layout, Materials handling,Assembly line balancing, Work design,	DESIGN OF PRODUCTION SYSTEMS

			Methods engineering, Human Factorsengineering, Project Management and Network models, Recent trends **References/Text Books:**	
IME642	3-0-0--4		**Course Contents:** Overview of Manufacturing Planning and Control; Forecasting; SmoothingMethods, Time Series Analysis, Decomposition Methods. Autoregressive and BoxJenkins Models. Qualitative Models; Aggregate ProductionPlanning, MasterProduction Scheduling. Capacity Planning. Demand Management. Scheduling;Performance Measures, Single Machine Models, Flow Shop and Job Shops, DynamicScheduling, Evaluation of Heuristics and Dispatching Rules. **References/Text Books:**	OPERATIONS MANAGEMENT
IME642A	3-0-0-0-9		**Course Contents:** Overview of Manufacturing Planning and Control; Forecasting; SmoothingMethods, Time Series Analysis, Decomposition Methods. Autoregressive and BoxJenkins Models. Qualitative Models; Aggregate ProductionPlanning, MasterProduction Scheduling. Capacity Planning. Demand Management. Scheduling;Performance Measures, Single Machine Models, Flow Shop and Job Shops, DynamicScheduling, Evaluation of Heuristics and Dispatching Rules. **References/Text Books:**	OPERATIONS MANAGEMENT
IME671	3-0-0--4		**Course Contents:** This course will cover the techniques for managing software projects. It isintended to give the students both knowledge about, and practical experiencein, the design and development of production quality software. The techniquestaught in the class will be applied to a substantial teamproject.Course topics will be as follows: Software Process; Software ConfigurationManagement, CMM Levels, Software Project Planning and Costing; RequirementsEngineering; Software Project Design; Testing; Software Metrics; Quality, SoftwareProject Management; Human Factor. **References/Text Books:**	SOFTWARE PROJECT MANAGEMENT
IME692	3-0-0-0-4		**Course Contents:** The course is designed to train students on understanding research problems and situations requiring multivariate approaches, selecting appropriate multivariate techniques of data analysis, interpreting the results of analysis, and applying the techniques to business and research problems. The course includes topics dealing with multiple noninterdependence techniques (such as Factor Analysis, Cluster Analysis, Multidimensional Scaling), multiple dependence techniques (such as Multiple Regression Analysis, Discriminant Analysis, Path analysis, Multivariate Analysis of Variance), and nonparametric techniques of data analysis. **References/Text Books:**	ADVANCED STATISTICAL METHODS FOR BUSINESS ANALYTICS
IME692A	3-0-0-0-9		**Course Contents:** The course is designed to train students on understanding research problems and situations requiring multivariate approaches, selecting appropriate multivariate techniques of data analysis, interpreting the results of analysis, and applying the techniques to business and research problems. The course includes topics dealing with multiple noninterdependence techniques (such as Factor Analysis, Cluster Analysis, Multidimensional Scaling), multiple dependence techniques (such as Multiple Regression Analysis, Discriminant Analysis, Path analysis, Multivariate Analysis of Variance), and nonparametric techniques of data analysis. **References/Text Books:**	ADVANCED STATISTICAL METHODS FOR BUSINESS ANALYTICS

IME697	-0-0--0		**Course Contents:** A 68 week industrial project for M Tech students during the period interveningthe II and III semesters on a problem of practical relevance completed in anindustrial or service organization. The student will study, analyze and then solvethe problem and prepare its implementation details, under the supervision andguidance of an officer/executive of the host organization. On completion ofthe summer project the student will submit a written report and give a seminarto the IME Department. **References/Text Books:**	INDUSTRIAL PROJECT
IME698	0-0-0--0		**Course Contents:** SEMINAR **References/Text Books:**	SEMINAR
IME698A	0-0---0		**Course Contents:** SEMINAR **References/Text Books:**	SEMINAR
IME699	-0-0--		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
IME700	3-0-0-0-4		**Course Contents:** Introduction to Social Science Research Perspective, Different Approaches to Social Research, Approaches to Theory Building, Sampling , Measurement Issues & Scale construction, Research Design , Qualitative Research, Experimental Research, Survey Research, Quantitative Data Analysis Techniques , Research Writing and Presentation, Research Evaluation and Critique, Issues in Current Research Practice. **References/Text Books:**	RESEARCH METHODOLOGY
IME700A	3-0-0-0-9		**Course Contents:** Introduction to Social Science Research Perspective, Different Approaches to Social Research, Approaches to Theory Building, Sampling , Measurement Issues & Scale construction, Research Design , Qualitative Research, Experimental Research, Survey Research, Quantitative Data Analysis Techniques , Research Writing and Presentation, Research Evaluation and Critique, Issues in Current Research Practice. **References/Text Books:**	RESEARCH METHODOLOGY
IME797	3-0-0-0-4		**Course Contents:** Market Efficiency, Capital Structure, Asset Pricing, Corporate Governance, PortfolioTheory, Financial Intermediation, Credit Risk Modeling & Market Microstructure **References/Text Books:** 1. Ananth Madhavan, Market microstructure: A survey, Journal of Financial Markets,Volume 3, Issue 3, August 2000, Pages 2052582. Bhattacharya Sudipto & Thakor Anjan V., 1993."Contemporary Banking Theory," Journal ofFinancial Intermediation, Elsevier, vol. 3(1), pages 250, October.3. Black, F., and M. Scholes (1973)., The Pricing of Options, and Corporate Liabilities, Journal of Political Economy, MayJune, 637659.4. Burton G. Malkiel., The Efficient Market Hypothesis and Its Critics, Princeton University CEPS Working Paper No. 91 April 20035. Coase, Ronald H. (1937). The Nature of the Firm, Economica, N.S. 4, 3864056. Eugene F. Fama, "Random Walks in Stock Market Prices," Financial Analysts Journal,September/October 1965 (reprinted JanuaryFebruary 1995)7. Fama, E. F., 1970. "Efficient Capital	INDEPENDENT STUDY

			Markets: A Review of Theory and Empirical work," Journal of Finance, 25 , 383417.	
IME797A	3-0-0-0-9		**Course Contents:** Market Efficiency, Capital Structure, Asset Pricing, Corporate Governance, PortfolioTheory, Financial Intermediation, Credit Risk Modeling & Market Microstructure **References/Text Books:** 1. Ananth Madhavan, Market microstructure: A survey, Journal of Financial Markets,Volume 3, Issue 3, August 2000, Pages 2052582. Bhattacharya Sudipto & Thakor Anjan V., 1993."Contemporary Banking Theory," Journal ofFinancial Intermediation, Elsevier, vol. 3(1), pages 250, October.3. Black, F., and M. Scholes (1973)., The Pricing of Options, and Corporate Liabilities, Journal of Political Economy, MayJune, 637659.4. Burton G. Malkiel., The Efficient Market Hypothesis and Its Critics, Princeton University CEPS Working Paper No. 91 April 20035. Coase, Ronald H. (1937). The Nature of the Firm, Economica, N.S. 4, 3864056. Eugene F. Fama, "Random Walks in Stock Market Prices," Financial Analysts Journal,September/October 1965 (reprinted JanuaryFebruary 1995)7. Fama, E. F., 1970. "Efficient Capital Markets: A Review of Theory and Empirical work," Journal of Finance, 25 , 383417.	INDEPENDENT STUDY
IME799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
MBA601	3-0-0-0-4		**Course Contents:** Balance sheet, profit and loss concepts, accounting principles and mechanics,Inventory Valuation and Depreciation accounting, Ratio and Fund flow analysis.Introduction to cost Accounting. Various methods of cost determination and costaccounting systems such as activity based costing systems and responsibilityaccounting. Use of costing systems in decision making. Extensive case studieswill employed in this course. **References/Text Books:**	ACCOUNTING & FINANCE
MBA601A	3-0-0-1-10		**Course Contents:** 1) Introduction: Forms of Organization & Corporate Reporting, Reporting Fundamentals & Financial Reporting. 2) Financial Accounting: Accounting Principles, Accounting Mechanics, Accounting Standards & Financial Statement Analysis. 3) Management Accounting: Cost Volume Profit (CVP) Analysis, Costing SystemsTools & Techniques, Activity Based Costing (ABC). 4) Corporate finance: The Time Value of Money, Valuation, Capital Budgeting, Capital Structure & Dividend Policy, Working Capital Management. **References/Text Books:** 1. Williams et al., Financial and Managerial Accounting, Tata McGraw Hill. 2. Fundamentals of Financial management, J. Van Horne & J M Wachowicz. 3. Principles of Corporate Finance Brealey, Myers & Allen.	ACCOUNTING & FINANCE
MBA606	3-0-0-0-4		**Course Contents:** Basic concepts in business economics, Economics of Market, Utility theory,Determination of Price, Production Function, Theories of Competition, Theoryof Supply and Demand, Micro Level Firm Behaviour, Market Structure and Price,Concept of GDP, Theories of Money Supply, theory of Macro Economics. NationalIncome and domestic product. Keynesian theory of income determination,Monetary approach, Inflation, balance of Payments, Structure of Indian economy,Indian economic growth and development. **References/Text Books:**	ECONOMIC ANALYSIS FOR MANAGEMENT
MBA606A	3-0-0-1-10		**Course Contents:** Basic concepts in business economics, Economics of Market, Utility theory, Determination of Price, Production Function, Theories of Competition, Theory of Supply and Demand, Micro Level Firm Behaviour,	ECONOMIC ANALYSIS FOR MANAGEMENT

			Market Structure and Price, Concept of GDP, Theories of Money Supply, theory of Macro Economics, National Income and domestic product. Keynesian theory of income determination, Monetary approach, Inflation, balance of Payments, Structure of Indian economy, Indian economic growth and development, Aggregate Supply and Demand, Game Theory, Factor Markets, Student Project (Field research & Data Interpretation based term projects) **References/Text Books:**	
MBA607	3-0-0--4	MBA601	**Course Contents:** Fund and Cost Flow Analysis, Working capital management, Determination ofcapital structure of the firm, Cost of Capital, Capital asset pricing models,Leverages, Investment Analysis, Portfolio Management, Debt Management,Dividend Policy, Concept of Financial Strategy, Course will be based on casestudy and journal articles. **References/Text Books:**	FINANCIAL MANAGEMENT
MBA607A	3-0-0-1-10	MBA601A	**Course Contents:** Fund and Cost Flow Analysis, Working capital management, Determination ofcapital structure of the firm, Cost of Capital, Capital asset pricing models,Leverages, Investment Analysis, Portfolio Management, Debt Management,Dividend Policy, Concept of Financial Strategy, Course will be based on casestudy and journal articles. **References/Text Books:**	FINANCIAL MANAGEMENT
MBA610	3-0-0--4		**Course Contents:** Investment Valuation Estimating Cost of Equity and Cost of Capital, Option PricingTheory, Option Pricing Applications in Valuation Real Options in ManagerialDecision Making Binomial Tree Method for Valuing Real Options, Option to Delay,Option to Expand Option to Abandon, Valuing Natural Resoures Using Real Options,Appraising Projects with Real Options. **References/Text Books:**	INVESTMENT VALUATION AND REAL OPTIONS
MBA610A	3-0-0-1-10		**Course Contents:** Introduction to Valuation methods, Investment Valuation, Estimating Cost of Equity and Cost of Capital, Derivatives, Option Pricing Theory, Option Pricing Applications ain Valuation, Real Options in Managerial Decision Making, Binomial Tree Method for Valuing Real Options, Option to Delay, Option to Expand, Option to Abandon, Valuing Natural Resources Using Real Options, Mini Project Identifying Real Options in Practice, Appraising Projects with Real Options. **References/Text Books:** Damodaran, Ashwath (2002), Investment Valuation, (Second Edition), Wiley.Broyles, Jack (2003), Financial Managemnt and Real Options, Wiley.Mun, Johnathan (2005), Real Options Analysis: Tools and Techniques for Valuing Strategic Investment and Decisions, 2nd Edition, Wiley.Schwartz, Eduardo S. & Trigeorgis, Lenos (eds.) (2001), Real Options and Investment Under Uncertainty, MIT.Copeland, Tom & Antikarov, Valdimir (2001), Real Options: A Practitioner's Guide, Textre. Selected Case Studies on Valuation and Real Options.	INVESTMENT VALUATION AND REAL OPTIONS
MBA611	3-0-0-0-4		**Course Contents:** Introduction to Organizations, Organization Goals, Organizations and Markets,Organization Structures and Systems, Strategy, Structure & Technology, OrganizationEnvironment and Culture, Various Design Options, Power and Politics, OrganizationConflict, Change and Restructuring, Growth and Evolution, Learning Organizationsand organization Effectiveness, Service Organizations, Organizations as Networks.State ofart	ORGANIZATION STRUCTURE AND BEHAVIOUR

			research papers and case studies will be used for the selected topics. **References/Text Books:**	
MBA611A	3-0-0-1-10		**Course Contents:** Introduction to Organizations, Work motivation and Organization Goals, Organizations and Markets, Organization Structures and Systems, Strategy, Structure & Technology, Organization Environment and Culture, Various Design Options, Power and Politics, Organization Conflict, Change and Restructuring, Growth and Evolution, Employee empowerment, Learning Organizations and organization Effectiveness, Service Organizations, Organizations as Networks. State ofart research papers and case studies will be used for the selected topics, Student Project (Field research & Data Interpretation based term projects). **References/Text Books:**	ORGANIZATION STRUCTURE AND DESIGN
MBA616	3-0-0--4		**Course Contents:** Meaning of Work and Humans as Resource, Human Resource Planning andSelection, Motivation and Compensation Management, Performance Appraisal,Career Management, Training and HRD, Group Dynamics and Leadership, TradeUnions and Industrial Disputes, Public Policy and Collective Bargaining, DueProcess, Empowerment and Participation, Technology & HRM, Japanese HRM. **References/Text Books:**	HUMAN RESOURCE MANAGEMENT
MBA616A	3-0-0-1-10		**Course Contents:** Meaning of Work and Humans as Resource, Human Resource Planning andSelection, Motivation and Compensation Management, Performance Appraisal,Career Management, Training and HRD, Group Dynamics and Leadership, TradeUnions and Industrial Disputes, Public Policy and Collective Bargaining, DueProcess, Empowerment and Participation, Technology & HRM, Japanese HRM. **References/Text Books:**	HUMAN RESOURCE MANAGEMENT
MBA617	3-0-0--4		**Course Contents:** Industrial revolution and industrialization, Political economy of underdevelopment,Sociology of development, Indian rural and urban society, Influence of religionand karma, Multiplicity of languages, cultures, castes, Feudalism, Work ethic,Constitution of India, Party system, Fundamental rights, Local self government,Directive principles of state policy, Welfare state and Civil society, Socialstratification, Environmental issues and legislation, and social movements,Corporate social responsibility and business ethics, Judicial system, Businesslaw, Contract act, Arbitration, Companies Act, Sale of goods act, partnershipact, negotiable instruments act, Income tax Act, Environmental legislation. **References/Text Books:**	SOCIAL, POLITICAL AND LEGAL ENVIRON OF BUSINESS
MBA617A	3-0-0-0-9		**Course Contents:** Industrial revolution and industrialization, Political economy of underdevelopment,Sociology of development, Indian rural and urban society, Influence of religionand karma, Multiplicity of languages, cultures, castes, Feudalism, Work ethic,Constitution of India, Party system, Fundamental rights, Local self government,Directive principles of state policy, Welfare state and Civil society, Socialstratification, Environmental issues and legislation, and social movements,Corporate social responsibility and business ethics, Judicial system, Businesslaw, Contract act, Arbitration, Companies Act, Sale of goods act, partnershipact, negotiable instruments act, Income tax Act, Environmental legislation. **References/Text Books:**	SOCIOPOLITICAL AND LEGAL ENVIRONMENT FOR BUSINESS
MBA618	----4		**Course Contents:**	GLOBALIZATION , STATE

			Globalisation perhaps is one of the most debated and contested concept ofthe contemporary times. As we are living in an era of unprecedented economicpolitical and social interconnections there is a need to reexamine our assumptionsabout social and econmic organization. The purpose of the course is to studythe concept of globalisation and develop a multifaceted understanding of it.The course will focus on the role of corporations as drives of the contemporarywave of globalisation. It would also examine the changing role of State, especiallyin the framework of state corporation relations, both in the context of thedeveloped economies as well as the third world. Further it would attempt tosituate the significance of global institutions like the IMF and the WTO in theCorporation vs. State debate on the one hand and the tension between theinterests of the developed countries and the third world on the other. The courseproposes to develop a historical understanding of the present wave of globalisationby delving in to the evolution of capitalism from its early mercantilist phase,to the industrial phase and finallly to its present finance capitalism phase. Itwill also discuss the contradictions of globalisation prosperity vs. poverty growthvs. underdevelopment and the underlying reasons for the same. Finally the coursewill endeavour to evaluate some alternate forms of globalisation which havethe possibility of going beyond the problems of the current form of globalisation.The course proposes to adopt a multi disciplinary approach in developing anunderstadnding of the dominant theories and concepts. The classroom discussionswill be based primarily on appropriate case studies of various countries andcorporations. **References/Text Books:**	& CORPORATIONS
MBA621	3-0-0-0-4		**Course Contents:** The Manager, Interpersonal Communication, Ongoing Communication Process andflow, Organizational Managerial Communication, Personal Language, use andCommunication System, The Media and Tools of Communication Climate, LowStructure: One to One Communication, High Structure: One to One Communication,Meetings and Conferences, Interactional Presentation, Keys to Functional Writings,Formats for Business letters and Memos, Exposure to eCommunication, Planningand Producing Effective Business Reports, Business and Managerial CommunicationResearch. There will be atleast one case/exercise in each class. **References/Text Books:**	MANAGERIAL COMMUNICATIONS
MBA621A	3-0-0-0-9		**Course Contents:** The Manager, Interpersonal Communication, Ongoing Communication Process andflow, Organizational Managerial Communication, Personal Language, use andCommunication System, The Media and Tools of Communication Climate, LowStructure: One to One Communication, High Structure: One to One Communication,Meetings and Conferences, Interactional Presentation, Keys to Functional Writings,Formats for Business letters and Memos, Exposure to eCommunication, Planningand Producing Effective Business Reports, Business and Managerial CommunicationResearch. There will be atleast one case/exercise in each class. **References/Text Books:**	MANAGERIAL COMMUNICATIONS
MBA622	3-0-0-0-4		**Course Contents:** Product and factory life cycle, strategic dimensions of technology, characteristicsof job shops and flow shops, learning curve effects, economies of scale,resolution of conflicts between manufacturing and marketing, concept of PWP,design of organization structure of manufacturing divisions, interactions ofdesign department with manufacturing, marketing, service and purchasing.Concept of aligning of manufacturing and the corporate strategy. **References/Text Books:**	MANUFACTURING STRATEGY
MBA622A	3-0-0-0-9		**Course Contents:** Product and factory life cycle, strategic dimensions of technology, characteristicsof job shops and flow shops,	MANUFACTURING STRATEGY

			learning curve effects, economies of scale,resolution of conflicts between manufacturing and marketing, concept of PWP,design of organization structure of manufacturing divisions, interactions ofdesign department with manufacturing, marketing, service and purchasing.Concept of aligning of manufacturing and the corporate strategy. **References/Text Books:**	
MBA623	3-0-0-0-4		**Course Contents:** General Management Function, Introduction to the corporate strategy, conceptof organizational purpose, environmental scanning and formulation of objectives,strategy for growth such as concentric growth and diversification, role of valuesin strategy formulation and evaluation, managing diversity and growth, choiceof organizational structure and designing control systems to support theimplementation of the strategy. Role of implementation issues in strategyformulation. Impact of organizational culture, structure, systems in strategyimplementation and Merger and Acquisitions. **References/Text Books:**	STRATEGIC MANAGEMENT
MBA623A	3-0-0-0-10		**Course Contents:** General Management Function, Introduction to the corporate strategy, conceptof organizational purpose, environmental scanning and formulation of objectives,strategy for growth such as concentric growth and diversification, role of valuesin strategy formulation and evaluation, managing diversity and growth, choiceof organizational structure and designing control systems to support theimplementation of the strategy. Role of implementation issues in strategyformulation. Impact of organizational culture, structure, systems in strategyimplementation and Merger and Acquisitions. **References/Text Books:**	STRATEGIC MANAGEMENT
MBA624	3-0-0-0-4		**Course Contents:** In the first module this course will take an applied approach to learn theimperatives of lateral thinking and accelerated innovation in large organizationsunder relentless pressure of discontinuity. It will explore integrative frameworkfor individuals, virtual teams, using CPC and other rapid development/deploymentIT tools for accelerating targeted innovation and new product concept to marketprocesses.In the second module this course will develop from theories of entrepreneurshipan applied approach for managing disruptive innovation to create new highgrowth businesses. The crafting approach to finance, operations and otherentrepreneurial strategies, real time monitoring and adaptive control systemsfor small businesses and the role of clusters, community of practitioners forstrategic flexibility will be some of the emerging paradigms covered in thiscourse. **References/Text Books:**	CORPORATE INNOVATION & ENTERPRENEURSHIP
MBA626	3-0-0--4		**Course Contents:** Policy Technology Choice: Linkage; National Technology Policies; Technology,Competition and Industrial Structure; formulating the technology strategy,Technology Development and Acquisition process; Managing Technologies,Technology in Indian Industries, Strategic R&D management and TechnologicalConsortia; Licensing and joint Ventures, Managing Technology Spillovers;Justification of new technology; management accounting and technology;Integration of New with Old technology, Assimilation of Technology; IntellectualProperty Rights and their Implications for Industry Policy and TechnologyManagement. **References/Text Books:**	MANAGEMENT OF TECHNOLOGY
MBA626A	3-0-0-0-9		**Course Contents:** Policy Technology Choice: Linkage; National Technology Policies; Technology,Competition and Industrial Structure; formulating the technology strategy,Technology Development and Acquisition process; Managing	MANAGEMENT OF TECHNOLOGY

			Technologies,Technology in Indian Industries, Strategic R&D management and TechnologicalConsortia; Licensing and joint Ventures, Managing Technology Spillovers;Justification of new technology; management accounting and technology;Integration of New with Old technology, Assimilation of Technology; IntellectualProperty Rights and their Implications for Industry Policy and TechnologyManagement. **References/Text Books:**	
MBA628	3-0-0-0-4		**Course Contents:** This course is relevant to all executives who plan or operationalise businessstrategies across multiple countries for international marketing, internationalsourcing, or international ownership. It focuses on learning about the globalbusiness environment, strategic opportunities and competeness forinternationalising, design and marketing of appropriate products and services,and key aspects in operationalising the strategy through organization structure,human resource, international coordination and leadership.While working towards these learning objectives, the course will maintain aclose proximity to some themes of particular interest. We shall invite frequentattention to businesses that originate or operate in India/Asia. We will also beconscious of Governance relationships of investors from developed countries thataffect their businesses in less developed ones. Cultural patterns as well as theRegulatory environment in different countries will be a recurrent theme in ourdiscussions. And, we shall be conscious of how organizations may, throughbusiness without borders, stretch their capacities, and develop new competencesand relationships.Much of the course will be through Casediscussions. Country and product basedpresentations will also be utilised for building specific understanding. **References/Text Books:**	INTERNATIONAL BUSINESS MANAGEMENT
MBA628A	3-0-0-0-9		**Course Contents:** This course is relevant to all executives who plan or operationalise businessstrategies across multiple countries for international marketing, internationalsourcing, or international ownership. It focuses on learning about the globalbusiness environment, strategic opportunities and competeness forinternationalising, design and marketing of appropriate products and services,and key aspects in operationalising the strategy through organization structure,human resource, international coordination and leadership.While working towards these learning objectives, the course will maintain aclose proximity to some themes of particular interest. We shall invite frequentattention to businesses that originate or operate in India/Asia. We will also beconscious of Governance relationships of investors from developed countries thataffect their businesses in less developed ones. Cultural patterns as well as theRegulatory environment in different countries will be a recurrent theme in ourdiscussions. And, we shall be conscious of how organizations may, throughbusiness without borders, stretch their capacities, and develop new competencesand relationships.Much of the course will be through Casediscussions. Country and product basedpresentations will also be utilised for building specific understanding. **References/Text Books:**	INTERNATIONAL BUSINESS MANAGEMENT
MBA629	3-0-0--4	#	**Course Contents:** The purpose of this course is to acquaint students with the current global markettrends, issues of global governance and emarging debates about new technologiesand corporate ethics. The expectation is to add value in the making of studentsworldviews on economy and society and provide a conceptual framework for themanagerial tasks of diagnosing predicting and responding to changes in the worldeconomy. **References/Text Books:**	MANAGEMENT IN A GLOBAL ECONOMY: AN INDIAN PERSPECTIVE
MBA630	3-0-0-0-4		**Course Contents:** Internationally, a lot of intergration is taking place between economic theory,particularly industrial organization theory and management sterategy theory. Onthe one hand, industrial organization theorists are trying to draw on real lifemanagement practices to develop never and more relavent theories. On the	ECONOMICS OF BUSINESS POLICY

			otherhand, management strategy theorists are coming to depend on industrialorganization theory to provide a general framework for organizing the otherwiseincoherent mass of facts available to them.In this context, Economics of Business Policy seeks to provide managementstudents an introduction to the interface between industrial organization theoryand strategic management theory. It uses the business related tenents ofeconomics (old and new) to develop a coherent analytical basis for the formulationand evaluation of the external and internal strategies of the firm. This is truewith respect to both a firms external market environment and its internalorganization. The course emphasizes practical managerial applications of topicsfrom industrial economics and strategy: economics of scale and scope, industryanalysis market structure commitment dynamic competition entry/exit theeconmics of competitive advantage incentives in firms internal labour marketsand executive remuneration. **References/Text Books:**	
MBA630A	3-0-0-0-9		**Course Contents:** Internationally, a lot of intergration is taking place between economic theory,particularly industrial organization theory and management sterategy theory. Onthe one hand, industrial organization theorists are trying to draw on real lifemanagement practices to develop never and more relavent theories. On the otherhand, management strategy theorists are coming to depend on industrialorganization theory to provide a general framework for organizing the otherwiseincoherent mass of facts available to them.In this context, Economics of Business Policy seeks to provide managementstudents an introduction to the interface between industrial organization theoryand strategic management theory. It uses the business related tenents ofeconomics (old and new) to develop a coherent analytical basis for the formulationand evaluation of the external and internal strategies of the firm. This is truewith respect to both a firms external market environment and its internalorganization. The course emphasizes practical managerial applications of topicsfrom industrial economics and strategy: economics of scale and scope, industryanalysis market structure commitment dynamic competition entry/exit theeconmics of competitive advantage incentives in firms internal labour marketsand executive remuneration. **References/Text Books:**	ECONOMICS OF BUSINESS POLICY
MBA631	3-0-0-0-4		**Course Contents:** Marketing Environment, Company analysis (strength, weaknesses, opportunitiesand threats), the concept of marketing mix., four Ps of marketing, and theconcept of marketing strategy. The concept of market segmentation anddifferentiation, product positioning and its applications in demand forecasting.Consumer Behaviour and Marketing Research. International marketing. Marketingeconomy and public policy issues. Emarketing. In this course concepts willelaborated by the use of cases and research papers. **References/Text Books:**	MARKETING MANAGEMENT
MBA631A	3-0-0-1-10		**Course Contents:** Marketing Environment, Company analysis (strength, weaknesses, opportunities and threats), the concept of marketing mix., four Ps of marketing, and the concept of marketing strategy. The concept of market segmentation and differentiation, product positioning and its applications in demand forecasting, Consumer Behaviour and Marketing Research, International marketing, Marketing economy and public policy issues, Emarketing. In this course concepts will elaborated by the use of cases and research papers, Brand Management, Marketing matrix, Assignment based on business databases (quantitative as well as qualitative), Student Project (Field research & Data Interpretation based term projects) **References/Text Books:**	MARKETING MANAGEMENT
MBA632	3-0-0-0-4		**Course Contents:** Marketing Fundamentals (environment, competition, consumer behavioursegmentation, Targeting, and positioning, 4Ps product, price, promotion,place), Marketing strategy, Digital marketing Opportunities,	E- MARKETING

			EParadigm, InternetNetworking, Enterprise Middleware, Right Enterprise Applications, operationalchallenges web sales and marketing, web services, ASP and other financialchoices, Realtime Analytic, Frontline Access, Miscellaneous Emerging opportunities. **References/Text Books:**	
MBA633	3-0-0-0-4		**Course Contents:** Nature and scope of Marketing research: (a) The marketing research process,(b) Research design and Implementation. Data collection : (a) Secondary sourcesof marketing data, (b) Standardized sources, (c) Information collection: qualitative and observational methods, (d) Information from respondents,(e) Attitude measurement, (f) Experimentation, (g) Sampling fundamentals. Data Analysis: (a) Hypothesis testing: Basic concepts and tests of associations, (b)Correlation regression analysis, (c) Discriminant and Canonical analysis, (d)Factor and cluster analysis, (e) Multidimensional scaling and conjoint analysis,(f) Presenting the results. Recent Trends: (a) Social media for market research (b) Bayesian methods for marketing research (c) Agent based modeling. **References/Text Books:**	MARKETING RESEARCH
MBA633A	3-0-0-1-10		**Course Contents:** Nature and scope of Marketing research: (a) The marketing research process,(b) Research design and Implementation. Data collection : (a) Secondary sourcesof marketing data, (b) Standardized sources, (c) Information collection: qualitative and observational methods, (d) Information from respondents,(e) Attitude measurement, (f) Experimentation, (g) Sampling fundamentals. Data Analysis: (a) Hypothesis testing: Basic concepts and tests of associations, (b)Correlation regression analysis, (c) Discriminant and Canonical analysis, (d)Factor and cluster analysis, (e) Multidimensional scaling and conjoint analysis,(f) Presenting the results. Recent Trends: (a) Social media for market research (b) Bayesian methods for marketing research (c) Agent based modeling. **References/Text Books:**	MARKETING RESEARCH
MBA634	3-0-0-0-4		**Course Contents:** Consumers in the Market place: (a) An introduction to Consumer Behaviour,Consumers as individuals: (a) Perception, (b) Learning and Memory, (c) Motivation,Values and Involvement, (d) Attitudes, (e) Attitude change and PersuasiveCommunication, (f) Self, Consumers as decision Markers: (a) Individual decisionMaking, (b) The Purchase Situation, Postpurchase Evaluation and ProductDisposal, (c) Group Influence, Opinion Leadership, (d) Organizational andHousehold Decision Making, Consumers and Sub Cultures: (a) Income and SocialClass, (b) Ethic, Ratial and Religious Subcultures,Consumers and Cultures: (a) Cultural Influences on Consumer Behaviour, (b)Lifestyles and Global Culture, (c) Sacred and Profane Consumption. **References/Text Books:**	CONSUMER BEHAVIOUR
MBA634A	3-0-0-0-10		**Course Contents:** Consumers in the Market place: (a) An introduction to Consumer Behaviour,Consumers as individuals: (a) Perception, (b) Learning and Memory, (c) Motivation,Values and Involvement, (d) Attitudes, (e) Attitude change and PersuasiveCommunication, (f) Self, Consumers as decision Markers: (a) Individual decisionMaking, (b) The Purchase Situation, Postpurchase Evaluation and ProductDisposal, (c) Group Influence, Opinion Leadership, (d) Organizational andHousehold Decision Making, Consumers and Sub Cultures: (a) Income and SocialClass, (b) Ethic, Ratial and Religious Subcultures,Consumers and Cultures: (a) Cultural Influences on Consumer Behaviour, (b)Lifestyles and Global Culture, (c) Sacred and Profane Consumption. **References/Text Books:**	CONSUMER BEHAVIOUR

MBA635	3-0-0--4		**Course Contents:** Service Businesses today are global from inception yet needs intricate localization. Managing on line and on demand multi tasking multiplexities makes Service Marketing challenging and a thriving area of academic pursuit. Hands on field investigation and service prototyping for problem based learning, Extensive comtemporary research findings. Strategic Marketing of Services, Comtemporary issues, understanding Customer Requirements, expectations and complexities of Customer Behaiour in the service domain, Extended Marketing Mix and creating the Service Value ProportionSegmentation and Targeting of Services Positioning and Relationship Marketing. Service Delivery and Service Recovery, Service scapes, Service Quality, aligning Service Design and Standards, Service Pricing, Yield Management. KanoQFD and other models, Service dominant Logic and energing customer roles in multilayer networks of Services delivery. Besides a number of case studies there will be an extended term project for Case Building. **References/Text Books:**	MARKETING OF SERVICES
MBA635A	3-0-0-1-10	MBA631A	**Course Contents:** Service Businesses today are global from inception yet needs intricate localization. Managing on line and on demand multi tasking multiplexities makes Service Marketing challenging and a thriving area of academic pursuit. Hands on field investigation and service prototyping for problem based learning, Extensive comtemporary research findings. Strategic Marketing of Services, Comtemporary issues, understanding Customer Requirements, expectations and complexities of Customer Behaiour in the service domain, Extended Marketing Mix and creating the Service Value ProportionSegmentation and Targeting of Services Positioning and Relationship Marketing. Service Delivery and Service Recovery, Service scapes, Service Quality, aligning Service Design and Standards, Service Pricing, Yield Management. KanoQFD and other models, Service dominant Logic and energing customer roles in multilayer networks of Services delivery. Besides a number of case studies there will be an extended term project for Case Building. **References/Text Books:**	MARKETING OF SERVICES
MBA637	3-0-0-0-4	MBA631	**Course Contents:** Business to Business Marketing encompasses those management activities thatenable a supplier firm to understand, create, and deliver value to otherbusinesses, governments, and/or institutional customers. Business to businessmarketing is also referred to as business market management an industrialmarketing. In year past, the topical area applied largely to industrial manufacturingfirms. Today, business to business marketing provides practical frameworks,concepts, and tools for organizations as diverse as management consulting firms,investment banks, software solutions providers, and integrated supplymanagement operations, among many other leadingedge technology and servicecompanies.As business to business marketing expands its scope and stature, this courseaims at reinvigorating training in marketing beyond the tired old, 4Ps plusindustrial examples format. This course will emphasize the interrelatednessof concepts such as multifunctional teams, strategic alliance environmentalsensitivity, interorganizational trust, organizational learning and adherence toethical principles. Furthermore, with the advent of relationship and networktheories, this course emphasises that business marketer must learn not onlyto create value, but also to equitably share value with customer firms.Understanding of business buying and marketing behaviour within the contextof relationship/network theories is the central learning from this proposedelective.Given this background, the overall objectives of this course are to create anunderstanding of the current stateofart of organizational buying behaviour andbusinesstobusiness marketing. **References/Text Books:**	BUSINESS TO BUSINESS MARKETING
MBA637A	3-0-0-0-10		**Course Contents:** Business to Business Marketing encompasses those management activities thatenable a supplier firm to understand, create, and deliver value to otherbusinesses, governments, and/or institutional customers. Business to businessmarketing is also referred to as business market management an industrialmarketing. In year past, the topical area applied largely to industrial manufacturingfirms. Today, business to business	BUSINESS TO BUSINESS MARKETING

			marketing provides practical frameworks,concepts, and tools for organizations as diverse as management consulting firms,investment banks, software solutions providers, and integrated supplymanagement operations, among many other leadingedge technology and servicecompanies.As business to business marketing expands its scope and stature, this courseaims at reinvigorating training in marketing beyond the tired old, 4Ps plusindustrial examples format. This course will emphasize the interrelatednessof concepts such as multifunctional teams, strategic alliance environmentalsensitivity, interorganizational trust, organizational learning and adherence toethical principles. Furthermore, with the advent of relationship and networktheories, this course emphasises that business marketer must learn not onlyto create value, but also to equitably share value with customer firms.Understanding of business buying and marketing behaviour within the contextof relationship/network theories is the central learning from this proposedelective.Given this background, the overall objectives of this course are to create anunderstanding of the current stateofart of organizational buying behaviour andbusinesstobusiness marketing. **References/Text Books:**	
MBA639	3-0-0-0-4		**Course Contents:** Successful Marketing in highly competitive global markets of today needs breakthrough concepts, socially responsible and innovative execution. And mastering that blend entails participatory, immersive learning. This practice oriented course will be based on integrative and investigative projects to consolidate the learning from foundations courses.Course Plan and Modules: 1) Market opportunity recognition and evaluation 2) Generating business models 3) Green and sustainable marketing scenarios 4) Contextual strategies for products, services & brands 5)Emerging perspectives on marketing practices and corporate reputation. **References/Text Books:**	STRATEGIC MARKETING-CONTEMPORARY ISSUES
MBA639A	3-0-0-0-9		**Course Contents:** Successful Marketing in highly competitive global markets of today needs breakthrough concepts, socially responsible and innovative execution. And mastering that blend entails participatory, immersive learning. This practice oriented course will be based on integrative and investigative projects to consolidate the learning from foundations courses.Course Plan and Modules: 1) Market opportunity recognition and evaluation 2) Generating business models 3) Green and sustainable marketing scenarios 4) Contextual strategies for products, services & brands 5)Emerging perspectives 14on marketing practices and corporate reputation. **References/Text Books:**	STRATEGIC MARKETING-CONTEMPORARY ISSUES
MBA640	3-0-0-0-4		**Course Contents:** ModuleI: Intellectual Property Management. Market Capitalization, Intellectual Capital (IC), Components of Intellectual Capital, Tangible and Intangible Assets of Firms, Goodwill, Linkage between IC, Corporate Strategy, and Profits, Relationship between Intellectual Capital and Intellectual Property, Knowledge Economy and the need for Intellectual Property Management, Various Types of Intellectual Property trademarks, Copyrights, Patents, Trade Secrets, and Industrial Design, International IP Treaties/Agreements on IP Rights, Types of Patents, Patenting Advantage, Offensive and Defensive IP Strategies, Global Innovation Indexs and IP Management, Intellectual Property Strategies in Indian Context Universities, CSIR and Commercial Firms ModuleII: The Dynamics of Value Creation and Value Capture. ModuleIII: Patent Mapping. **References/Text Books:**	INTELLECTUAL PROPERTY MANAGEMENT, VALUE CREATION AND VALUE CAPTURE
MBA640A	3-0-0-1-10		**Course Contents:** ModuleI: Intellectual Property Management. Market Capitalization, Intellectual Capital (IC), Components of Intellectual Capital, Tangible and Intangible Assets of Firms, Goodwill, Linkage between IC, Corporate	INTELLECTUAL PROPERTY MANAGEMENT, VALUE CREATION AND VALUE

			Strategy, and Profits, Relationship between Intellectual Capital and Intellectual Property, Knowledge Economy and the need for Intellectual Property Management, Various Types of Intellectual Property trademarks, Copyrights, Patents, Trade Secrets, and Industrial Design, International IP Treaties/Agreements on IP Rights, Types of Patents, Patenting Advantage, Offensive and Defensive IP Strategies, Global Innovation Indexs and IP Management, Intellectual Property Strategies in Indian Context Universities, CSIR and Commercial Firms ModuleII: The Dynamics of Value Creation and Value Capture. ModuleIII: Patent Mapping. **References/Text Books:**	CAPTURE
MBA641	3-0-0-0-4		**Course Contents:** Computers and Management Function, Introduction to an appropriate high levellanguage, Introduction to Data Structures, Computer Organization, SystemConfiguration, Introduction to data base management, management informationsystems, decision support systems and simulation. **References/Text Books:**	COMPUTING FOR MANAGEMENT
MBA641A	3-0-0-0-9		**Course Contents:** Computers and Management Function, Introduction to an appropriate high levellanguage, Introduction to Data Structures, Computer Organization, SystemConfiguration, Introduction to data base management, management informationsystems, decision support systems and simulation. **References/Text Books:**	COMPUTING FOR MANAGEMENT
MBA643	3-0-0-0-4		**Course Contents:** Simulation Philosophy and Methodologies, Review of Basic Probability andStatistics, Random number Generation, Programming Considerations, Languagesand Data Structures, Verification and Validation, Simulation Languages, Animation,Design and Execution of Simulation Experiments, Applications: Case Flow andRisk Analysis by Simulation Using Spreadsheets, Simulation of Production System Inventories, Queues and Production Scheduling. **References/Text Books:**	SIMULATION OF BUSINESS SYSTEMS
MBA643A	3-0-0-0-9		**Course Contents:** Simulation Philosophy and Methodologies, Review of Basic Probability andStatistics, Random number Generation, Programming Considerations, Languagesand Data Structures, Verification and Validation, Simulation Languages, Animation,Design and Execution of Simulation Experiments, Applications: Case Flow andRisk Analysis by Simulation Using Spreadsheets, Simulation of Production System Inventories, Queues and Production Scheduling. **References/Text Books:**	SIMULATION OF BUSINESS SYSTEMS
MBA645	3-0-0--4		**Course Contents:** Foundation Concepts: Basic information systems concepts about the components and the operations, managerial, and strategic roles of information systems; Technology: Major concepts, developments, and managerial implications involved in computer hardware, software, telecommunications and database management: technologies; Applications: How the Internet, intranets, extranets and other information technologies are used in modern information systems to support electronic commerce, enterprise collaboration, business operations, managerial decision making, and strategic advantage; Development: Developing information system solutions to business problems using a systems approach to problem solving and variety of business application development methodologies; Management: The challenges of managing information systems technologies,resources, and strategies, including global IT management, strategic IS planning and implementation, and security and ethical challenges. This course also includes case	MANAGEMENT INFORMATION SYSTEMS

			presentations/discussions along with a final term paper. **References/Text Books:**	
MBA645A	3-0-0-1-10		**Course Contents:** Foundation Concepts: Basic information systems concepts about the components and the operations, managerial, and strategic roles of information systems; Technology: Major concepts, developments, and managerial implications involved in computer hardware, software, telecommunications and database management: technologies; Applications: How the Internet, intranets, extranets and other information technologies are used in modern information systems to support electronic commerce, enterprise collaboration, business operations, managerial decision making, and strategic advantage; Development: Developing information system solutions to business problems using a systems approach to problem solving and variety of business application development methodologies; Management: The challenges of managing information systems technologies,resources, and strategies, including global IT management, strategic IS planning and implementation, and security and ethical challenges. This course also includes case presentations/discussions along with a final term paper. **References/Text Books:**	MANAGEMENT INFORMATION SYSTEMS
MBA646	3-0-0--4		**Course Contents:** Need for integration, Evolution of ERP, Components of ERP, Enterprise evaluation,Business process mapping, Business Process Reengineering ,Understanding andevaluating ERP packages, Technology evaluation, Networking issues, ERPimplementation, Human resource issues and change management, SAP system,Project on SAP system, Case studies **References/Text Books:**	ENTERPRISE INTEGRATION WITH IT
MBA646A	3-0-0-0-9		**Course Contents:** Need for integration, Evolution of ERP, Components of ERP, Enterprise evaluation,Business process mapping, Business Process Reengineering ,Understanding andevaluating ERP packages, Technology evaluation, Networking issues, ERPimplementation, Human resource issues and change management, SAP system,Project on SAP system, Case studies **References/Text Books:**	ENTERPRISE INTEGRATION WITH IT
MBA647	3-0-0-0-4		**Course Contents:** Introduction to Business Process Management (BPM); History; Importance of improving business processes; Drivers and triggers of BPM; Stakeholders; Importance of organizational strategy and process architecture; Selling BPM technology; Critical success factors in a BPM project.Critical implementation aspects for a BPM solution; Importance of a structured approach to implementing BPM; The BPM implementation framework:Organizational strategy phase, process architecture phase, Launch pad phase, Understand phase, Innovate phase, People phase, Develop phase, Implement phase, Realize phase, Sustainable performance phase; Project management; People change management; Leadership.BPM maturity; Embedding BPM within the organization; Methods, tools and techniques of business process modelling, analysis and design.BPM Process Patterns: Basic control patterns, Advanced branching and synchronization patterns, Structural patterns, Multiple instance patterns, State based patterns, cancellation patterns; Business Process Languages.Best practices in BPM; BPM in eBusiness, eCommerce and eGovernment; BPM case studies. **References/Text Books:**	BUSINESS PROCESS MANAGEMENT
MBA647A	3-0-0-0-9		**Course Contents:** Introduction to Business Process Management (BPM); History; Importance of improving business processes; Drivers and triggers of BPM; Stakeholders; Importance of organizational strategy and process architecture;	BUSINESS PROCESS MANAGEMENT

			Selling BPM technology; Critical success factors in a BPM project.Critical implementation aspects for a BPM solution; Importance of a structured approach to implementing BPM; The BPM implementation framework:Organizational strategy phase, process architecture phase, Launch pad phase, Understand phase, Innovate phase, People phase, Develop phase, Implement phase, Realize phase, Sustainable performance phase; Project management; People change management; Leadership.BPM maturity; Embedding BPM within the organization; Methods, tools and techniques of business process modelling, analysis and design.BPM Process Patterns: Basic control patterns, Advanced branching and synchronization patterns, Structural patterns, Multiple instance patterns, State based patterns, cancellation patterns; Business Process Languages.Best practices in BPM; BPM in eBusiness, eCommerce and eGovernment; BPM case studies. **References/Text Books:**	
MBA648	3-0-0-0-4		**Course Contents:** Introduction, Software Quality Practices, Software Quality Benchmarks, Software Quality Economics, Software Quality and the Cost of Ownership, Software Quality and the Cost to Developers, Software Quality and Profitability, Calculating Return on InvestmentSoftware Product Quality, Role of Metrics in Software Quality, Software Quality Attributes, Software Reliability, Software Maintenance, Software Reuse, Software Verification and Validation, Software Inspections:Effectiveness and Efficiency, Unit Analysis and Testing, Intellectual Property Protection for SoftwareSoftware Process Quality: Need, Models and Frameworks, Structure, Classification, Automation, Improvement, Measuring Software Process, Software Development Process Audits, Agile Software Development Quality Assurance, Agile & Iterative Software Development, Agile Software Methods: State oftheArt Requirements Specification using User Stories in Agile Software Development, Handling of Software Quality Defects in Agile Software Development, Agile Quality Assurance Techniques for GUIBased Applications, Software Configuration Management in Agile Software Development, 17Improving Quality by Exploiting Human Dynamics in Agile Methods, Software Quality and Culture, Sustaining Quality, Software Technical Review Process, Case Studies **References/Text Books:**	SOFTWARE QUALITY MANAGEMENT
MBA649	3-0-0-0-4		**Course Contents:** eBusiness Models, Building ecommerce infrastructure, eBusiness challenges,Supplychain, Data exchange standards, Returns, Customer Service, ePayments, security and frauds, Outsourcing, Laws pertaining to ecommerce. **References/Text Books:**	E -COMMERCE
MBA649A	3-0-0-0-9		**Course Contents:** eBusiness Models, Building ecommerce infrastructure, eBusiness challenges,Supplychain, Data exchange standards, Returns, Customer Service, ePayments, security and frauds, Outsourcing, Laws pertaining to ecommerce. **References/Text Books:**	E -COMMERCE
MBA651	3-0-0-0-4		**Course Contents:** Introduction to decision analysis and process. Elementary probability theory,conditional probability, Bayesian decision analysis, EVPI, moment generatingfunctions, the central limit theorem, Descriptive and deductive statistics,Hypothesis testing and Regression **References/Text Books:**	QUANTITATIVE METHODS FOR DECISION MAKING
MBA651A	3-0-0-1-10		**Course Contents:** Introduction to decision analysis and process, Simplex Method, Duality Theory, Network Problems, Elementary probability theory, Decision Sciences, EVPI, random variables, probability distributions,	QUANTITATIVE METHODS FOR DECISION MAKING

			conditional probability, Bayes theorem, moment generating functions, central limit theorem, Descriptive and deductive statistics, Sampling techniques, Estimation, Hypothesis testing and Regression (linear and nonlinear), Student Project (Field research & Data Interpretation based term projects) **References/Text Books:**	
MBA652	3-0-0-0-4		**Course Contents:** Economic questions and data, Review of probability, Review of statistics, Linear regression with one regressor, Hypothesis tests and confidence intervals for ain simple regression, Linear regression with multiple regressors, Hypothesis tests and confidence intervals in multiple regression, Nonlinear regression functions, Regression with binary dependent variable, Regression with panel data, Introduction to Time Series Regression and Forecasting. Estimation of Dynamic Causal Effects, Additional topics in Time Series Regression (VAR, ARCH, GARCH). **References/Text Books:**	STATISTICAL MODELLING FOR BUSINESS ANALYTICS
MBA652A	3-0-0-1-10		**Course Contents:** Economic questions and data, Review of probability, Review of statistics, Linear regression with one regressor, Hypothesis tests and confidence intervals for ain simple regression, Linear regression with multiple regressors, Hypothesis tests and confidence intervals in multiple regression, Nonlinear regression functions, Regression with binary dependent variable, Regression with panel data, Introduction to Time Series Regression and Forecasting. Estimation of Dynamic Causal Effects, Additional topics in Time Series Regression (VAR, ARCH, GARCH). **References/Text Books:**	STATISTICAL MODELLING FOR BUSINESS ANALYTICS
MBA654	3-0-0-0-4		**Course Contents:** ModuleI: Innovation Concepts and Principles. Historical Perspectives, Innovation Myths and Realities, Challenges, Triggers and Sources for Creativity and Innovation, Innovation by individuals, communities and Corporations, Innovators Profile, Innovation Cycle, Phases of Innovation Cycle, Differences between Structured and Unstructured Innovation, Link between Corporate Vision, Strategy and Innovation, Components of Strategic Innovation, Organizational Architecture for Strategic Innovation, The Role of Government Policy in Innovation, The Roles of Venture Capitalists and Business Angels in Innovation, Eight Barriers to Innovation, Twelve Principles for Breaking Innovation Barriers, Innovation Principles for Sustainable Competitive Advantage and Generation of Wealth and ValueModuleII: Innovation Approaches and Frameworks. Incremental, Breakthrough and Disruptive Innovation, Design based Innovation, Open vs. Closed Innovation; Kotlers Four Levels of Innovation: Business Model Innovation, Process Innovation, Market Innovation and Product/Service Innovation; Innovation Frameworks: HansenBirkinshaw, TracyWiersema, SawhneyWolcott; Reverse Innovation, Essential Principles and Practice of Reverse Innovation, Changing the Mind and the Management Model; Jugad Innovation, Essential Principles and Practice of Jugad Innovation, Jugad Innovations Future for Emerging Markets, Illustrative commercial examples for Innovation ModuleIII: Innovation Project. A practical project that illustrates the Innovation principles **References/Text Books:**	INNOVATION FOR SUSTAINABLE BUSINESS ADVANTAGE
MBA654A	3-0-0-0-9		**Course Contents:** ModuleI: Innovation Concepts and Principles. Historical Perspectives, Innovation Myths and Realities, Challenges, Triggers and Sources for Creativity and Innovation, Innovation by individuals, communities and Corporations, Innovators Profile, Innovation Cycle, Phases of Innovation Cycle, Differences between Structured and Unstructured Innovation, Link between Corporate Vision, Strategy and Innovation, Components of Strategic Innovation, Organizational Architecture for Strategic Innovation, The Role of Government Policy in Innovation, The Roles of Venture Capitalists and Business Angels in Innovation, Eight	INNOVATION FOR SUSTAINABLE BUSINESS ADVANTAGE

			Barriers to Innovation, Twelve Principles for Breaking Innovation Barriers, Innovation Principles for Sustainable Competitive Advantage and Generation of Wealth and ValueModuleII: Innovation Approaches and Frameworks. Incremental, Breakthrough and Disruptive Innovation, Design based Innovation, Open vs. Closed Innovation; Kotlers Four Levels of Innovation: Business Model Innovation, Process Innovation, Market Innovation and Product/Service Innovation; Innovation Frameworks: HansenBirkinshaw, TracyWiersema, SawhneyWolcott; Reverse Innovation, Essential Principles and Practice of Reverse Innovation, Changing the Mind and the Management Model; Jugad Innovation, Essential Principles and Practice of Jugad Innovation, Jugad Innovations Future for Emerging Markets, Illustrative commercial examples for InnovationModuleIII: Innovation Project. A practical project that illustrates the Innovation principles **References/Text Books:**	
MBA661	3-0-0-1-4		**Course Contents:** Concepts, Context and decision process in production system; Policy, product and process decisions;Forecasting methods; Product design and process selection; Theory of constraints; Value analysis. Facilities location and layout; Capacity planning; Line balancing; Learning curves, Production planning; Aggregate planning; Lot sizing; Product scheduling. Inventory Management: Inventory costs; EOQ model; Stochastic models and safety stock. Integration; MRP and ERP; Supply chain concepts; JIT and Kanban systems. Quality control; Project management; Managing waiting lines. **References/Text Books:** 1. S. Nahmias; Production and Operations Analysis; McGraw Hill. 2. Cachon and Terwiesch; Matching Supply with Demand; McGraw Hill. 3. W. Stevenson; Operations Management; McGraw Hill.	PRODUCTION AND OPERATIONS MANAGEMENT
MBA661A	3-0-0-1-10		**Course Contents:** Concepts, Context and decision process in production system; Policy, product and process decisions;Forecasting methods; Product design and process selection; Theory of constraints; Value analysis. Facilities location and layout; Capacity planning; Line balancing; Learning curves, Production planning; Aggregate planning; Lot sizing; Product scheduling. Inventory Management: Inventory costs; EOQ model; Stochastic models and safety stock. Integration; MRP and ERP; Supply chain concepts; JIT and Kanban systems. Quality control; Project management; Managing waiting lines. **References/Text Books:** 1. S. Nahmias; Production and Operations Analysis; McGraw Hill. 2. Cachon and Terwiesch; Matching Supply with Demand; McGraw Hill. 3. W. Stevenson; Operations Management; McGraw Hill.	PRODUCTION AND OPERATIONS MANAGEMENT
MBA663	3-0-0--4		**Course Contents:** Total Quality Management, quality management Philosophies, Leadership, Employeeinvolvement and customer Value Evaluation, Kaizin, Problem Solving and QualityManagement, problem solving Fundamentals, Problem Identification, Definition,Diagnosis, Alternative Generation and Evaluation, Elementry concepts relatedto 7 Old and 7 New Tools for quality Assurance, Basic Statistical Concepts, Controlof Accuracy and Precision, Process Capability, SPC, Acceptance Sampling, MILSTD105D. Quality Management Systems, ISO 9000, Quality Engineering, QualityFunction Development, Introduction to Design of Experiments, Process Optimizationand Robust Product Design, Steps to Six Sigma, Management of Service Quality,Management of Software Quality, Course will include projects and industry casestudies. **References/Text Books:**	TOTAL QUALITY MANAGEMENT
MBA663A	3-0-0-1-10		**Course Contents:** Total Quality Management, quality management Philosophies, Leadership, Employeeinvolvement and customer Value Evaluation, Kaizin, Problem Solving and QualityManagement, problem solving Fundamentals, Problem Identification, Definition,Diagnosis, Alternative Generation and Evaluation,	TOTAL QUALITY MANAGEMENT

			Elementry concepts relatedto 7 Old and 7 New Tools for quality Assurance, Basic Statistical Concepts, Controlof Accuracy and Precision, Process Capability, SPC, Process Control Charts, Acceptance Sampling, MILSTD105D. Quality Management Systems, ISO 9000, Quality Engineering, QualityFunction Development, Introduction to Design of Experiments, Process Optimizationand Robust Product Design, Steps to Six Sigma, Management of Service Quality, SERVQUAL, Management of Software Quality, Course will include live industry projects and industry case studies. **References/Text Books:**	
MBA664	3-0-0-0-4		**Course Contents:** Strategic Framework for Supply Chain, Materials Management Functions,Forecasting and market Analysis, Purchasing and Procurement, Physical Supply,Managing Inventories, MRP and Capacity Planning, Inventory Valuation, LogisticalManagement Materials Handling, Warehousing/Storage and Retrieval,Transportation and Distribution, IT and Role of EBusiness, Financial Evaluation. **References/Text Books:**	SUPPLY CHAIN MANAGEMENT
MBA664A	3-0-0-0-10		**Course Contents:** Strategic Framework for Supply Chain, Materials Management Functions,Forecasting and market Analysis, Purchasing and Procurement, Physical Supply,Managing Inventories, MRP and Capacity Planning, Inventory Valuation, LogisticalManagement Materials Handling, Warehousing/Storage and Retrieval,Transportation and Distribution, IT and Role of EBusiness, Financial Evaluation. **References/Text Books:**	SUPPLY CHAIN MANAGEMENT
MBA665	3-0-0-0-4		**Course Contents:** Framework of Manufacturing Planning, Forecasting Models, Hierarchical PlanningSystem, Facility Location and Layout, Resource Scheduling, Flexible Manufacturinganalysis,design and Planning, JustinTime Manufacturing, Simulation andPerformance Evaluation, Lean and Agile Manufacturing. **References/Text Books:**	MANUFACTURING PLANNING AND CONTROL
MBA665A	3-0-0-0-9		**Course Contents:** Framework of Manufacturing Planning, Forecasting Models, Hierarchical PlanningSystem, Facility Location and Layout, Resource Scheduling, Flexible Manufacturinganalysis,design and Planning, JustinTime Manufacturing, Simulation andPerformance Evaluation, Lean and Agile Manufacturing. **References/Text Books:**	MANUFACTURING PLANNING AND CONTROL
MBA666	3-0-0-0-4		**Course Contents:** Characteristics of Projects, Project Economics, Screening and Selection, Evaluation, Structuring Organizational and Work Breakdown, Scheduling, Budgeting,Resource Management, Life Cycle Costing, Project Control, R&D Projects,Computer Supports, Project Termination. Agile Project Management, Privacy and Security. Agile Project Management, Privacy and Security. **References/Text Books:** John Nicholas and Herman Steyn: Project Management for Engineering, Business and Technology, Routledge Taylor and Francis Group, Fourth Edition, Indian Special Edition.	PROJECT MANAGEMENT
MBA666A	3-0-0-1-10		**Course Contents:** Characteristics of Projects, Project Economics, Screening and Selection, Evaluation, Structuring Organizational and Work Breakdown, Scheduling, Budgeting,Resource Management, Life Cycle Costing, Project Control, R&D Projects,Computer Supports, Project Termination. Agile Project Management, Privacy	PROJECT MANAGEMENT

			and Security. Agile Project Management, Privacy and Security. **References/Text Books:** John Nicholas and Herman Steyn: Project Management for Engineering, Business and Technology, Routledge Taylor and Francis Group, Fourth Edition, Indian Special Edition.	
MBA671	3-0-0-0-4		**Course Contents:** Service as Product, Design of Service Systems, Location and Layout of ServiceFacilities, Service Engineering including Work Design, Human Factors, Automationand Communication, Productivity and Service Effectiveness, Network Planningincluding Queuing Networks, Manpower and Resource Scheduling and DistributionPlanning. Professional Service: Achieving differentiation through knowledge andrelationship, Service and Competitive Strategy; Service delivery systems andIT applications; IT enabled services and Technology Convergence; Managing forWorld Class; Service Quality and Service Level best practices for call centersand related services, Cross Cultural issues; Pricing and Transfer Pricing ofConnected Services, Project Implementation, Learning, Innovation and KnowledgeManagement in the Service based business. **References/Text Books:**	MANAGING SERVICE OPERATIONS
MBA671A	3-0-0-0-10		**Course Contents:** Service as Product, Design of Service Systems, Location and Layout of ServiceFacilities, Service Engineering including Work Design, Human Factors, Automationand Communication, Productivity and Service Effectiveness, Network Planningincluding Queuing Networks, Manpower and Resource Scheduling and DistributionPlanning. Professional Service: Achieving differentiation through knowledge andrelationship, Service and Competitive Strategy; Service delivery systems andIT applications; IT enabled services and Technology Convergence; Managing forWorld Class; Service Quality and Service Level best practices for call centersand related services, Cross Cultural issues; Pricing and Transfer Pricing ofConnected Services, Project Implementation, Learning, Innovation and KnowledgeManagement in the Service based business. **References/Text Books:**	MANAGING SERVICE OPERATIONS
MBA675	3-0-0-0-4		**Course Contents:** Role of Infrastructure in Economic Development, Natural Monopoly and Economicsof Infrastructure Regulation, Rate of Return Regulation, Performance BasedRegulation, Pricing for Infrastructure Sector, Role of Subsidies, Reforms in theInfrastructure Sector (Power, Telecom, Roads, Ports, Urban Services) Restructuringand Privatisation in Infrastructure Sector, Reform Acts, Competition in InfrastructureSector (Bulk Power, Telecom, Transportation), Issues in Infrastructure Finance,Modes of Project Financing, Risks in Infrastructure Sector, Development ofInfrastructure Projects BOO, BOOT, BOLT etc. **References/Text Books:**	INFRASTRUCTURE REGULATION, POLICY & FINANCE
MBA675A	3-0-0-0-9		**Course Contents:** Role of Infrastructure in Economic Development, Natural Monopoly and Economicsof Infrastructure Regulation, Rate of Return Regulation, Performance BasedRegulation, Pricing for Infrastructure Sector, Role of Subsidies, Reforms in theInfrastructure Sector (Power, Telecom, Roads, Ports, Urban Services) Restructuringand Privatisation in Infrastructure Sector, Reform Acts, Competition in InfrastructureSector (Bulk Power, Telecom, Transportation), Issues in Infrastructure Finance,Modes of Project Financing, Risks in Infrastructure Sector, Development ofInfrastructure Projects BOO, BOOT, BOLT etc. **References/Text Books:**	INFRASTRUCTURE REGULATION, POLICY & FINANCE
MBA676	3-0-0--4		**Course Contents:**	SECURITY ANALYSIS,

			Financial Markets, Investment Alternatives, Risk and Return, Portfolio Theoryand Capital Asset Pricing, Capital Asset Pricing Theory and Arbitrate PricingTheory, Efficient Market Hypothesis, Security Analysis and Valuation, Valuationof equity and Fixedincome securities, Fundamental Analysis, Technical Analysis,Investment Strategies, Derivatives, Options, Futures, Swaps, BlackScholesmodel, Value at risk, Estimating volatility and correlations, Hedging and PortfolioManagement. **References/Text Books:**	DERIVATIVES & PORTFOLIO MANAGEMENT
MBA676A	3-0-0-0-9		**Course Contents:** Financial Markets, Investment Alternatives, Risk and Return, Portfolio Theoryand Capital Asset Pricing, Capital Asset Pricing Theory and Arbitrate PricingTheory, Efficient Market Hypothesis, Security Analysis and Valuation, Valuationof equity and Fixedincome securities, Fundamental Analysis, Technical Analysis,Investment Strategies, Derivatives, Options, Futures, Swaps, BlackScholesmodel, Value at risk, Estimating volatility and correlations, Hedging and PortfolioManagement. **References/Text Books:**	SECURITY ANALYSIS, DERIVATIVES & PORTFOLIO MANAGEMENT
MBA677	3-0-0--4		**Course Contents:** Generation and Screening of Project Ideas, Project Appraisal and Evaluation,Financial Projections, Investment Criteria, Cost Benefit Analysis, Project Finance,Financing Infrastructure Projects, Sources of Finance, Multilateral ProjectFinancing, Consortium Financing, Venture Capital, Risk Analysis, Project LifeCycle, Techniques for Project Management. **References/Text Books:**	PROJECT FINANCING & MANAGEMENT
MBA677A	3-0-0-0-10		**Course Contents:** Generation and Screening of Project Ideas, Project Appraisal and Evaluation,Financial Projections, Investment Criteria, Cost Benefit Analysis, Project Finance,Financing Infrastructure Projects, Sources of Finance, Multilateral ProjectFinancing, Consortium Financing, Venture Capital, Risk Analysis, Project LifeCycle, Techniques for Project Management. **References/Text Books:**	PROJECT FINANCING & MANAGEMENT
MBA678	3-0-0--4		**Course Contents:** Concept of Risk and Risk Management., Different types of Risks like SystematicRisk, Interest Rate Risk, Liquidity Risk, Operational Risk, Regulatory Risk,Market Risk, Foreign Exchange Risk, Commodity Price Risk, Industry ConcentrationRisk, Environmental Risk, Counter party Risk, Credit Risk, Legal Risk, RegulatoryRisk etc. Methods of identifying and measuring different types of risks. Useof Risk Models. Methods of Risk control and Management, i.e., requirementof active Risk Management techniques through use of VaR model; monitoringof ALM (Asset Liability Management); use of derivatives like currency swaps,interest rate futures, forward rate agreements etc. **References/Text Books:**	MANAGEMENT OF RISK IN FINANCIAL SYSTEM
MBA678A	3-0-0-0-9		**Course Contents:** Concept of Risk and Risk Management., Different types of Risks like SystematicRisk, Interest Rate Risk, Liquidity Risk, Operational Risk, Regulatory Risk,Market Risk, Foreign Exchange Risk, Commodity Price Risk, Industry ConcentrationRisk, Environmental Risk, Counter party Risk, Credit Risk, Legal Risk, RegulatoryRisk etc. Methods of identifying and measuring different types of risks. Useof Risk Models. Methods of Risk control and Management, i.e., requirementof active Risk Management techniques through use of VaR model; monitoringof ALM (Asset Liability Management); use of derivatives like currency swaps,interest rate futures, forward rate agreements etc.	MANAGEMENT OF RISK IN FINANCIAL SYSTEM

			References/Text Books:	
MBA679	3-0-0-0-4		**Course Contents:** The course will deal with the theory, tools and techniques necessary for efficient modeling and management of risk in financial services with emphasis on commercial banking. At the macro level emphasis is placed on the effect of regulatory and country specific factors on the functioning and the adherent risk in the operation of a commercial bank. At the micro level various facets of risk management which include interest rate, credit and market risk are covered in sufficient depth. The course also covers related topics in derivative pricing and hedging and application of option valuation models in modeling and managing the above risk. The course does not have a specific text book and consists of prescribed readings provided by the instructor. **References/Text Books:**	COMMERCIAL BANKING, RISK MODELING AND RISK MANAGEMENT
MBA679A	3-0-0-0-10	MBA601A & MBA607A	**Course Contents:** The course will deal with the theory, tools and techniques necessary for efficient modeling and management of risk in financial services with emphasis on commercial banking. At the macro level emphasis is placed on the effect of regulatory and country specific factors on the functioning and the adherent risk in the operation of a commercial bank. At the micro level various facets of risk management which include interest rate, credit and market risk are covered in sufficient depth. The course also covers related topics in derivative pricing and hedging and application of option valuation models in modeling and managing the above risk. The course does not have a specific text book and consists of prescribed readings provided by the instructor. **References/Text Books:**	COMMERCIAL BANKING, RISK MODELING AND RISK MANAGEMENT
MBA681	3-0-0-0-4		**Course Contents:** Energy and Economic Development: National and International Perspective, Structure of Energy Demand and Supply,, Energy Value Chain and Energy Accounting, India Energy Scenario 2047, Economics of Energy and Exhaustible Resources , Energy Security, Energy Policy and Planning, Modelling for Energy Markets: Applications in General Algaebric Modelling System (GAMS), International Markets for Energy: Oil, Coal, Natural Gas and Uranium, Indian Energy Markets: Oil & Gas, Coal and Electricity, Private Investment in Energy Sectors: NELP, Coal Policy, Power Policy, Regulation of Indian Energy Sectors Electricity, Oil & Gas and Coal Sectors, Pricing in Energy Markets: Electricity, Coal, Oil and Natural Gas, Functioning of Power Exchange and Commodity Exchanges (Energy), Cross Border Energy Cooperation, Energy and Environment, Climate Change, UNFCC, Kyoto Protocol and beyond, Clean Development Mechanism and its Process, International Carbon Markets and Carbon Finance, National Action Plan on Climate Change, JNN National Solar Mission, Renewable Energy: Technology, Economics and Policy, Market for Renewable Energy Certificates, Energy Conservation, Market for Energy Efficiency: ESCO and Market for Ecerts (White Certificates). One project work on relevant topic. **References/Text Books:** Recommended Test: 1. Environmental and Natural Resource Economics, Tom Tietenberg, AddisonWesley, 2000. 2. International Energy Markets: Understanding Pricing, Policies, and Profits, Carol Dahl, Penn Well Books, ISBN: 9780878147991, 2004.3. Energy Efficiency: Principles and Practices, Penni McLeanConner, ISBN: 9781593701789, 2009.4. Economics of Regulation and Antitrust Viscusi, Vernon & Harrington, MIT Press, 2000.5. Integrated Energy Policy, Report of the Expert Committee, Govt. of India, Planning Commission, New Delhi, August 2006.6. Relevant Publications of World Energy Council and International Energy Agency, World Bank and Asian Development Bank.7. Relevant reports of respective Ministries.8. Other relevant journal articles, reports, policy documents, regulations of regulatory commissions, case studies and class notes.	ENERGY AND CARBON MARKETS: ECONOMICS, POLICY AND REGULATION
MBA681A	3-0-0-1-10		**Course Contents:** Energy and Economic Development: National and International Perspective, Structure of Energy Demand and Supply,, Energy Value Chain and Energy Accounting, India Energy Scenario 2047, Economics of	ENERGY AND CARBON MARKETS: ECONOMICS, POLICY AND REGULATION

			Energy and Exhaustible Resources , Energy Security, Energy Policy and Planning, Modelling for Energy Markets: Applications in General Algaebric Modelling System (GAMS), International Markets for Energy: Oil, Coal, Natural Gas and Uranium, Indian Energy Markets: Oil & Gas, Coal and Electricity, Private Investment in Energy Sectors: NELP, Coal Policy, Power Policy, Regulation of Indian Energy Sectors Electricity, Oil & Gas and Coal Sectors, Pricing in Energy Markets: Electricity, Coal, Oil and Natural Gas, Functioning of Power Exchange and Commodity Exchanges (Energy), Cross Border Energy Cooperation, Energy and Environment, Climate Change, UNFCC, Kyoto Protocol and beyond, Clean Development Mechanism and its Process, International Carbon Markets and Carbon Finance, National Action Plan on Climate Change, JNN National Solar Mission, Renewable Energy: Technology, Economics and Policy, Market for Renewable Energy Certificates, Energy Conservation, Market for Energy Efficiency: ESCO and Market for Ecerts (White Certificates). One project work on relevant topic. **References/Text Books:** Recommended Test: 1. Environmental and Natural Resource Economics, Tom Tietenberg, AddisonWesley, 2000. 2. International Energy Markets: Understanding Pricing, Policies, and Profits, Carol Dahl, Penn Well Books, ISBN: 9780878147991, 2004.3. Energy Efficiency: Principles and Practices, Penni McLeanConner, ISBN: 9781593701789, 2009.4. Economics of Regulation and Antitrust Viscusi, Vernon & Harrington, MIT Press, 2000.5. Integrated Energy Policy, Report of the Expert Committee, Govt. of India, Planning Commission, New Delhi, August 2006.6. Relevant Publications of World Energy Council and International Energy Agency, World Bank and Asian Development Bank.7. Relevant reports of respective Ministries.8. Other relevant journal articles, reports, policy documents, regulations of regulatory commissions, case studies and class notes.	
MBA683A	3-0-0-0-9		**Course Contents:** Electricity value chain and economic development. Structure of Electricity Demand and Supply: Power Sector Scenario in India. Theories of Regulation and Economics of Regulation. Power Sector Reform and Regulation: International and Indian Experience. Electricity Act 2003 and related policies including National Electricity Policy, National Tariff Policy, Rural Electrification Policy.Regulatory Process: Functions of Electricity Regulatory Commissions and APTEL. Rate of Return Regulation and Performance Based Regulation. Determining Aggregate Revenue Requirement and Tariffs for Regulated Entities. Availability Based Tariff and Multiyear Tariff. Principles of Retail Tariff Design Single Part, Multipart, TOD Tariffs etc. Unbundling, Privatization and Franchisee Development. Power Purchase Agreement. Competitive Bidding Guidelines & Ultra Mega Power Projects. Competition in Power Sector: Open Access and Retail Competition. Functioning of Power Exchanges and Market Monitoring. Distribution Reforms and Performance incl. RAPDRP and RGGVY. Regulatory Approach to Promote Renewable Energy: Renewable Portfolio Obligation, FeedinTariff and Renewable Energy Certificates.Demand Side Management. Consumer issues in electricity sector **References/Text Books:** 1.Electricity Markets, Harris,Chris, John Wiley, 2006. 2.Electricity Economics: Electricity Economics: Regulation and Deregulation, Geoffrey Rothwell, Toms Gmez, Wiley IEEE Press, 2003. 3. Economics of Regulation and Antitrust Viscusi, Vernon & Harrington, MIT Press, 2000. 4.Economics of Regulation Alfred Kahn. MIT Press, 1998.5. India Infrastructure Reports 3iNetwork, OUP. 6. Power System Economics: Designing Markets for Electricity, Steven Stoft, Wiley IEEE Press, 2001. 7. Privatisation, Restructuring and Regulation of Network Utilities David M. Newbery, MIT Press, 2001.8. Other relevant books, journal articles, reports, laws, policy documents, regulations and tariff orders of regulatory commissions, forum of regulators, case studies and class notes.	POWER SECTOR REFORM & REFORM AND REGULATION
MBA697	0-0-0--0		**Course Contents:** During the summer after first two semesters, each student will take up a summerproject in an industrial or service organization for 810 weeks. During this period,the student will work under the guidance of an executive of the host organization,complete the assignment, prepare a written report, and make a	SUMMER PROJECT

			presentationduring the third semester. **References/Text Books:**	
MBA697A	0-0-0-0-0		**Course Contents:** During the summer after first two semesters, each student will take up a summerproject in an industrial or service organization for 810 weeks. During this period,the student will work under the guidance of an executive of the host organization,complete the assignment, prepare a written report, and make a presentationduring the third semester. **References/Text Books:**	SUMMER PROJECT
MBA698	----0		**Course Contents:** Management Seminars **References/Text Books:**	MANAGEMENT SEMINARS
MBA698A	0-0-0--0		**Course Contents:** Management Seminars **References/Text Books:**	MANAGEMENT SEMINARS
MBA699	----4		**Course Contents:** In this course, each student will take up a management project or management topic under the guidance of a specific faculty. Towards the end of the semester, the student will present a final report of the project. **References/Text Books:**	PROJECT I
MBA699.	----4		**Course Contents:** In this course, each student will take up a management project or management topic under the guidance of a specific faculty. Towards the end of the semester, the student will present a final report of the project. **References/Text Books:**	PROJECT I
MBA699A	0-0-0-0-9		**Course Contents:** In this course, each student will take up a management project or management topic under the guidance of a specific faculty. Towards the end of the semester, the student will present a final report of the project. **References/Text Books:**	CAPSTONE PROJECT
MBA711A	3-0-0-0-5		**Course Contents:** Understanding Organizational Change: Definition and Types, Systems Perspective, Identification and Assessment of Factors Leading to Change, Change Management Process: An Overview, Resistance to the Process of Change, Reasons and Mitigating Measures, Lewin's Process, Constructive Destruction, Role of IT in Change Management, Business Process Reengineering, Appreciative Inquiry, Change Management through OD Intervention. **References/Text Books:** 1. Grieves, J. (2010). Organizational Change: Themes and Issues. Oxford. 2. Brown, D., & Harvey, D. (2206). An Experiential Approach to Organizational Development. Pearson. 3. Cummings, C.G. & Worley, C.G. (2005). Organizational Development and Change. Thomson.4. Additional readings: relevant cases and articles.	CHANGE MANAGEMENT AND ORGANIZATIONAL DEVELOPMENT
MBA712A	3-0-0-0-5		**Course Contents:**	ORGANIZATIONAL

			Introduction to Organizational Staffing: Steps and Strategic Linkages; Manpower Planning; Job Analysis Techniques; Competency Based Staffing; Models and Mapping Techniques; External and Internal Recruitment Process; External and Internal Selection Process; Concept of Measurement, Reliability and Validity; Selection Methods and Tools: Utility, Relevance and Applicability; Organizational Socialization and Deployment; Succession Planning and Career Progression; Use of IT in Staffing; Other Emerging Issues. **References/Text Books:** 1. Herbert G. Heneman & T.A. Judge, Staffing Organizations. McGraw Hill. 2. Phillips, J. M. Strategic Staffing. Prentice Hall. 3. Additional readings: relevant cases and articles.	STAFFING
MBA713A	3-0-0-0-5		**Course Contents:** Objectives of Performance Mangement, Historical Account, Performance Planning: Synchronization with Organization's vision, mission, strategy and goals, Issues and Problems, Defining and Measureing Performance, Methods of Performance Appraisal, Communication of Feedback, 360 degree Performance Feedback, Rewards and Recognition, Career Management, Role of Performance Management in fostering Employee Engagement, Re designing Jobs for better Performance, Key Implications of Performance Management, Legal and Ethical Perspectives. **References/Text Books:** 1. Aguinis, H. Performance Management (3rd ed.). McGraw Hill. 2. Cardy, R.L. & Leonard, B. Performance Management: Concepts, Skills and Exercises (2nd ed.). M. E. Sharpe.3. Rao, T.V. Performance Management and Appraisal Systems: HR Tools for Global Competitiveness. Sage. 4. Additional readings: relevant cases and articles.	PERFORMANCE MANAGEMENT
MBA781A	3-0-0-0-5		**Course Contents:** Infrastructure, Economic Development and need for PPP. Definition and scope of infrastructure. Economics of infrastructure Natural Monopoly. Modes of PPP. Policy Framework for Infrastructure Investment in India VGF and its alternatives. Structuring a PPP Project Proposal RPQ & RFP. Selected Case Studies from Power, Roads, WTE, Railways, Metro, Ports, Airports etc. Policy Framework for PPP Across Major Sectors. Global Best Practices for PPP Projects. Dealing with Unsolicited Bids The Swiss Challlange. Projects Caselets A Case Analysis of a PPP Project (on mutually agreed topic). **References/Text Books:** 1. E.R. Yescommbe, Public Private Partnerships Priciples of Policy and Finance, Elsevier Finance (2007). 2. A Guidebook on Public Private Partnership in Infrastructure, UNESCAP, Bangkok, 2011. 3. "A World Bank Resource for PPPs in Ifrasctructure", ppp.worldbank.org. 5. PPP Toolkit, http://toolkit.pppinindia.com. 6. "Database of Infrastrcture Projects in India", https://infrastructureindia.gov.in/. 7. India Infrastructure Reports 3iNetwork, OUP. 8. Other relevant books, journal articles, reports, laws, policy documents, regulations and tariff orders of regulatory commissions, forum of regulators, case studeis and class notes.	PUBLIC PRIVATE PARTNERSHIP (PPP) IN INFRASTRUCTURE
MBA782A	3-0-0-0-5		**Course Contents:** Drivers for Renewable Energy. RES Wind, Solar, Biomass, SHP, Ocean, WTE etc. RE Development National and International Perspective. Economics of Renewable Energy. Policy and Regulatory Instruments to Promote RE. Electricity Act 2003 and other relevant legislations policies. Renewable Portfolio Obligationa and Feed in Tariff. Market for Renewable Energy Certificates (RECs). NAPCC and Jawaharlal Nehru National Solar Mission. Competitive Bidding for Renewable Energy. Developing and Implementing a Solar Rooftop Program. Challenges for VRE integration Forecasting and Solutions. Climate Change and Green Energy Finance : Business Models. Projects Caselets on mutually agreed topics. **References/Text Books:** 1. Miguel Mendonca, Feed in Tariff, Earthscan, 2007. 2. Evaluating Policies in Support of the Development of Renewable Power. 3. REN21. Renewables 2015, Global Status Report. 4. Re Policy Database. 5. Indian Renewable and Energy Efficiency and Policy Database.6. Other relevant books, journal articles, reports,	RENEWABLE ENERGY - ECONOMICS, POLICY AND REGULATION

			laws, policy documents, regulations and tariff orders of regulatory commissions, forum of regulators, case studies and class notes.	
** Department of LT **				
LT601	3-0-0--4		**Course Contents:** Introduction to general lasers and their types, Brief intro. quantum physics,Schrodinger wave eqn., Atomic systems, emission and absorption processes,Population inversion, gain, optical cavities, three and four level lasers, CWand pulsed lasers, Qswitching and modelocking, Physics of gas discharge,Atomic, Ionic, molecular, liquid, and excimer lasers, Optical pumping. **References/Text Books:**	INTRODUCTION TO LASERS
LT611	3-0-0--4		**Course Contents:** Atomic, ionic, molecular, excimer and liquid laser systems and applications, Solidstate lasers. Short Pulse generation and measurement. Laser applications inmedicine and surgery, Materials processing, Optical Communication Lasers,Metrology and LIDAR. **References/Text Books:**	LASER SYSTEMS AND APPLICATIONS
LT631	3-0-3--4		**Course Contents:** Maxwell eqns. and electro magnetic waves, Wave properties of light andpropagation. Waveguides, Optical resonators. Ray Optics, Matrix methods,Optical Anisotropic materials. Interference and interferometers, Diffractionand Fourier Optics, Optical components (Laser mirrors, windows, Polarizors,Holography, Meteorology. **References/Text Books:**	INTRODUCTION TO COHERENT AND LASER OPTICS
LT699	----		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
LT799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
** Department of MDES **				
DES601	2-0-2--4		**Course Contents:** Design Philosophy, Art (aesthetics) in ID, History of Design, Human Experiencein Design, Design Elements, Design Principles, Theory of Colour, Colour Aesthetics,Subject of Colour, Design Paradigm, Art Design & Society, Indian Tradition andProducts.Studio: Form, Space and Texture; 2D and 3D Form Analysis, Colour and Texturein 2D and 3D surface; Colour Aesthetics; Product Analysis and Ergonomics,Product Design and Developments. **References/Text Books:**	DESIGN THEORY
DES601A	2-0-3-0-9		**Course Contents:** Design Philosophy, Art (aesthetics) in ID, History of Design, Human Experiencein Design, Design Elements, Design Principles, Theory of Colour, Colour Aesthetics,Subject of Colour, Design Paradigm, Art Design & Society, Indian Tradition andProducts.Studio: Form, Space and Texture; 2D and 3D Form Analysis, Colour	DESIGN THEORY

			and Texturein 2D and 3D surface; Colour Aesthetics; Product Analysis and Ergonomics,Product Design and Developments. **References/Text Books:**	
DES602	2-0-2-0-4		**Course Contents:** Stages of a Product and Concurrent Engineering; Problem Formulation, Specificationsand Constraints; Creating Forms; Configuration Optimisation; Coupled, Decoupledand Uncoupled designs; Product of Static and Dynamic Societies; MaterialExperimentation; Construction Technique; Model Building; Decision Making,Addressing Failures and Courage to Create; Interpersonal Skills; Robust Design,Incubation; Economic Considerations; Micro and Macro Designs; Introduction toElectronics; Laboratory on Problem Formulation, Innovation, Decision Making,Interpersonal Skills, etc., through Group Discussion, Case studies, Books andJournals Review. **References/Text Books:**	DESIGN PRACTICE I
DES602A	2-0-3-0-9		**Course Contents:** Stages of a Product and Concurrent Engineering; Problem Formulation, Specificationsand Constraints; Creating Forms; Configuration Optimisation; Coupled, Decoupledand Uncoupled designs; Product of Static and Dynamic Societies; MaterialExperimentation; Construction Technique; Model Building; Decision Making,Addressing Failures and Courage to Create; Interpersonal Skills; Robust Design,Incubation; Economic Considerations; Micro and Macro Designs; Introduction toElectronics; Laboratory on Problem Formulation, Innovation, Decision Making,Interpersonal Skills, etc., through Group Discussion, Case studies, Books andJournals Review. **References/Text Books:**	DESIGN PRACTICE I
DES603	2-0-3-0-4		**Course Contents:** Construction of Forms, Geometrical Transformations; Surface Modeling;Representation of 3D Shapes; Solid Modeling; Simulation in CAED, RapidPrototyping & Tooling; Strength and Stiffness of Structural Elements andMechanisms; Introduction to Control; Electronics Signal Processing; Sensors andActuators; Micro ElectroMechanical Systems; Mechatronics; Design of EmbeddedSystems; Intelligent Product Design.Laboratory: 2D3D Modeling, Operation of Rapid Tooling and PrototypingInstruments, Development of Simple Sensors and Actuators, Design of Productswith Embedded Sensors etc. **References/Text Books:**	DESIGN PRACTICE II
DES621	2-0-3-0-4		**Course Contents:** Theory: Art movements and design : Principles of style in art, product design,architecture and graphic design : Photography : Design and performing art :Art and perception : Methodology of criticism and appreciation.Studio: Short workshops, projects, and field trips in the above mentioned areas(photography, film making, lights, stage craft, script writing, editing, productdevelopment) to emphasize visualization powers in an attempt to build a personalvision. **References/Text Books:**	CREATIVE VISUALIZATION
DES621A	2-0-3-0-9		**Course Contents:** Theory: Art movements and design : Principles of style in art, product design,architecture and graphic design : Photography : Design and performing art :Art and perception : Methodology of criticism and appreciation.Studio: Short workshops, projects, and field trips in the above mentioned areas(photography, film making, lights, stage craft, script writing, editing, productdevelopment) to emphasize visualization powers in an attempt to build a personalvision.	CREATIVE VISUALIZATION

			References/Text Books:	
DES623	2-0-3-0-4		**Course Contents:** Topics in motion pictures require a combined practical and theoretical approachfor realizing the creative media in its totality. The proposed course would offerstudents the opportunity to acquire a range of transferable and practical skillsin film and television productions.Concise and brief history of motion pictures; Analysis and a general approachto the criticism of film and television media; Approach and methods in theseforms of media productions; Overview of the digital media arts field with anemphasis on technological developments and their integration in art researchand production.Students would be introduced to contemporary and historical directions, keyconcepts and methodologies through seminar lectures, research presentations,practical exercises and a final project. Classes would be supplemented withviewing a range of productions, individual and group critiques, presentations,demonstrations and practical exercises to explore traditional and modernmethods and explore both technical and creative approaches to the medium.The course will also include short workshops supported by specialized professionalsin the related fields. **References/Text Books:**	TOPICS IN MOTION PICTURES
DES623A	2-0-3-0-9		**Course Contents:** Topics in motion pictures require a combined practical and theoretical approachfor realizing the creative media in its totality. The proposed course would offerstudents the opportunity to acquire a range of transferable and practical skillsin film and television productions.Concise and brief history of motion pictures; Analysis and a general approachto the criticism of film and television media; Approach and methods in theseforms of media productions; Overview of the digital media arts field with anemphasis on technological developments and their integration in art researchand production.Students would be introduced to contemporary and historical directions, keyconcepts and methodologies through seminar lectures, research presentations,practical exercises and a final project. Classes would be supplemented withviewing a range of productions, individual and group critiques, presentations,demonstrations and practical exercises to explore traditional and modernmethods and explore both technical and creative approaches to the medium.The course will also include short workshops supported by specialized professionalsin the related fields. **References/Text Books:**	TOPICS IN MOTION PICTURES
DES624	2-0-2-4-4		**Course Contents:** The course intends to develop the following areas(i) Elements of Design value, color, form, shape, line and texture. Eachelenment is to be examined theoretically along with studio exercises andevaluated through consumer products (2D & 3D).(ii) Principal of Design would evaluate contrast, rhythm, unity, emphasis,pattern, movement, and balance on the basis of Design Elements. Thecourse proposes to develop through understanding of the elements andprinciples of design and their corelationship.The course intends in developing understanding on the above issues andexecutes projects to examine elements and principles of design. Studentsare expected to develop knowledge and practical skill through theoreticaland practical training. Students are required to develop products, giveseminars and submit research paper on chosen topics. **References/Text Books:**	ELEMENTS AND PRINCIPAL OF DESIGN
DES625	2-0-2--4		**Course Contents:** Theory : Form envelops and assists function and in the process creates a networkof values that is termed as Style. Studies in form and style concerns theconceptualization, exploration, and development of form and style in bothproduct design and Visual commnication. The course will explore various basesfor creative visualization like Fantasy. Metaphors, Cultural connotations andBionics in the context of form making.From analysis Analysis of principles of form in relation with society study ofevolution of forms in products 2D and 3D space analysis Dominant sub dominant subordinate relationship, Recall of forms Tensile design Motion andform, Light space analysisFor Visual communication form will ne explored in the context of conceptcommunicationand the application of information theory to visual structures.This will include case	FORM AND STYLE

			studies of advertisement campaigns like Amul Silk cuntetc.The course evaluates patterns of aesthetic, ergonomic and market behaviortowards forms.Studio: Form development assignments in both Product and visual communicationswill deal with the evolution of form in relation with exploration and function.Each assignment will complete the design process and its various stages fromconceptualization, comparative studies, and usability issues to market trendsas related to the study of Form. The study of the design process will help inunderstanding the shifts between analytical and creative phases in differentstages of design that is conceptualizattion and manufacturability gaps.Various visual structures and alternative display formats wiill be explored throughthe assignments.The course is envisaged in collaboration with assignments from the industrywherever possible in which the primary work will take place in the Lab andthe critical evaluatiion in the industry. The course requires extensive field studyfor usability and market trends. **References/Text Books:**	
DES625A	2-0-3-0-9		**Course Contents:** Theory : Form envelops and assists function and in the process creates a networkof values that is termed as Style. Studies in form and style concerns theconceptualization, exploration, and development of form and style in bothproduct design and Visual commnication. The course will explore various basesfor creative visualization like Fantasy. Metaphors, Cultural connotations andBionics in the context of form making.From analysis Analysis of principles of form in relation with society study ofevolution of forms in products 2D and 3D space analysis Dominant sub dominant subordinate relationship, Recall of forms Tensile design Motion andform, Light space analysisFor Visual communication form will ne explored in the context of conceptcommunicationand the application of information theory to visual structures.This will include case studies of advertisement campaigns like Amul Silk cuntetc.The course evaluates patterns of aesthetic, ergonomic and market behaviortowards forms.Studio: Form development assignments in both Product and visual communicationswill deal with the evolution of form in relation with exploration and function.Each assignment will complete the design process and its various stages fromconceptualization, comparative studies, and usability issues to market trendsas related to the study of Form. The study of the design process will help inunderstanding the shifts between analytical and creative phases in differentstages of design that is conceptualizattion and manufacturability gaps.Various visual structures and alternative display formats wiill be explored throughthe assignments.The course is envisaged in collaboration with assignments from the industrywherever possible in which the primary work will take place in the Lab andthe critical evaluatiion in the industry. The course requires extensive field studyfor usability and market trends. **References/Text Books:**	FORM AND STYLE
DES626	2-0-2--4		**Course Contents:** Interaction Design defines behavioral pattern and builds the performance levelof technical, environmental, biological and organizational systems i.e. software,products, mobile devices, environments, services, wearable, and even organizationsthemselves to name a few. The behavior or the "interaction" of a manufacturedarticle or a scheme in response to its usergroup is the primary concern ofthis topic in design. Students are expected to collect information through userresearch following the various user research methodologies, generate interactivescenarios and strategies, design stressing upon behaviour as well as form, andconsider the evaluation process of design in terms of usability and emotionalfactors and propose solutions for the ease of use in physical or virtual productsor a system. Interactive objects, spaces and services are concieved taking intoconsideration the different design concerns as well as by exploiting Informationand Communication Technogy (ICT) potentialities as term projects. **References/Text Books:**	INTERACTION DESIGN
DES627	2-0-2--4		**Course Contents:** Identification of Opportunities and the creative mind, Problem Based ideation,Creative Problem solving, Market Innovation and Brands, Strategy and Organizationfor the Creative Business, Networks and Collaboration for Design Innovationand cultural Industries, Competitive Design performance Management	MANAGEMENT OF DESIGN AND INNOVATION

			for theDesign Business over the Life Cycle. **References/Text Books:**	
DES628	2-0-2--4		**Course Contents:** Understanding the Dynamics of Indian Society : Social Units and Institutions,Cultural Adaptations, Exploring Culture : Attributes, Cultural Practices, CulturalGrowth and Cultural Integration , Methods of cultural Inquiry : ComparativeMethods, Fieldwork, Ethnographic Study, and Perspective on Design trends,Indigenous Design Culture : Proletarian Design Innovations, Role of Design withinSocietal Structure and Cultural Framework and Understanding Users, UserExperience Design : UE Research Tecniques, Trend Mapping : Research Methodologyassessing,scoping, digging and refining the data, information, knowledge andinsight layers ; Cultural triangulationhow observation, interrogation and intuitionadd the key and core vital layer to understanding the data assessed, theknowledge acquired and the insights delivered; Quantitative sampling; Visualand trend mapping techniques turning insights into market strategies; Usingforecasting to develop products and new brand directions. **References/Text Books:**	DESIGN, CULTURE AND SOCIETY
DES629	2-0-2-0-4		**Course Contents:** Contemporary Art Theory & Practice, Art and its implications Society & Culture,Role of Art and Artist in Socio Cultural Framework, Understanding Visual CultureHistorical and Global Perspective, Methodology for Critical Thinking in thecontext of Art Appreciation, Principles and Norms of Art, Communication in VisualArts, Relative studies in diverse cultural expressions. **References/Text Books:**	INTRODUCTION TO CRITICAL ART APPRECIATION
DES681	0-0-6--4		**Course Contents:** Introduction to Graphics, Introduction to Graphics Software, Introduction toStyle, Introduction to Multimedia Application, Introduction to CAD Application,User Consumer Interaction Study, Media Communication, Ergonomics, MaterialExploration. **References/Text Books:**	DESIGN PROJECT I
DES681A	1-0-6-0-9		**Course Contents:** Introduction to Graphics, Introduction to Graphics Software, Introduction toStyle, Introduction to Multimedia Application, Introduction to CAD Application,User Consumer Interaction Study, Media Communication, Ergonomics, MaterialExploration. **References/Text Books:**	DESIGN PROJECT I
DES682	2-0-6-0-4		**Course Contents:** Manufacturability Studies, Embedded products, Product styling, Package Designing,Information design, HCI, GUI, Animation, Film appreciation, Print Making. **References/Text Books:**	DESIGN PROJECT II
DES682A	1-0-6-0-9		**Course Contents:** Manufacturability Studies, Embedded products, Product styling, Package Designing,Information design, HCI, GUI, Animation, Film appreciation, Print Making. **References/Text Books:**	DESIGN PROJECT II
DES689	2-0-3-0-4		**Course Contents:**	TOPICS IN DESIGN

			Lectures and Workshops on Various Topics in Design like Ergonomics, GraphicDesign and Typography, Design Management, Visual Image Design, Compositionand Media Art, Aesthetics and Forms, Role of Design in ICT, Auto Design, ProductSimulation, Packaging Design, Sustainable Design through Practical Exercises,Studio Projects, Field Trips. **References/Text Books:**	
DES698	0-0-0--4	#	**Course Contents:** Cognitive Design; Design Management; Human factors in Ergonomics Design;Usability & Usercentric Design; Axiomatic Design; Human Computer InterfaceDesign (HCI), etc. **References/Text Books:**	SPECIAL STUDIES/PROJECT COURSES IN DESIGN
DES698A	0-0-0-0-9		**Course Contents:** Cognitive Design; Design Management; Human factors in Ergonomics Design;Usability & Usercentric Design; Axiomatic Design; Human Computer InterfaceDesign (HCI), etc. **References/Text Books:**	SPECIAL STUDIES/PROJECT COURSES IN DESIGN
DES699	0-0-0--		**Course Contents:** M. Des. Thesis **References/Text Books:**	M DES THESIS
DES699B	0-0-0--4		**Course Contents:** M DES THESIS **References/Text Books:**	M DES THESIS
DES799	-0-0-0-		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PH.D THESIS
***** Department of ME *****				
ESO202	3-1-0-1-4		**Course Contents:** Introduction & scope of thermodynamics; system, thermodynamic state & equilibrium, work & heat,zeroth law, temperature scale, properties of pure substances, tables of thermodynamic properties, I law ofthermodynamics: internal energy, enthalpy, specific heats; application of I law to (i) nonflow, (ii) flow,(iii) transient flow processes, (iv) chemical reactions; II law: heat engines and refrigerators, KelvinPlanckand Clausius statements, Reversible and irreversible processes, Carnot cycle and efficiency,Thermodynamic temperature scale, Clausius inequality, Entropy, II law analysis of CV, Availability, IIlaw efficiency, Thermodynamic relations & potentials; Clayperon equation; Phase rule, Power andrefrigeration cycles: Rankine (ideal & reheat), Otto, Diesel and Brayton cycles; Vapor compression cycle,Airstandard refrigeration cycle. **References/Text Books:** * Sonntag, Borgnakke, Van Wylen, Fundamentals of Thermodynamics, 6th Edition, Wiley India. * Y V C Rao, An Introduction to Thermodynamics, Universities Press, 2005. * Cengel and Boles, Thermodynamics An Engineering Approach, 6th Edition Tata McGraw Hill,2008.	THERMODYNAMICS
ESO204A	3-1-0-0-11		**Course Contents:**	FLUID MECHANICS AND

			FLUID MECHANICS: Introduction to fluids, Fluid statics; pressure as a scalar, manometry, forces on submerged surfaces (NO moments NOR center of pressure), Description of flows; field approach, Euler acceleration formula, streamlines, streaklines, etc., Reynolds transport theorem Conservation of mass; stream function, Linear (NOT angular) Momentum balance, NavierStokes (NS) equation; elementary derivation; application; Poiseuille flow, Couette flow, Energy equationBernoulli equation, applications including flow measurement (Pitot tube, Orifice meters); Pipe flows and losses in fittings; Similitude and modelling: using nondimensionalization of NS equations and boundary conditions, simplifications for cases without free surfaces and without cavitation (scale factor approach should NOT be done); High Re flow: Prandtls approximation; basic inviscid flow;need for boundary layer; Magnus effect (mathematical derivations be avoided), Boundary layerselementary results for flat plates. Separation, flow past immersed bodies (bluff, streamlined); physics of ballgames (qualitative) Heat Transfer: Introduction, rate law and conservation law, Conduction equation; nondimensionalization, various approximations, Steady state conductionconcept of resistances in series and of critical thickness of insulation, Unsteady conduction; significance of Biot and Fourier numbers, Heissler charts; Low Bi case; **References/Text Books:**	RATE PROCESSES
ESO206	3----4		**Course Contents:** Introduction to coordinate system and phase space, review of vectors and tensors, dynamics ofsystem of particles, steady mass flow and variable mass problems, coordinate transformationinvolving 3d rotations and the concept of angular velocity, kinematics of rigid bodies, kineticsof rigid bodies, general planar motions, general 3D motions, advanced examples. **References/Text Books:** (1) Engineering Mechanics, Dynamics, vol. 2, J.L. Meriam and L.G. Kraige.(2) Engineering Mechanics Dynamics, R.C. Hibbeler.(3) Engineering Mechanics, Den Hartog.(4) Principles of Dynamics, Donald T. Greenwood (Advanced Text).	DYNAMICS
ESO209A	2-1-0-0-8		**Course Contents:** Introduction to coordinate system and phase space, review of vectors and tensors, dynamics ofsystem of particles, steady mass flow and variable mass problems, coordinate transformationinvolving 3d rotations and the concept of angular velocity, kinematics of rigid bodies, kineticsof rigid bodies, general planar motions, general 3D motions, advanced examples. **References/Text Books:**	DYNAMICS
ME222A	2-0-1-0-7		**Course Contents:** History of engineering materials, Engineering materials, Materials property chart, Crystalstructure, Imperfections of solids, Mechanism of strengthening in metals, HallPetch effect, Xraydiffraction, Fracture: Ductile, brittle, fatigue. Griffith criterion, SN curve, Creep, Phase diagram(binary), Ironcarbon system, Heat treatment of metals, Electrical properties, Thermalproperties, Magnetic properties, Optical properties, Corrosion, Oxidation, Thermal stability ,Wear, abrasion, friction of materials, Characterization techniques: Optical microscopy, scanningelectron microscopy, transmission electron microscopy, atomic force microscopy, Polymer andits characterization, Viscoelasticity, Nanomaterials and its important properties at nanoscale,Composites: Characterization of composites, Ionic polymer matrix composites, Shape memoryalloy, Intelligent Multifunctional materials, Economics, Environment, and Sustainability **References/Text Books:**	NATURE AND PROPERTIES OF MATERIALS
ME231	3-0-0-1-4		**Course Contents:** Reynolds Transport Theorem; Integral form of continuty, momentum and energy;Eulerian and lagrangian viewpoints; Constitutive relations; Navier Stokesequations: Exact solutions; Potential flow; Boundary layer theory; Separationand drag; Turbulent flow: Reynolds averaged equations; Turbulent flows in pipesand	FLUID MECHANICS

			channels; compressible flows. **References/Text Books:**	
ME231A	3-0-1-0-10		**Course Contents:** Reynolds Transport Theorem; Integral form of continuty, momentum and energy;Eulerian and lagrangian viewpoints; Constitutive relations; Navier Stokesequations: Exact solutions; Potential flow; Boundary layer theory; Separationand drag; Turbulent flow: Reynolds averaged equations; Turbulent flows in pipesand channels; compressible flows. **References/Text Books:**	FLUID MECHANICS
ME251	2-0-3-0-4		**Course Contents:** Theory of general engineering design, conceptual design, embodimentdesign, designing to standard, basic sketching, machine drawing, dimensioning as perstandards, fits and tolerances, machine elements, assembly drawing, geometrical modeling,and use of CAD software for modeling and animation. **References/Text Books:** 1. Machine Drawing by Ajeet Singh, Me Graw Hill2. Machine Drawing by N.D. Bhatt and V.M. Panchal, Charotar Publications.	ENGINEERING DESIGN AND GRAPHICS
ME251A	1-0-2-0-5	TA101A	**Course Contents:** Theory of general engineering design, conceptual design, embodimentdesign, designing to standard, basic sketching, machine drawing, dimensioning as perstandards, fits and tolerances, machine elements, assembly drawing, geometrical modeling,and use of CAD software for modeling and animation. **References/Text Books:** 1. Machine Drawing by Ajeet Singh, Me Graw Hill2. Machine Drawing by N.D. Bhatt and V.M. Panchal, Charotar Publications.	ENGINEERING DESIGN AND GRAPHICS
ME300	-0-0--0		**Course Contents:** Six weeks training after the sixth semester in the Industry. **References/Text Books:**	SUMMER INDUSTRIAL TRAINING
ME301	3-0-0-0-4		**Course Contents:** Introduction to energy resources and conversion systems: Fossil fuels,Nuclear energy, Hydrogen, Renewable energy sources. Thermal energy to MechanicalEnergy Conversion: Internal Combustion Engine Technology, Real Cycles, Combustion,Emissions, Performance and Testing. Mechanical Energy to Thermal Energy Conversion:Modern Refrigeration and Airconditioning Systems **References/Text Books:** Energy Conversion Systems, Sorensen, H, McGrawHill, USA Principles of Energy Conversion, Cup! A.W., TMH Internal Combustion Engine Fundamental, I B Heywood, McGrawHill, USA A course in internal combustion engines, by: Mathur and Sharma, Dhanpat Rai &Sons. Internal Combustion Engine, Pundir B P, Narosa. Refrigeration and Air Conditioning, Arora C P, TMH Principles of Refrigeration, Dossat R, PHI	ENERGY SYSTEMS I
ME301A	2-0-0-0-6	ESO201A	**Course Contents:** Introduction to energy resources and conversion systems: Fossil fuels,Nuclear energy, Hydrogen, Renewable energy sources. Thermal energy to MechanicalEnergy Conversion: Internal Combustion Engine Technology, Real Cycles, Combustion,Emissions, Performance and Testing. Mechanical Energy to Thermal Energy Conversion:Modern Refrigeration and Airconditioning Systems	ENERGY SYSTEMS I

			References/Text Books: Energy Conversion Systems, Sorensen, H, McGrawHill, USA Principles of Energy Conversion, Cup! A.W., TMH Internal Combustion Engine Fundamental, I B Heywood, McGrawHill, USA A course in internal combustion engines, by: Mathur and Sharma, Dhanpat Rai &Sons. Internal Combustion Engine, Pundir B P, Narosa. Refrigeration and Air Conditioning, Arora C P, TMH Principles of Refrigeration, Dossat R, PHI	
ME321	3-0-0-0-4		**Course Contents:** Introduction to Cartesian tensors; Strains: Concept of strain, derivation ofsmall strain tensor and compatibility; Stress: Derivation of Cauchy relations and,equilibrium and symmetry equations, principal stresses and directions; Constitutiveequations: Generalized Hooke's law including thermoelasticity, Material symmetry;Boundary Value Problems: Definition of the bvp in linear elasticity including concepts ofuniqueness and superposition; 2d plane stress and plane strain problems, introduction togoverning equations in cylindrical and spherical coordinates, axisymmetric problems(examples may include problems on curved beams, thermoelasticity, torsion of noncircularcross sections, contact problems in 2d, problems on wedges and crack tip fields);3d problems by potential methods; Energy methods and problems. **References/Text Books:** Timoshenko and Goodier, Theory of Elasticity, McGraw Hill Publishing Company, 1970.Bower, Applied Mechanics of Solids, CRC Press, 2009.Saad, Elasticity: Theory Application and Numerics, Academic Press, 2004.	ADVANCED MECHANICS OF SOLIDS
ME321A	2-0-1-0-7	ESO202A	**Course Contents:** Introduction to Cartesian tensors; Strains: Concept of strain, derivation ofsmall strain tensor and compatibility; Stress: Derivation of Cauchy relations and,equilibrium and symmetry equations, principal stresses and directions; Constitutiveequations: Generalized Hooke's law including thermoelasticity, Material symmetry;Boundary Value Problems: Definition of the bvp in linear elasticity including concepts ofuniqueness and superposition; 2d plane stress and plane strain problems, introduction togoverning equations in cylindrical and spherical coordinates, axisymmetric problems(examples may include problems on curved beams, thermoelasticity, torsion of noncircularcross sections, contact problems in 2d, problems on wedges and crack tip fields);3d problems by potential methods; Energy methods and problems. **References/Text Books:** Timoshenko and Goodier, Theory of Elasticity, McGraw Hill Publishing Company, 1970.Bower, Applied Mechanics of Solids, CRC Press, 2009.Saad, Elasticity: Theory Application and Numerics, Academic Press, 2004.	ADVANCE MECHANICS OF SOLIDS
ME341	3-0-0-0-4		**Course Contents:** Introduction. Onedimensional and Twodimensional Steady and Transient Conduction.Forced Convection over a flat plate and inside tubes. Natural Convection over a vertical flatplate. Mass Transfer. Boiling and Condensation. Heat Exchangers. Thermal Radiation. HeatTransfer Applications. **References/Text Books:** 1. Fundamentals of Heat and Mass Transfer by Frank P. Incropera and David P. Dewitt (4th ed.,John Wiley & Sons, New York, 1998)2. Heat Transfer by J.P.Holman (9th ed., Tata McGrawHill Edition, New Delhi, 2004)3. Heat Transfer by P.S.Ghoshdastidar (Oxford University Press India, New Delhi, 2004)4. Heat and Mass Transfer by Yunus A. Cengel (3rd ed., Tata McGrawHill Edition, New Delhi,2007)5. Solar Energy by S. P.Sukhatme (2nd ed., Tata McGrawHill, New Delhi, 1996)	HEAT AND MASS TRANSFER
ME341A	3-0-1-0-10	ME231A	**Course Contents:** Introduction. Onedimensional and Twodimensional Steady and Transient Conduction.Forced Convection over a flat plate and inside tubes. Natural Convection over a vertical flatplate. Mass Transfer. Boiling and Condensation. Heat Exchangers. Thermal Radiation. HeatTransfer Applications.	HEAT & MASS TRANSFER

			References/Text Books: 1. Fundamentals of Heat and Mass Transfer by Frank P. Incropera and David P. Dewitt (4th ed.,John Wiley & Sons, New York, 1998)2. Heat Transfer by J.P.Holman (9th ed., Tata McGrawHill Edition, New Delhi, 2004)3. Heat Transfer by P.S.Ghoshdastidar (Oxford University Press India, New Delhi, 2004)4. Heat and Mass Transfer by Yunus A. Cengel (3rd ed., Tata McGrawHill Edition, New Delhi,2007)5. Solar Energy by S. P.Sukhatme (2nd ed., Tata McGrawHill, New Delhi, 1996)	
ME351	3-0-2-0-4		**Course Contents:** Introduction to design of systems and machine elements; Modes of failure,strength, stiffness and stability; Failure theories; Fatigue failure; Probabilistic approach todesign; Design of Bolted and Welded joints, Helical compression springs and leaf springs, Spurand Helical gear sets; Selection of Rolling contact bearings; Design of shafts. Lab sessions:Detailed design of the above machine elements starting functional specifications to final sizing;Design of a subsystem involving multiple machine elements. Introduction to use of techniqueslike FEM for design. **References/Text Books:** 1. Mechanical Engineering Design by).E. Shigley, C.R. Mischke & R.G. Budynas, McGraw Hill2. Machine elements in Mechanical Design by R.L. Mott, Prentice Hall3. Mechanical Design by P. Childs, Elsevier4. Fundamentals of Machine Component Design by R. C.)uvinall & K. M. Marshek, Wiley5. Machine Design by R.L. Norton	DESIGN OF MACHINE ELEMENTS
ME351A	2-0-2-0-8	ESO202A	**Course Contents:** Introduction to design of systems and machine elements; Modes of failure,strength, stiffness and stability; Failure theories; Fatigue failure; Probabilistic approach todesign; Design of Bolted and Welded joints, Helical compression springs and leaf springs, Spurand Helical gear sets; Selection of Rolling contact bearings; Design of shafts. Lab sessions:Detailed design of the above machine elements starting functional specifications to final sizing;Design of a subsystem involving multiple machine elements. Introduction to use of techniqueslike FEM for design. **References/Text Books:** 1. Mechanical Engineering Design by).E. Shigley, C.R. Mischke & R.G. Budynas, McGraw Hill2. Machine elements in Mechanical Design by R.L. Mott, Prentice Hall3. Mechanical Design by P. Childs, Elsevier4. Fundamentals of Machine Component Design by R. C.)uvinall & K. M. Marshek, Wiley5. Machine Design by R.L. Norton	DESIGN OF MACHINE ELEMENTS
ME352	3-0-0-0-4		**Course Contents:** Kinematic pairs, diagrams and inversion. Mobility and range of movement.Displacement, velocity and acceleration analysis of planar linkages .. Dimensional synthesis formotion, path and function generation. Dynamic force analysis, flywheels. Inertia forces andbalancing for rotating and reciprocating machines. Cam mechanisms, Cam profile synthesis.Gears and gear trains. **References/Text Books:** Theory of Mechanisms and Machines by Ghosh and Mallik (EWP).	THEORY OF MECHANISMS & MACHINES
ME352A	2-0-1-0-7	ESO209A	**Course Contents:** Kinematic pairs, diagrams and inversion. Mobility and range of movement.Displacement, velocity and acceleration analysis of planar linkages .. Dimensional synthesis formotion, path and function generation. Dynamic force analysis, flywheels. Inertia forces andbalancing for rotating and reciprocating machines. Cam mechanisms, Cam profile synthesis.Gears and gear trains. **References/Text Books:** Theory of Mechanisms and Machines by Ghosh and Mallik (EWP).	THEORY OF MECHANISMS & MACHINES

ME353	3-0-0-0-4		**Course Contents:** Three dimensional motion of rigid bodies kinematics and kinetics. Gyrodynamics.Vibrations of single, two and multiple degrees of freedom systems, free andforced vibrations; Time and frequency domain analysis, Free vibration of onedimensional continuous systems, approximate methods. **References/Text Books:**	DYNAMICS AND VIBRATION OF MACHINERY
ME354	3-0-0-1-4		**Course Contents:** Introduction to modeling of dynamical systems. Single Degree of FreedomSystems Free undamped vibration, Free damped vibration, Forced vibration, Transmissibility, Convolution method, Mechanisms of damping. Two Degree of Freedom System (undamped vibration only) Free and forced vibrations, vibration absorber. Multi Degree of Freedom Systems(undamped and proportional damping) Matrix methods, Modal analysis. Approximate Methods.Vibration of continuous systems (free vibration only).Introduction to controls. Review of Laplace transforms. Block diagrams. Root locus method.Stability RouthHurwith criterion, Nyquist plots. Bode plots. Controller performance and types.Steady state errors and constants. Types of feedback control systems Derivative errorcompensation, Integral error compensation, Proportional error compensation. Modern control. Digital control. **References/Text Books:** 1. Theory of Vibrations. W. T. Thomson, Prentice Hall.2. Control Systems Engineering. N. S. Nise, john Wiley & Sons.3. Vibration Problems in Engineering. W. Weaver, S. P. Timoshenko and D. H. Young, johnWiley & Sons.4. Mechanical Vibration.). P. Den Hartog, Dover Publications.5. Feedback Control of Dynamic Systems. G. Franklin,). D. Powell, and A. EmamiNaeini,Prentice Hall.6. Modern Control Engineering. K. Ogata, Prentice Hall.	VIBRATION & CONTROL
ME354A	3-0-1-0-10		**Course Contents:** Introduction to modeling of dynamical systems. Single Degree of FreedomSystems Free undamped vibration, Free damped vibration, Forced vibration, Transmissibility,Convolution method, Mechanisms of damping. Two Degree of Freedom System (undampedvibration only) Free and forced vibrations, vibration absorber. Multi Degree of Freedom Systems(undamped and proportional damping) Matrix methods, Modal analysis. Approximate Methods.Vibration of continuous systems (free vibration only).Introduction to controls. Review of Laplace transforms. Block diagrams. Root locus method.Stability RouthHurwith criterion, Nyquist plots. Bode plots. Controller performance and types.Steady state errors and constants. Types of feedback control systems Derivative errorcompensation, Integral error compensation, Proportional error compensation. Modern control.Digital control. **References/Text Books:** 1. Theory of Vibrations. W. T. Thomson, Prentice Hall.2. Control Systems Engineering. N. S. Nise, john Wiley & Sons.3. Vibration Problems in Engineering. W. Weaver, S. P. Timoshenko and D. H. Young, johnWiley & Sons.4. Mechanical Vibration.). P. Den Hartog, Dover Publications.5. Feedback Control of Dynamic Systems. G. Franklin,). D. Powell, and A. EmamiNaeini,Prentice Hall.6. Modern Control Engineering. K. Ogata, Prentice Hall.	VIBRATION & CONTROL
ME359	3-0-0--4		**Course Contents:** Classification, Construction, Valve arrangements. Fuels, Fuel air cycle. Combustion,Effect of engine variables, Combustion chambers, Carburation and fuel injection,Knocking. Engine cooling, Friction and lubrication Supercharging. Wankel engine.Testing and performance. Pollution. **References/Text Books:**	INTERNAL COMBUSTION ENGINES
ME359A	3-0-0-0-9		**Course Contents:** Classification, Construction, Valve arrangements. Fuels, Fuel air cycle. Combustion,Effect of engine variables, Combustion chambers, Carburation and fuel injection,Knocking. Engine cooling, Friction and	INTERNAL COMBUSTION ENGINES

			lubrication Supercharging. Wankel engine.Testing and performance. Pollution. **References/Text Books:**	
ME361	3-0-0-0-4		**Course Contents:** Introduction to manufacturing processes and system concept and itsevolution; Metal casting: Solidification Mechanism, Gating and Riser Design, Defects andProduct Design; Metal Forming: Fundamentals of Plasticity, Force Equilibrium Method,Forging/upsetting, Drawing, Extrusion, Deep Drawing and Bending, Defects; Machining: ToolSpecifications, Orthogonal and Oblique cutting, Tool wear and Tool Life, Economics ofMachining; Shaping processes for Plastics and Tool Design; joining Processes; UnConventionalMaterial Removal Processes: ECM, EDM, LBM and jet Machining; Rapid Prototyping andTooling; Microfabrication technologies; Metrology and Selection of Manufacturing Processes. **References/Text Books:** 1. Ghosh, A., Mallik, A.K., Manufacturing Science (2nd edition}, EastWest Press, 2010.2. Lal, G.K., Introduction to Machining Science (2nd edition}, New Age Internationalpublishers, 2009.3. Groover, M.P, Fundamentals of Modern Manufacturing (2nd edition}, john Wiley.4. Kalpakjian, S., Schmid, S.C., Manufacturing Engineering and Technology, PearsonEducation5. Galyer, j.F.W., Shotbolt, C.R., Metrology for Engineers, ELBS	MANUFACTURING TECHNOLOGY
ME361A	3-0-1-0-10	TA201A,TA202A	**Course Contents:** Introduction to manufacturing processes and system concept and itsevolution; Metal casting: Solidification Mechanism, Gating and Riser Design, Defects andProduct Design; Metal Forming: Fundamentals of Plasticity, Force Equilibrium Method,Forging/upsetting, Drawing, Extrusion, Deep Drawing and Bending, Defects; Machining: ToolSpecifications, Orthogonal and Oblique cutting, Tool wear and Tool Life, Economics ofMachining; Shaping processes for Plastics and Tool Design; joining Processes; UnConventionalMaterial Removal Processes: ECM, EDM, LBM and jet Machining; Rapid Prototyping andTooling; Microfabrication technologies; Metrology and Selection of Manufacturing Processes. **References/Text Books:** 1. Ghosh, A., Mallik, A.K., Manufacturing Science (2nd edition}, EastWest Press, 2010.2. Lal, G.K., Introduction to Machining Science (2nd edition}, New Age Internationalpublishers, 2009.3. Groover, M.P, Fundamentals of Modern Manufacturing (2nd edition}, john Wiley.4. Kalpakjian, S., Schmid, S.C., Manufacturing Engineering and Technology, PearsonEducation5. Galyer, j.F.W., Shotbolt, C.R., Metrology for Engineers, ELBS	MANUFACTURING SCIENCE & TECHNOLOGY
ME371	0-0-6-0-4		**Course Contents:** Experimentation in machine dynamics, Materials, Manufacturing Sciences andFluid mechanics. **References/Text Books:**	MECHANICAL ENGINEERING LAB-I
ME374	----4		**Course Contents:** To learn about a topic in depth through independent study under the guidanceof a faculty member from the department. Based on a Original Research Project/design project/experimental project. **References/Text Books:**	MECHANICAL ENGG. RESEARCH
ME398A	0-0-4-0-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UNDER GRADUATE PROJECT I
ME399A	0-0-0-2-2		**Course Contents:**	MECHANICAL

			MECHANICAL ENGINEERING COMMUNICATION SKILLS **References/Text Books:**	ENGINEERING COMMUNICATION SKILLS
ME401	3-0-0-0-4		**Course Contents:** Introduction: General Theory and Classification of Turbomachines; Similarity andDimensional Analysis; Twodimensional Cascade Theory; Axial and Radial Flow Machines: Turbines,Compressors and Fans; Gas Turbine Power Plant Cycles; Thermal Power plant: Flow through Nozzleand Steam Turbines; Hydraulic Machines: Pelton, Francis and Kaplan Turbines; Pump and Cavitation. **References/Text Books:** I. S. L. Dixon and C. A. Hall, Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier,Sixth Edition, 2010.2. H. Cohen, G. F. C. Rogers and H. I. H. Saravanamuttoo, Gas Turbine Theory, Addison WesleyLongman Ltd, Fourth Edition, 1996.3. S.M.Yahya, Turbines, Compressor and Fan, Tata McGrawHill, Second Edition, 2003.4. B.Lakshminarayana, Fluid Dynamics and Heat Transfer ofTurbomachinery, John Wiley and Sons,Inc, 1996.	ENERGY SYSTEMS - II
ME401A	3-0-1-0-10	ESO201A ME231A	**Course Contents:** Introduction: General Theory and Classification of Turbomachines; Similarity andDimensional Analysis; Twodimensional Cascade Theory; Axial and Radial Flow Machines: Turbines,Compressors and Fans; Gas Turbine Power Plant Cycles; Thermal Power plant: Flow through Nozzleand Steam Turbines; Hydraulic Machines: Pelton, Francis and Kaplan Turbines; Pump and Cavitation. **References/Text Books:** I. S. L. Dixon and C. A. Hall, Fluid Mechanics and Thermodynamics of Turbomachinery, Elsevier,Sixth Edition, 2010.2. H. Cohen, G. F. C. Rogers and H. I. H. Saravanamuttoo, Gas Turbine Theory, Addison WesleyLongman Ltd, Fourth Edition, 1996.3. S.M.Yahya, Turbines, Compressor and Fan, Tata McGrawHill, Second Edition, 2003.4. B.Lakshminarayana, Fluid Dynamics and Heat Transfer ofTurbomachinery, John Wiley and Sons,Inc, 1996.	ENERGY SYSTEMS-II
ME451	0-0-6-0-4		**Course Contents:** Project work involving the analysis, synthesis, material/component selection and detaileddesign of a mechanical system including the preparation of working drawings. The systemmay be integrated with electronics, electrical, hydraulic and other systems. Projects may beselected by students from any of the four specific areas (or a combination there of) Fluidmechanics and Thermal sciences, Solid Mechanics and Design, Manufacturing Science andRobotics and/or any other related mechanical system(s). **References/Text Books:**	PROJECT - I
ME451A	0-0-0-0-9		**Course Contents:** Project work involving the analysis, synthesis, material/component selection and detaileddesign of a mechanical system including the preparation of working drawings. The systemmay be integrated with electronics, electrical, hydraulic and other systems. Projects may beselected by students from any of the four specific areas (or a combination there of) Fluidmechanics and Thermal sciences, Solid Mechanics and Design, Manufacturing Science andRobotics and/or any other related mechanical system(s). **References/Text Books:**	ME PROJECT-1
ME452	0-0-4-0-2		**Course Contents:** Fabrication of a prototype and appropriate modification in the design (if necessary) to meetthe qualitative and quantitative performance parameters as envisaged in the Project I **References/Text Books:**	PROJECT II

ME452.	0-0-0--3		**Course Contents:** PROJECT II **References/Text Books:**	PROJECT II
ME452A	0-0-6-0-6	ME451A	**Course Contents:** Fabrication of a prototype and appropriate modification in the design (if necessary) to meetthe qualitative and quantitative performance parameters as envisaged in the Project I **References/Text Books:**	PROJECT II
ME453	3-0-0-0-4		**Course Contents:** Modeling, Analysis, and Simulation of Dynamic System; Mechanical, electronic,electrohydraulic and electomechanical systems; Stepper and Servomotors; useof MATLAB; StateSpace, laplace and frequency domain system behaviour; Bode,Nyquist, and rootlocus plots; open and closed loop control systems; stabilityand sensitivity; PID, Phase lag and Phase lead compensation; Sampled datasystems and Digtal controllers; DA/AD converters; Microprocessors; Sensors andactuators; interfacing with computers. **References/Text Books:**	AUTOMATION AND CONTROL
ME461	3-0-0-0-4		**Course Contents:** Introduction to manufacturing, Manufacturing system concept.Manufacturing automation, FMS, CIMS, Flow lines and assembly systems, Automated storage /retrieval systems, AGV. Introduction to CAD/CAM, NC, CNC, DNC, Adaptive control. Manual andcomputer assisted part programming. Introduction to robots and their application inmanufacturing. Process planning and Computer Aide Process planning. Group Technology,Opitz System and GT benefits. Material Management and Inventory control, MRP and MRP II.Just in time (JIT) and Lean manufacturing. Introduction to quality assurance and control,Statistical Quality Control, control charts, sampling. Total Quality Management. Manufacturingsystem simulation. **References/Text Books:** 1. Computer Integrated Design and Manufacturing by Nanua Singh, john Wiley.2. Computer Aided Manufacturing by Chang, Wysk, Wang, Prentice Hall.3. Computer Aided Manufacturing by Rao, Tewari, Kundra, TMH	MANUFACTURING SYSTEMS
ME461A	3-0-0-0-9	ME361A	**Course Contents:** Introduction to manufacturing, Manufacturing system concept.Manufacturing automation, FMS, CIMS, Flow lines and assembly systems, Automated storage /retrieval systems, AGV. Introduction to CAD/CAM, NC, CNC, DNC, Adaptive control. Manual andcomputer assisted part programming. Introduction to robots and their application inmanufacturing. Process planning and Computer Aide Process planning. Group Technology,Opitz System and GT benefits. Material Management and Inventory control, MRP and MRP II.Just in time (JIT) and Lean manufacturing. Introduction to quality assurance and control,Statistical Quality Control, control charts, sampling. Total Quality Management. Manufacturingsystem simulation. **References/Text Books:** 1. Computer Integrated Design and Manufacturing by Nanua Singh, john Wiley. 2. Computer Aided Manufacturing by Chang, Wysk, Wang, Prentice Hall. 3. Computer Aided Manufacturing by Rao, Tewari, Kundra, TMH	MANUFACTURING SYSTEMS
ME471N	0-0-6--4	ME301 ME321 ME341	**Course Contents:** Experimentation in automation and control, Solid Mechanics, Heat transfer,Energy conversion. **References/Text Books:**	MECHANICAL ENGINEERING LAB

ME600	1-1-0--0		**Course Contents:** COMMUNICATION SKILLS FOR ENGINEERS **References/Text Books:**	COMMUNICATION SKILLS FOR ENGINEERS
ME600A	2-0-0-0-6		**Course Contents:** COMMUNICATION SKILLS FOR ENGINEERS **References/Text Books:**	COMMUNICATION SKILLS FOR ENGINEERS
ME613	3-0-0-0-4		**Course Contents:** Moist air and psychrometric processes. Physiological principles of thermal comfort, calculation of cooling and heating loads; ADP determination, solar radiation and shading devices, duct design; Heat and mass transfer in air washers, cooling towers, finned heat exchangers; Air dehumidification. **References/Text Books:**	THERMAL ENVIROMENTAL CONTROL
ME613A	3-0-0-0-9		**Course Contents:** Moist air and psychrometric processes. Physiological principles of thermal comfort, calculation of cooling and heating loads; ADP determination, solar radiation and shading devices, duct design; Heat and mass transfer in air washers, cooling towers, finned heat exchangers; Air dehumidification. **References/Text Books:**	THERMAL ENVIROMENTAL CONTROL
ME617	3-0-0--4		**Course Contents:** The equations of motion in rotating coordinate system, effects of Coriolis andCentrifugal forces, energy equation, classification of turbomachines; twodimensionalcascade theory and experimental results; two dimensional flowanalysis of axial impellers; three dimensional flow in axial turbomachines, radialequilibrium, secondary flows and loss estimation; offdesign performance; radialand mixed flow machines; multistage axial compressors and turbines; predictionof stage performance and stacking; rotating stall and surge; turbine blade heatload and blade cooling; **References/Text Books:**	ADVANCED THEORY OF TURBOMACHINERY
ME620A	3-0-0-0-9		**Course Contents:** Applications of Radiation. Half Life Determination. Radiation Dose Levels and Calculation :Inverse Square Law Verification, ALARA Principle, Linearnothreshold model. Basic Principles of Radiation Detection. Gamma Ray Interactions: photoelectric, Compton scattering, pairproduction Empirical calculation of crosssections, Linear Attention Coefficient Measurement. Evaluation of GM Detector Characteristics: Plateau determination, Dead time calculations, paralyzable and nonparalyzable detectors. Measurements and Counting Statistics for Error Evalution Limits. Ionizing radiation and detection, Neutron and special nuclear material (SNM) detection for security applications. Mechanisms of neutron interaction: capture, scientillation etc. Scintillation detectors, Capture detectors, Fission chambers. Semiconductor Detectors. Pulse shaping and signal processing. Radiation detection and shielding methods for safety at various nuclear facilities. Measuring gamma dose and shielding calculations. Measuring neutron spectrum and dose and shielding calculations. Measuring other forms of radiation, dose and shielding calculations. Principles of particle accelerator and measurements on the 1.7 MeV TANDETRON* OR Instrumentation and controls used in existing and advanced nuclear power plants* **References/Text Books:** 1. G.F. Knoll, Radiation Detection and Measurements, John Wiley & Sons, Hoboken, New Jersey (2010)2. S. S. Kapoor and V.S. Ramamurthy, Nuclear Radiation Detectors, Wiley Eastern Limited (1986)3. K.S. Ram, Nuclear Measurements and Techniques, Affiliated West Press, New Delhi (1986)	RADIATION INTERACTION, DETECTION, AND SHIELDING- THEORY ON NUCLEAR MEASUREM

ME621	3-0-0--4		**Course Contents:** I. Introduction. 1. Review of strength of Materials and its limitations. II. Mathematical Preliminaries. 1.Vector and tensor calculus. 2. Indicial notationIII. Strains. 1. Definition of small strain, StrainDisplacement relations in 3D, Physical interpretation of strain components, Principal Strains. IV. Stress and equilibrium. 1.Stress components in 3D and their physical interpretations. 2. Principal Stresses. 3. Cauchys principle and derivations of stress equilibrium equations in stress components. V. Constitutive law, Naviers equations, compatibility. 1. Constitutive law for general linear elastic solid, Discussions on isotropic, orthotropic and transversely isotropic solid. 2. Naviers equations. 3. Stress and displacement approaches. 4.Compatibility equations. VI. Formulation of boundary value problems and solution methods. 1. Formulation of boundary value problems. 2.Plane Problems plane stress, plane strain, antiplane shear (also in axisymmetric coordinates) 3. Examples of plane problems: Stress function approach, Series solutions. 4.Fourier transform methods with examples. 5. Superposition principle: Flamants solutions; Kelvins solution; Boussinesqs solution. VII. Additional topics a few topics to be selected from below. 1.Further examples: Torsion of prismatic shaft; Contact problems; Wedge problems; Dislocations and inclusions; Cracks; Thinfilm problems. 2. Further methods: Advanced transform methods; Complex variable techniques; Potential methods. 3.Further ideas: Energy methods; Numerical approaches; Finite elements; Eigenstrains; Micromechanics. **References/Text Books:** 1.Elasticity, J. R. Barber2.The Linearized Theory of Elasticity, W. L. Slaughter3.Continuum Mechanics for Engineers, G. T. Mase and G. E. Mase4.Theory of Elasticity, S. Timoshenko and J. N. Goodier5.Elasticity: Theory, Applications and Numerics, M. H. Sadd6.Applied Mechanics of Solids, A. Bower	INTRODUCTION TO SOLID MECHANICS
ME621A	3-0-0-0-9		**Course Contents:** I. Introduction. 1. Review of strength of Materials and its limitations. II. Mathematical Preliminaries. 1.Vector and tensor calculus. 2. Indicial notationIII. Strains. 1. Definition of small strain, StrainDisplacement relations in 3D, Physical interpretation of strain components, Principal Strains. IV. Stress and equilibrium. 1.Stress components in 3D and their physical interpretations. 2. Principal Stresses. 3. Cauchys principle and derivations of stress equilibrium equations in stress components. V. Constitutive law, Naviers equations, compatibility. 1. Constitutive law for general linear elastic solid, Discussions on isotropic, orthotropic and transversely isotropic solid. 2. Naviers equations. 3. Stress and displacement approaches. 4.Compatibility equations. VI. Formulation of boundary value problems and solution methods. 1. Formulation of boundary value problems. 2.Plane Problems plane stress, plane strain, antiplane shear (also in axisymmetric coordinates) 3. Examples of plane problems: Stress function approach, Series solutions. 4.Fourier transform methods with examples. 5. Superposition principle: Flamants solutions; Kelvins solution; Boussinesqs solution. VII. Additional topics a few topics to be selected from below. 1.Further examples: Torsion of prismatic shaft; Contact problems; Wedge problems; Dislocations and inclusions; Cracks; Thinfilm problems. 2. Further methods: Advanced transform methods; Complex variable techniques; Potential methods. 3.Further ideas: Energy methods; Numerical approaches; Finite elements; Eigenstrains; Micromechanics. **References/Text Books:** 1.Elasticity, J. R. Barber2.The Linearized Theory of Elasticity, W. L. Slaughter3.Continuum Mechanics for Engineers, G. T. Mase and G. E. Mase4.Theory of Elasticity, S. Timoshenko and J. N. Goodier5.Elasticity: Theory, Applications and Numerics, M. H. Sadd6.Applied Mechanics of Solids, A. Bower	INTRODUCTION TO SOLID MECHANICS
ME622	3-0-0--4		**Course Contents:** Analysis of stress and strain; Equilibrium, Compatibility and constitutiveequations; Plane problems; Stress functions; Applications; Complex potentialsin two dimensional and axisymmetric problems; Variational methods; Anisotropicelasticity; Finite deformation elasticity. **References/Text Books:**	THEORY OF ELASTICITY
ME622A	3-0-0-0-9		**Course Contents:** Analysis of stress and strain; Equilibrium, Compatibility and constitutiveequations; Plane problems; Stress	THEORY OF ELASTICITY

			functions; Applications; Complex potentialsin two dimensional and axisymmetric problems; Variational methods; Anisotropicelasticity; Finite deformation elasticity. **References/Text Books:**	
ME623	3-0-0--4		**Course Contents:** Introduction to ID FEM. Problems in structural mechanics using two dimensionalelements; Plane stress, plane strain, axisymmetric analysis; Three dimensionalstress analysis; Shell analysis; Solution of heat conduction, fluid flow, vibration,stability, and nonlinear, large scale systems. **References/Text Books:**	FINITE ELEMENT METHODS IN ENGINEERING MECHANICS
ME623A	3-0-0-0-9	ESO202A MSO203B	**Course Contents:** Introduction to ID FEM. Problems in structural mechanics using two dimensionalelements; Plane stress, plane strain, axisymmetric analysis; Three dimensionalstress analysis; Shell analysis; Solution of heat conduction, fluid flow, vibration,stability, and nonlinear, large scale systems. **References/Text Books:**	FINITE ELEMENT METHODS IN ENGINEERING MECHANICS
ME625	3-0-0--4		**Course Contents:** Review of single degree of freedom systems; Generalised coordinates, constraints,virtual work; Lagranges equation; Continuous systems; strings, beams;RaleighRitz and Galerkins methods; Dynamics of rigid bodies in threedimensions; Euler angles; Eulers equations of motion, Gyrodynamics. **References/Text Books:**	APPLIED DYNAMICS AND VIBRATIONS
ME625A	3-0-0-0-9		**Course Contents:** I: NewtonEuler mechanics. 1. Mathematical preliminaries: Coordinate systems, Vectors, Tensors, Outer product; Coordinate transformation. 2. Rotating frames; Rotation tensor; Euler angles; Angular velocity. 3. Rigidbody kinematics; Fiveterm acceleration formula; Examples. 4. Rigidbody kinetics: Linear Momentum; Angular momentum; Inertia tensor; Kinetic energy. 5. Rigidbody kinetics: Balance laws; Governing equations; Eulers equations. 6. Examples: Rigid body in free space; Gyroscopes. Part II: Analytical mechanics. 1. Generalized coordinates; Constraints; Degrees of freedom. 2. Principal of virtual work in statics: Virtual displacements; Virtual work; Constraint forces; Workless constraints; Principal of virtual work; Lagrange multipliers; Equilibria and stability of conservative systems; Examples. 3. Dynamics: dAlemberts principal; Lagranges equations of motion for holonomic and nonholonomic systems; 4. Examples: Rigid bodies; aplygins sleigh. 5. Conservative systems. Legendre transformation; Hamiltonian mechanics; Energy theorem; Examples. Part III: Vibrations. 1. Single degree of freedom system: free, damped, forced. 2. Convolution integral. 3. Twodegree of freedom systems: Normal modes; 4. Extension to multidegree of freedom systems. 5. Examples. 6. Laboratory demos/sessions: Summary: Mathematical preliminaries: Vectors; Tensors; Coordinate transformations. NewtonEuler Mechanics: Rotation; Threedimensional Rigidbody kinematics and dynamics; Specialisation to twodimensions; Gyroscopes. Analytical Mechanics: Virtual work; Lagrange multipliers; Lagranges equations; Holonomic and nonholonomic systems; Hamiltonian mechanics. Vibrations: Free, damped and forced singledegree of freedom system; Two degree of freedom system; Normal modes; Multidegree of freedom systems; Lab demos/sessions. **References/Text Books:** 1. Greenwood, D. T. 1987. Principles of Dynamics 2nd edition. Pearson Education.2. Beatty, M. F. 1986. Principles of Engineering Mechanics: Part I, II. Springer.3. Meirovitch, L. 1986. Elements of Vibration Analysis 2nd edition. McGraw Hill Education (India).4. Meirovitch, L. 2010 Methods of Analytical Mechanics. Dover publications.5. Thomson, W. T. 2002. Theory of Vibrations with Applications 3rd edition. CBS publishers.6. Hartog, D. 1985. Mechanical Vibrations. Dover publishers.7. Lanczos, C. 1986. The	APPLIED DYNAMICS AND VIBRATIONS

			Variational Principles of Mechanics 4th edition. Dover publications.8. Sharma, I. & S. S. Gupta. 2016. Understanding Rigid Body Dynamics. (under preparation)	
ME626	3-0-0--4		**Course Contents:** Vibration of discrete systems with single and multi degree of freedom. Hamiltonsprinciple, Langranges equations. Longitudinal vibration of bars, lateralvibration of straight and curved beams, vibration of membranes and plates,free and forced vibrations. Effect of damping. Wave motion in continuoussystems. **References/Text Books:**	VIBRATION OF CONTINUOUS SYSTEM
ME626A	3-0-0-0-9		**Course Contents:** Vibration of discrete systems with single and multi degree of freedom. Hamiltonsprinciple, Langranges equations. Longitudinal vibration of bars, lateralvibration of straight and curved beams, vibration of membranes and plates,free and forced vibrations. Effect of damping. Wave motion in continuoussystems. **References/Text Books:**	VIBRATION OF CONTINUOUS SYSTEMS
ME627	3-0-0--4		**Course Contents:** Phase space, singular points, limit cycle; Analytical methods, perturbationtechniques, equivalent linearization; Duffings equation, jump phenomenon,Van der Pol equation. Stability criterion; Floquets theory, Hills and Mathieusequations, Bifurcation and chaos. **References/Text Books:**	NON-LINEAR VIBRATION
ME627A	3-0-0-0-9		**Course Contents:** Phase space, singular points, limit cycle; Analytical methods, perturbationtechniques, equivalent linearization; Duffings equation, jump phenomenon,Van der Pol equation. Stability criterion; Floquets theory, Hills and Mathieusequations, Bifurcation and chaos. **References/Text Books:**	NONLINEAR VIBRATION
ME630	3-0-0--4		**Course Contents:** ODE, matrix methods, root finding. Classification of PDE, finite differences,Steady and unsteady conduction, explicit and implicit method, advectiondiffusionproblems, upwinding, boundarylayers, NavierStokes equations, MACand SIMPLE finite element method for heat conduction. **References/Text Books:**	NUMERICAL FLUID FLOW AND HEAT TRANSFER
ME630A	3-0-0-0-9		**Course Contents:** ODE, matrix methods, root finding. Classification of PDE, finite differences,Steady and unsteady conduction, explicit and implicit method, advectiondiffusionproblems, upwinding, boundarylayers, NavierStokes equations, MACand SIMPLE finite element method for heat conduction. **References/Text Books:**	NUMERICAL FLUID FLOW AND HEAT TRANSFER
ME631	3-0-0--4		**Course Contents:** Stressdeformation relations, NavierStokes equation, exact solutions, twodimensional and axisymmetric boundary layers, Separation, Compressible boundarylayers, Elements of stability theory, Turbulent flow: logarithmic law of the wall,effect of wall roughness, two and three equation models, fluidsolid interaction. **References/Text Books:**	VISCOUS FLOW THEORY
ME631A	3-0-0-0-9		**Course Contents:** Introduction: Fluid Properties, Definition of Continuum, Examples of Viscous Flow Phenomena, Laminar	VISCOUS FLOW THEORY

			and Turbulent Flow, Vector and Tensor notation, Lagrangian/Eulerian Methods,Streamline, Path line, Streak line,Material Derivative and acceleration, Strain Rate, Translation, Rotation and Distortion of Fluid Element, Vorticity and Circulation.Fundamental Equations of Viscous Flow: Conservation of Mass, Momentum and Energy,Finite Volume Approach, Derivation of Continuity Equation: conservative and non conservative form, Derivation of NavierStokes (NS) equations for Compressible Flow, Stokes Hypothesis. Incompressible form of NS equations. Exact Solutions: Parallel Flow in a Straight Channel, Couette Flow, Lubrication Theory, HagenPoiseuille Flow,Unsteady Parallel Flow, Stokes Problems, Similarity Solution and Creeping Flow, Complex variable and Potential flow. BoundaryLayer Theory: Derivation of 2D Boundary Layer Equations, Displacement, Momentum and Energy Thickness, Order of Magnitude Analysis, Shape Factor, MomentumIntegral Approach, Boundary Layer Separation, Effect of Pressure Gradient, Boundary Layer Control by Suction and Blowing, BlassiusSolution of Boundary Layer Equation, KrmnPohlhausenMethod for NonZero Pressure Gradient, Holstenand Bohlen Method (Modified PohlhausenMethod), WaltzsQuadratureFormula and Example Problems. **References/Text Books:**	
ME634	3-0-0-0-4		**Course Contents:** Discretisation procedure in Finitedifference and Finitevolume. NavierStokes,Energy equations. Staggered rectilinear grids. Explicit methods : MAC, SMAC.Implicit Methods, SIMPLE and SIMPLER. Matrix methods, conjugate gradientmethod, strongly Implicit Procedure. GridGeneration:Algebraic, Transfinite,Poisson equation methods. Finitedifference NavierStokes solution on nonorthogonalgrids, transformation. Collocated grids. Finitevolume methods onnonorthogonal grids. Turbulence modelling, ke modelling **References/Text Books:**	ADVANCED COMPUTATIONAL FLUID DYNAMICS
ME634A	3-0-0-0-9		**Course Contents:** Discretisation procedure in Finitedifference and Finitevolume. NavierStokes,Energy equations. Staggered rectilinear grids. Explicit methods : MAC, SMAC.Implicit Methods, SIMPLE and SIMPLER. Matrix methods, conjugate gradientmethod, strongly Implicit Procedure. GridGeneration:Algebraic, Transfinite,Poisson equation methods. Finitedifference NavierStokes solution on nonorthogonalgrids, transformation. Collocated grids. Finitevolume methods onnonorthogonal grids. Turbulence modelling, ke modelling **References/Text Books:**	ADVANCED COMPUTATIONAL FLUID DYNAMICS
ME639	3-0-0--4		**Course Contents:** 1st Term (14 hours) o 2nd Term (14 hours) 3rd Term (14 hours) Introduction to twophase flow and heat transfer technology Liquidvapor phase change phenomena , Interfacial tension, Wetting phenomenon, Contact angles, Transport effects, Dynamic behavior of interfaces, Phase stability and nucleation Twophase flow fundamentals, Flow patterns and map representation, Development of homogeneous, separated flow and drift flux models, Flooding mechanismso Boiling Fundamentals, Homogeneous and heterogeneous nucleation, Pool boiling and convective flow boiling, Heat transfer and CFH mechanisms, Enhancement techniqueso Condensation fundamentals, External and internal condensation , Film condensation theory , Dropwise condensation theory , Enhancement techniqueso Experimental techniques, Practical boundary conditions, Void fraction measurement techniques, Flow visualization techniques, Contact angle/Surface tension measurement, Conventional thermometry , Limitations, Data reduction, Application examples Application of twophase t1ow and heat transfer, Theory and operation of Boilers/Evaporators and condensers for Nuclear/Power/RAC industry, Electronics thermal management, Latent heat storage devices, Gravity assisted thermosyphons/ Vapor chambers, Conventional heat pipes, Micro heat pipes, Pulsating heat pipes, Capillary pumped loops/ Loop heat pipes, Micro twophase heat exchangers Special related topics: for example, static and dynamic instabilities, microscale boiling and condensation , atomistic nucleation models, microgravity boiling, microfabrication/ integration techniques, contact resistance, surface roughness,	LIQUID VAPOUR PHASE CHANGE PHENOMENA

			Leidenfrost phenomena, etc. **References/Text Books:** (i) Liquid Vapor Phase Change Phenomena by Van P. Carey (Taylor & Francis)(ii) Convective Boiling And Condensation by Collier John (Oxford Engineering Science) (iii) Heat Transfer Characteristics in Boiling and Condensation by Karl Stephan (Springer) (iv) Twophase Flow and Heat Transfer P. B. Whalley (Oxford Engineering Science)(v) One Dimensional TwoPhase Flow G. B. Wallis (McGraw Hill)(vi) Heat Pipe Science and Technology by Amir Faghri (Taylor and Francis)(vii) Heat Pipe Technology and Applications by J . P. Peterson (John Wiley & Sons) (viii) Heat Transfer A practical approach by Yunus Cengel (Tata McGraw Hill)(ix) Heat Transfer lncropera and Dewitt (John Wiley and Sons)	
ME639A	3-0-0-0-9		**Course Contents:** 1st Term (14 hours) o 2nd Term (14 hours) 3rd Term (14 hours) Introduction to twophase flow and heat transfer technology Liquidvapor phase change phenomena , Interfacial tension, Wetting phenomenon, Contact angles, Transport effects, Dynamic behavior of interfaces, Phase stability and nucleation Twophase flow fundamentals, Flow patterns and map representation, Development of homogeneous, separated flow and drift flux models, Flooding mechanismso Boiling Fundamentals, Homogeneous and heterogeneous nucleation, Pool boiling and convective flow boiling, Heat transfer and CFH mechanisms, Enhancement techniqueso Condensation fundamentals, External and internal condensation , Film condensation theory , Dropwise condensation theory , Enhancement techniqueso Experimental techniques, Practical boundary conditions, Void fraction measurement techniques, Flow visualization techniques, Contact angle/Surface tension measurement, Conventional thermometry , Limitations, Data reduction, Application examples Application of twophase t1ow and heat transfer, Theory and operation of Boilers/Evaporators and condensers for Nuclear/Power/RAC industry, Electronics thermal management, Latent heat storage devices, Gravity assisted thermosyphons/ Vapor chambers, Conventional heat pipes, Micro heat pipes, Pulsating heat pipes, Capillary pumped loops/ Loop heat pipes, Micro twophase heat exchangers Special related topics: for example, static and dynamic instabilities, microscale boiling and condensation , atomistic nucleation models, microgravity boiling, microfabrication/ integration techniques, contact resistance, surface roughness, Leidenfrost phenomena, etc. **References/Text Books:** (i) Liquid Vapor Phase Change Phenomena by Van P. Carey (Taylor & Francis)(ii) Convective Boiling And Condensation by Collier John (Oxford Engineering Science) (iii) Heat Transfer Characteristics in Boiling and Condensation by Karl Stephan (Springer) (iv) Twophase Flow and Heat Transfer P. B. Whalley (Oxford Engineering Science)(v) One Dimensional TwoPhase Flow G. B. Wallis (McGraw Hill)(vi) Heat Pipe Science and Technology by Amir Faghri (Taylor and Francis)(vii) Heat Pipe Technology and Applications by J . P. Peterson (John Wiley & Sons) (viii) Heat Transfer A practical approach by Yunus Cengel (Tata McGraw Hill)(ix) Heat Transfer lncropera and Dewitt (John Wiley and Sons)	LIQUID VAPOUR PHASE CHANGE PHENOMENA
ME641	3-0-0--4		**Course Contents:** Conduction: Steady and unsteady problems and their solutions in cartesian,cylindrical and spherical coordinates. Separation of variables. Duhamels theorem.Laplace transform. Problems involving change of phase. Inverse heat conduction,Microscale heat transfer, Radiation: Radiative exchange among black and greyand spectral surfaces, Shape factors. Applications to cavities and enclosures.Integral equations approach. Radiation from gases, vapours and flames. **References/Text Books:**	CONDUCTION AND RADIATION
ME641A	3-0-0-0-9		**Course Contents:** Lec 1: Conduction: Derivation of Heat Conduction Equation for Heterogeneous, Isotropic Materials in Cartesian Coordinates. Heat conduction equation for homogeneous, isotropic materials in Cartesian, Cylindrical and Spherical Coordinates. Summary of basic steady 1D heat conduction solutions including concept of resistances. Lec 2: Heat transfer from a fin of uniform crosssection. Fin efficiency and fin	CONDUCTION AND RADIATION

			effectiveness. Fin with variable crosssection. Lec 3: Twodimensional Steady State Heat Conduction: Illustration 1: A rod with rectangular crosssection with three sides having temperature, To and other side at T f(x). Solution by Method of Separation of Variables. Isotherms and Heat Flux Lines. Lec 4: Illustration 2: 2D Steady State Heat Conduction with Constant Heat Generation in a Long Rod of Rectangular Crosssection with Boundaries at the ambient temperature (large heat transfer coefficient)methods for onedimensional media: The optically thin and optically thick approximations. Radiation in participating media: Gas radiation. Combined Conduction and Radiation: Example of a spacecraft radiator. Solar radiation. Greenhouse effect. **References/Text Books:**	
ME642	3-0-0--4		**Course Contents:** Introduction: Convective heat transfer and its applications; Forced, free and mixed convection; internal and external flow; heat transfer coefficient and its physical significance; dimensional analysis in convective heat transfer. Conservation Equations and boundary conditions: Mass, momentum, energy equations. External Laminar Forced Convection: Boundary layer equations; energy equation for flow over flat plate; similarity solution for flow over a flat plate having various boundary conditions and Prandtl numbers; Scale analysis; Approximate method; Viscous dissipation effect oflaminar boundary layer. Internal Laminar Forced Convection: Developing and developedflow and heat transfer in a duct and circular pipe having various boundary conditions. Natural/Free and Mixed Convection: Boussinesq approximations; Similarity solution for flow over a flat plate; Scale analysis; Approximate method; Mixed convection and the corresponding governing equations. **References/Text Books:** Course Reference : Suggested text books:Introduction to Convective Heat Transfer Analysis by Patrick H. Oosthuizen and DavidLaylor (McGrawHill)Convective Heat and Mass Transfer by Kays, Crawford and Weigand (4th Edition,McGrawHill)Convective Heat Transfer by L. C. Burmeister (John Wiley and Sons)Suggested reference books:Convective Heat Transfer by M FavreMarinet and S Tardu (John Wiley and Sons)Principles of Convective Heat Transfer by Massoud Kaviany (2nd Edition, Springer)Convective Heat Transfer by I. Pop and D. B. Ingham (Pergamon)Convective Heat Transfer by Adrian Bejan (John Wiley and Sons)Heat Convection by Latif M Jiji (Springer)Viscous Fluid Flow by Frank M White (McGrawHill)Boundary Layer Theory by H Sctllichting (McGrawHill)	CONVECTIVE HEAT AND MASS TRANSFER
ME642A	3-0-0-0-9		**Course Contents:** Introduction: Convective heat transfer and its applications; Forced, free and mixed convection; internal and external flow; heat transfer coefficient and its physical significance; dimensional analysis in convective heat transfer. Conservation Equations and boundary conditions: Mass, momentum, energy equations. External Laminar Forced Convection: Boundary layer equations; energy equation for flow over flat plate; similarity solution for flow over a flat plate having various boundary conditions and Prandtl numbers; Scale analysis; Approximate method; Viscous dissipation effect oflaminar boundary layer. Internal Laminar Forced Convection: Developing and developedflow and heat transfer in a duct and circular pipe having various boundary conditions. Natural/Free and Mixed Convection: Boussinesq approximations; Similarity solution for flow over a flat plate; Scale analysis; Approximate method; Mixed convection and the corresponding governing equations. **References/Text Books:** Suggested text books:Introduction to Convective Heat Transfer Analysis by Patrick H. Oosthuizen and DavidLaylor (McGrawHill)Convective Heat and Mass Transfer by Kays, Crawford and Weigand (4th Edition,McGrawHill)Convective Heat Transfer by L. C. Burmeister (John Wiley and Sons)Suggested reference books:Convective Heat Transfer by M FavreMarinet and S Tardu (John Wiley and Sons)Principles of Convective Heat Transfer by Massoud Kaviany (2nd Edition, Springer)Convective Heat Transfer by I. Pop and D. B. Ingham (Pergamon)Convective Heat Transfer by Adrian Bejan (John Wiley and Sons)Heat Convection by Latif M Jiji (Springer)Viscous Fluid Flow by Frank M White (McGrawHill)Boundary Layer Theory by H Sctllichting (McGrawHill)	CONVECTIVE HEAT AND MASS TRANSFER

ME643	3-0-0-0-4		**Course Contents:** Flame phenomena in premixed combustible gases. Diffusion flamesanalysis of single fuel droplet, chemical reactions. Burning in convective atmosphere, spray combustion, fire modelling, radiation in flames, formation and control of pollution, Combustion chambers. **References/Text Books:**	COMBUSTION AND ENVIROMNENT
ME643A	3-0-0-0-9		**Course Contents:** Flame phenomena in premixed combustible gases. Diffusion flamesanalysis of single fuel droplet, chemical reactions. Burning in convective atmosphere, spray combustion, fire modelling, radiation in flames, formation and control of pollution, Combustion chambers. **References/Text Books:**	COMBUSTION AND ENVIROMNENT
ME647	3-0-0-0-4		**Course Contents:** Measure of turbulence, diffusivity, length scales. Reynolds equation. Mixinglength models. Homogeneous, isotropic turbulence, correlation and energyspectrum functions, integral micro scales. Grid turbulence, jets, wakes andmixing layers, boundary layers, logarithmiclaw near walls. **References/Text Books:**	INTRODUCTION TO TURBULENT FLUID MECHANICS
ME647A	3-0-0-0-9		**Course Contents:** Measure of turbulence, diffusivity, length scales. Reynolds equation. Mixinglength models. Homogeneous, isotropic turbulence, correlation and energyspectrum functions, integral micro scales. Grid turbulence, jets, wakes andmixing layers, boundary layers, logarithmiclaw near walls. **References/Text Books:**	INTRODUCTION TO TURBULENT FLUID MECHANICS
ME648	3-0-0--4		**Course Contents:** Simulation of thermal processes, application to casting, extrusion, heat treatment,thermal design of heat exchangers, electronic circuitry. Optimization searchmethod and geometric programming, control strategy, data storage andretrieval. Expert systems. **References/Text Books:**	COMPUTER AIDED DESIGN OF THERMAL SYSTEMS
ME649	3-0-0--4		**Course Contents:** Probes and transducers; Calibration; Turbulence measurement via statisticalmeasures; Single and multipoint correlations; Signal conditioning; Opticalmethods, Interferometry, Schlieren, shadowgraph, LCT, Laser Doppler velocimeter;Transient and frequency response. Computer aided data acquisition,tomography. **References/Text Books:**	EXPERIMENTAL METHODS IN THERMAL SCIENCES
ME649A	3-0-0-0-9		**Course Contents:** Probes and transducers; Calibration; Turbulence measurement via statisticalmeasures; Single and multipoint correlations; Signal conditioning; Opticalmethods, Interferometry, Schlieren, shadowgraph, LCT, Laser Doppler velocimeter;Transient and frequency response. Computer aided data acquisition,tomography. **References/Text Books:**	EXPERIMENTAL METHODS IN THERMAL SCIENCES
ME652	3-0-0--4		**Course Contents:** Review of kinematics and kinetics of a particle and a rigid body in plane motion.Eulers equations; Methods of analytical dynamics, Lagranges equations; Hamiltonsprinciple; Dynamics in phase space and introduction	PRINCIPLES OF DYNAMICS

			to stability theory; Applicationsto engineering problems. **References/Text Books:**	
ME654	3-0-0--4		**Course Contents:** Simple dynamical models of ground vehicles, mechanics of pneumatic tires,mechanics of vehiclesterrain interaction, performance characteristics of roadvehicles, Handling characteristics. Directional stability, wheel shimmy, vehicleride characteristics. **References/Text Books:**	MECHANICS OF GROUND VEHICLES
ME658	3-0-0--4		**Course Contents:** Basic principle of numerical control, Classification of NC systems,. NC partprogrammingmanual and computer aided. Drives, feedback devices, Countingdevices used in NC system. Interpolators for Manufacturing system. Control loopsfor NC system, Adaptive control, Industrial robots. **References/Text Books:**	NUMERICAL CONTROL OF MACHINE TOOLS
ME661	3-0-0--4		**Course Contents:** Mechanics of chip formation, chip curl. Bluntness and cutting forces. Thermalaspects of machining. Tool wear, tool life and economics of machining. Mechanicsof grinding, forces and specific energy, temperature. wheel wear and surfacefinish. **References/Text Books:**	MACHINING SCIENCE I
ME661A	3-0-0-0-9	TA202A	**Course Contents:** 1. Introduction : Machining; Plastic Deformation, Tensile Test, Stress and Strain; Mechanism of Plastic Deformation: Slips, defects, plastic deformation on atomic scale.2. Machining Process : Types of machining processes; Chip formation; Orthogonal and Oblique Cutting; Types of Chips; Builtup edge formation. 3. Tool Geometry : Reference planes; Tool specification: American System (ASA), continental or Orthogonal System (ORS), International or Normal Rake system (NRS); Tool angle relationships in ORS, ASA and NRS; Selection of Tool Angles; Multiplepoint cutting tools: twist drill, helical milling cutter. 4 . Mechanics of Metal Cutting : Merchant's Circle Diagram; Coefficient of Friction: Determination of stress, strain and strain rate; Measurement of shear angle; Thin Zone model: Lee and Shaffer's Relationship; Thick Zone model: Okushima and Hitomi Analysis. 5. Friction in Metal Cutting : Nature of sliding friction; Friction in Metal Cutting: Sticking and Sliding Zones, Analysis of Stress Distribution on the tool face: Zorevs model; Determination of mean angle of friction. 6. Mechanism of Oblique cutting : Rake angles in oblique cutting: Analytical determination of Normal Rake angle, velocity rake angle and effective rake angle; their relationship; shear angles in oblique cutting; velocity relationship; Force relationships in oblique cutting. **References/Text Books:** References:1. E.J.A. Armarego and R.H.BrownThe machining of Metals2. G BoothroydFundamentals of Metal Machining and Machine tools3. A.Ghosh and Asok Mallik Machining Science4. G.K.Lal and S.K.ChoudhuryFundamental of Manufacturing Processes5. M.C.ShawMetal Cuttting PrinciplesJournals:1. Trans. of ASME: Journal of Manufacturing Science and Engineering.2. International Journal of Machine Tools and Manufacturing.3. Annals of CIRP.4. Journal of Materials processing technology.5. Precision Engineering.6. International Journal of Mechanical Sciences.7. Proceedings, International Machine Tool Design and Research Conference.	MACHINING SCIENCE I
ME662	3-0-0--4		**Course Contents:** General classification of unconventional machining, chemical machining, electricdischarge machining, Abrasive Jet and Ultrasonic Machining, electron beammachining, laser beam machining, ion beam machining, plasma arc machining;Comparative evaluation of different processes; Conventional machining	MACHINING SCIENCE II

			withmodifications. **References/Text Books:**	
ME662A	3-0-0-0-9	TA202A	**Course Contents:** I. Introduction to Advanced Manufacturing Processes. Introduction to manufacturing processes. Overview of non conventional machining processes with (AJM, USM, ECM, EDM, EBM, LBM, AFM, MRF, MAF, MFP and MRAFF etc.) Introduction to use of non conventional processes for micromachining. II. Mechanical Material Removal Processes (AJM, USM and WAJM) Abrasive Jet Machining (AJM): Introduction to abrasive jet machining (AJM), Mechanics of AJM, AJM process parameters Components of AJM (Abrasive, Gas, Setup), Mixing and Mass ratio and Material removal rate, Numerical approach to AJM, Modelling of Material Removal Rate (MRR). Ultrasonic Machining (USM): Basics of USM processes, Mechanics of USM, Process parameters of USM, Shaws model of USM mechanics, Compressed grain modelling and direct throw modelling and comparison, Dependence of process parameters in estimation of MRR, Numerical approach to USM, Ultrasonic machining setup, Design of acoustic ultrasonic head and feed mechanism in USM. Water Abrasive jet machining (WAJM): Introduction to WAJM (Basic principle and MRR estimation), WAJM process video. III. Nanofinishing processes. Introduction to nanofinishing and need of nanofinishing, Abrasive Flow Finishing (AFF), Introduction to AFF and self deformable feature, AFF machine elements, Magnetic Abrasive Finishing (MAF), Introduction to MAF, Elements of MAF, Setup and process parameters for AFF and MAF, Parametric analysis and applications of MAF and AFF. **References/Text Books:** References: Advanced manufacturing processes, Hassan Abdel, Gabad El Hoffy, McGraw Hill. V.K.Jain, Advance Machining Processes, Allied Publisher Bombay. Ghosh and Mallik, Manufacturing Science, EWP Private Ltd. Pandey P.C., Shan H.S., Modern machining processes, Tata McGrawHill Education. Weller E.J., Non traditional machining processes, Society of Manufacturing Engineers, Publications. The Science and Engineering of Microfabrication, Stephen P. Campbell, Oxford university press.	MACHINING SCIENCE II
ME663	3-0-0--4		**Course Contents:** Fundmentals of plasticity, yield and flow, anisotropy, instability, limit analysis,slipline field theory. Applications to forging, wire and tube drawing, deep drawing,extrusion and rolling. High velocity forming. **References/Text Books:**	METAL FORMING
ME663A	3-0-0-0-9		**Course Contents:** (I) Introduction. 1. Introduction to the course: different metal forming processes, importance of plasticity in the course. (II)Fundamentals of Plasticity. 1. ReviewAnalysis of stress: transformation relations, principal stresses and directions, maximum normal and shear stresses, invariants, hydrostatic and deviatoric parts; Analysis of (infinitesimal) strain: transformation relations, principal strains, invariants, hydrostatic and deviatoric parts; (Infinitesimal) rotation, Stressstrain relations for isotropic, linearly elastic material. 2. Experimental observations on plasticity: yielding, strainhardening, viscoplasticity, temperature softening, Baushinger effect, hysteresis, incompressibility of plastic deformation, anisotropy, plastic instability . 3. Yield criterion for isotropic materials: von Mises and Tresca yield criterion, their geometric interpretation, convexity of the yield surfaces, experimental validation. 4. Incremental and rate forms of the measures of plastic deformation: linear incremental strain tensor, strain rate (i.e. the rate of deformation) tensor and their relation, incremental rotation tensor and spin tensor. 5. Change in yield criteria due to isotropic hardening: strain hardening and work hardening hypotheses, experimental validation of the hypotheses. 6. Plastic stressstrain relations for isotropic materials: plastic potential and associated flow rule, incremental and rate forms of elastoplastic stressstrain relations, simplifications for nonhardening and rigidplastic materials (Prandtl Reuss and LevyMises relations), Objective measures of stress rate and incremental stress. 7. Incremental and flow formulations of plasticity: updated Lagrangian and Eulerian formulations, boundary and initial conditions, examples.	METAL FORMING

			References/Text Books: References :1. The Mathematical Theory of Plasticity by R. Hill, Oxford University Press, 19502. Engineering Plasticity by W. Johnson and P.B. Mellor, von Nostrand Co. Ltd,19723. Theory of Plasticity by J. Chakrabarty, McGrawHill Book Co., InternationalEdition, 19874. Metal Forming: Processes and Analysis by B. Avitzur, McGrawHill Book Co.,19685. Continuum Theory of Plasticity by A.S. Khan and S. Huang, John Wiley andSons Inc., 1995.	
ME664	3-0-0-0-4		**Course Contents:** 1 Introduction to Casting Problem: Principles of solidification, introduction to fluid flow and micrstntcture in a casting process.2 Solidification Transnort Phenomena in Casting: Solidification of pure metals and alloys; Nucleation and growth; Natwe of solicVIiquid interface; Constitutional undercooling; Dendritic grO:vth; Directional solidification.Mathematical treatment of soliditication transp01t phenomena involved in a casting process (mass and heat transfer, fluid dynamics, mushy zone); Mathematical analysis ofre distribution of solute during solidification, micro and macrosegregation.Defects: Casting defects (compositional, microstructural, mold filling, shrinkage and other flow and heat transfer related defects), their causes and remedies; Understanding the role of transport phenomena in the formation of these defects.4 Case Studies of Some Selected Casting Processes: Mold, die and investment casting; Direct chill casting; Ingot casting; Directional solidification, Micro casting.Manipulation and control of casting structure, properties and defects through advanced casting processes Inoculation practices, rheocasting, thixocasting, multiphysics casting processes involving magnetic fields.5 Casting Design bv Controlling the Accomnanied Heat Transfer2 Fluid Flow and Solidification: Mathematical treatment of solidification rates exact and approximate methods;mold casting heat transfer.Riser design, feeding distance, mold filling and their relation with temperature distribution and dimensional design of the casting. **References/Text Books:** 1. Science and Engineering of Casting Solidification, Doru M Stefanescu, 2nd ed.2. Solidification ProcessJng, M C Fleming, McGraw Hill.3. Principles of metal casting, R W Heine, C R Loper and Rosenthal, Tata McGraw Hill, New Delhi.4. Casting, J Campbell, ButterworthHeinemann.5. Manufacturing Engineering and Technology, S Kalpakjian.6. Fundamentals of Modern Manufacturing, M P Groover.7. Fundamentals of Manufacturing Processes, G K Lal and S K Choudhury.8. Metals HandbookMetal Casting, ASM.	FUNDAMENTALS OF CASTING & SOLIDIFICATION
ME664A	3-0-0-0-9		**Course Contents:** 1 Introduction to Casting Problem: Principles of solidification, introduction to fluid flow and micrstntcture in a casting process.2 Solidification Transnort Phenomena in Casting: Solidification of pure metals and alloys; Nucleation and growth; Natwe of solicVIiquid interface; Constitutional undercooling; Dendritic grO:vth; Directional solidification.Mathematical treatment of soliditication transp01t phenomena involved in a casting process (mass and heat transfer, fluid dynamics, mushy zone); Mathematical analysis ofre distribution of solute during solidification, micro and macrosegregation.Defects: Casting defects (compositional, microstructural, mold filling, shrinkage and other flow and heat transfer related defects), their causes and remedies; Understanding the role of transport phenomena in the formation of these defects.4 Case Studies of Some Selected Casting Processes: Mold, die and investment casting; Direct chill casting; Ingot casting; Directional solidification, Micro casting.Manipulation and control of casting structure, properties and defects through advanced casting processes Inoculation practices, rheocasting, thixocasting, multiphysics casting processes involving magnetic fields.5 Casting Design bv Controlling the Accomnanied Heat Transfer2 Fluid Flow and Solidification: Mathematical treatment of solidification rates exact and approximate methods;mold casting heat transfer.Riser design, feeding distance, mold filling and their relation with temperature distribution and dimensional design of the casting. **References/Text Books:** 1. Science and Engineering of Casting Solidification, Doru M Stefanescu, 2nd ed.2. Solidification ProcessJng, M C Fleming, McGraw Hill.3. Principles of metal casting, R W Heine, C R Loper and Rosenthal, Tata McGraw Hill, New Delhi.4. Casting, J Campbell, ButterworthHeinemann.5. Manufacturing Engineering and Technology, S Kalpakjian.6. Fundamentals of Modern Manufacturing, M P Groover.7. Fundamentals of	FUNDAMENTALS OF CASTING & SOLIDIFICATION

			Manufacturing Processes, G K Lal and S K Choudhury.8. Metals HandbookMetal Casting, ASM.	
ME665	3-0-0-0-4	ME361	**Course Contents:** 1. Introduction to the Course & Classification of MMPs, Part1: Mechanical Type Advanced Micromachining Processes, 2. Abrasive Jet Micro Machining (AJMM), 3. Ultrasonic Micro Machining (USMM), 4. Abrasive Water Jet Micro Machining (AWJMM), Part2: Abrasive Based Nano Finishing Processes, 5. Abrasive Flow Finishing (AFF), 6. Chemo mechanical Polishing (CMP), 7. Magnetic Abrasive Finishing (MAF), 8. Magnetorheological Finishing (MRF), 9. Magnetorheological Abrasive Flow Finishing (MRAFF), 10. Magnetic Float Polishing (MFP), 11. Elastic Emission Machining, Part3: Thermoelectric Type Micro Machining Processes, 12. Electric Discharge Micro Machining (EDMM), 13. Wire EDM, EDDG, ELID, 14. Laser Beam Micro Machining (LBMM), 15. Electron Beam Micro Machining (EBMM),16. Ion Beam Machining **References/Text Books:** 1. Introduction to Micromachining, V. K. Jain (Ed.), Narosa publisher, 2010.2. Micromachining, J. A. McGeough,3. Micromanufacturing, V. K. Jain (Ed.), CRC press, 2012.4. Micromanufacturing & Nanotechnology, N. P. Mahalik, Springer.5. Microfacbrication & Nanomanufacturing, Mark J. Jackson, CRC press.	MICROMACHINING
ME665A	3-0-0-0-9		**Course Contents:** 1. Introduction to the Course & Classification of MMPs, Part1: Mechanical Type Advanced Micromachining Processes, 2. Abrasive Jet Micro Machining (AJMM), 3. Ultrasonic Micro Machining (USMM), 4. Abrasive Water Jet Micro Machining (AWJMM), Part2: Abrasive Based Nano Finishing Processes, 5. Abrasive Flow Finishing (AFF), 6. Chemo mechanical Polishing (CMP), 7. Magnetic Abrasive Finishing (MAF), 8. Magnetorheological Finishing (MRF), 9. Magnetorheological Abrasive Flow Finishing (MRAFF), 10. Magnetic Float Polishing (MFP), 11. Elastic Emission Machining, Part3: Thermoelectric Type Micro Machining Processes, 12. Electric Discharge Micro Machining (EDMM), 13. Wire EDM, EDDG, ELID, 14. Laser Beam Micro Machining (LBMM), 15. Electron Beam Micro Machining (EBMM),16. Ion Beam Machining **References/Text Books:** 1. Introduction to Micromachining, V. K. Jain (Ed.), Narosa publisher, 2010.2. Micromachining, J. A. McGeough,3. Micromanufacturing, V. K. Jain (Ed.), CRC press, 2012.4. Micromanufacturing & Nanotechnology, N. P. Mahalik, Springer.5. Microfacbrication & Nanomanufacturing, Mark J. Jackson, CRC press.	MICROMACHINING
ME667	3-0-0-0-4		**Course Contents:** I. History of friction and lubrication studies, Origins of friction, Coulomb's theory, Archard's theory, Bowden and Tabor's theory, Hardness of metals and ductile materials, contact area calculations, Hertzian model, JKR model, Atomic scale understanding offriction, Surface forces (van der Waals, electrostatic, hydrogen bonding etc.), adhesion models/nanorheology, meniscus and surfce models, static friction, stickslip phenomenon, friction anisotropy, concept ofsuperlubricity, micronanoscale wearphenomenon, tribology in wet environment, capillary force, Young and Laplace equation (91ectures)2. Liquid lubrication, lubrication regimes, load bearing equation, journal bearings, elastohydrodynamic lubrication, film thickness calculation, Boundary lubrication, characteristics of boundary lubricants, liquid lubricants, additives, confined molecularly thin liquid films, Friction phase diagram, nanolubrication and effects ofnanotexturing on nanolubrication. (91ectures)3. Nanotribological measurements: nanoscratching, atomic force microscopy tests, friction force microscopy, surface force apparatus, Tabor and Winterton design for surface force measurement, surface analytical tools such as FTIR, XPS and FESEM fortribological research. Experimental results on model surfaces. (9 lectures)4. Effects of surface/material parameters on micro/nanoscale friction (Load effects, speed effects, surface energy, surface l roughness effects on adhesion and friction, humidity molecular structure, contact mechanical properties, hardness). Scaling effect,ribocharging (6 lectures)	ADHESION, FRICTION AND LUBRICATION FOR MICROMACHINES

			References/Text Books: Tribology on the Small Scale: A Bottom Up Approach to Friction, Lubrication, and Wear, C. Mathew Mates, Oxford University Press, 2007Nanotribology and Materials in MEMS, Sujeet K. Sinha, N. Satyanarayana and Seh Chun Lim (eds.), (ISBN 9783642369346) Springer Berlin,2013.Polymer Tribology by Sujeet K. Sinha and Brian J. Briscoe (editors) (Imperial College Press)Biological Micro and Nanotribology: Nature's Solutions by M. Scherge, S. N. Gorb, Springer Verlag	
ME667A	3-0-0-0-9		**Course Contents:** I. History of friction and lubrication studies, Origins of friction, Coulomb's theory, Archard's theory, Bowden and Tabor's theory, Hardness of metals and ductile materials, contact area calculations, Hertzian model, JKR model, Atomic scale understanding offriction, Surface forces (van der Waals, electrostatic, hydrogen bonding etc.), adhesion models/nanorheology, meniscus and surfce models, static friction, stickslip phenomenon, friction anisotropy, concept ofsuperlubricity, micronanoscale wearphenomenon, tribology in wet environment, capillary force, Young and Laplace equation (91ectures)2. Liquid lubrication, lubrication regimes, load bearing equation, journal bearings, elastohydrodynamic lubrication, film thickness calculation, Boundary lubrication, characteristics of boundary lubricants, liquid lubricants, additives, confined molecularly thin liquid films, Friction phase diagram, nanolubrication and effects ofnanotexturing on nanolubrication. (91ectures)3. Nanotribological measurements: nanoscratching, atomic force microscopy tests, friction force microscopy, surface force apparatus, Tabor and Winterton design for surface force measurement, surface analytical tools such as FTIR, XPS and FESEM fortribological research. Experimental results on model surfaces. (9 lectures)4. Effects of surface/material parameters on micro/nanoscale friction (Load effects, speed effects, surface energy, surface l roughness effects on adhesion and friction, humidity molecular structure, contact mechanical properties, hardness). Scaling effect,ribocharging (6 lectures) **References/Text Books:** Tribology on the Small Scale: A Bottom Up Approach to Friction, Lubrication, and Wear, C. Mathew Mates, Oxford University Press, 2007Nanotribology and Materials in MEMS, Sujeet K. Sinha, N. Satyanarayana and Seh Chun Lim (eds.), (ISBN 9783642369346) Springer Berlin,2013.Polymer Tribology by Sujeet K. Sinha and Brian J. Briscoe (editors) (Imperial College Press)Biological Micro and Nanotribology: Nature's Solutions by M. Scherge, S. N. Gorb, Springer Verlag	ADHESION, FRICTION AND LUBRICATION FOR MICROMACHINES
ME669A	3-0-0-0-9		**Course Contents:** 1. Review of fundamentals of thermal transport in manufacturing : 1. Introduction to the course Importance of heat transfer in manufacturing and applications. 2. Steady and transient heat conduction, Convection and Radiation, Natural convection. 3. Fluid flow and Mass transfer. 2. Finite Difference and Finite Volume based modeling of heat transfer in manufacturing and numerical implementation: 1. Basic introduction to FDM and FVM techniques, Mathematical formulation of thermal transport, Governing equations and general scalar transport equation, 2. Steady and unsteady problems, Initial and Boundary conditions, Convectiondiffusion problems, 3. Mesh terminology, Accuracy, Consistency, Stability and Convergence, 4. Phase change Enthalpy based algorithm for Melting/solidification, Twophase mushy zone flows, Liquidvapour phase change involved in manufacturing, 5. Illustration using code. 3. Case studies on modeling of thermal transport in manufacturing processes: 1. Solidification processing Modeling of moving melting/solidification phase change interface, Alloy solidification, Segregation, Twophase mushy zone flow, Modeling of casting, Marangoni convection driven flow, Modeling of welding, 2. Heat assisted manufacturing process Thermal modeling using enthalpy method for solid liquid and/ or liquidvapour phase change interface. Melt pool formation and flow behaviour, Beam heat flux models, Eample problems of thermal modeling in Laser Melting (LM), Electron Beam Melting(EBM), Machining: Electric Discharge Machining (EDM) and Heat assisted micro manufacturing process, 3. Thermal deposition process Modeling of free surface evolution, Modeling of droplet impact and deposition on substrates. **References/Text Books:** 1. R.N. Smith, C.H. Doumanidis, R. Pitchumani, Chapter 17, Heat Transfer in Manufacturing and Materials Processing, John Wiley & Sons Inc., 2006. 2. T.L. Bergman, A.S. Lavine, F.P. Incropera, D.P. DeWitt,	MODELING THERMAL TRANSPORT IN MANUFACTURING PROCESSES

			Fundamentals of Heat and Mass Transfer, 6th Edition, Wiley India Pvt. Ltd., 2006. 3. S.V> PLatankar, Numerical Heat Transfer and Fluid Flow, McGraw Hill, New York, 1980. 4. J. Dowden (Ed.), The Theory of Laser Materials Processing in Heat and Mass Transfer in Modern Technology, Springer, 2008. 5. D.M. Stefanescu Science and Engineering of Casting Solidification, 2nd ed., Springer, 2008. 6. M.P. Groover, Fundamentals of Modern Manufacturing, John Viley & Sons Inc., 2010. 7. Larry F. Jeffus, Welding: Principles and Applications, 4th ed., Thomson Learning, 1999. 8. L. Pawlowski, The Science and Engineering of Thermal Spray Coatings, 2nd ed., John Wiley & Sons Inc, 2008.	
ME670A	3-0-0-0-9		**Course Contents:** 1. Introduction to Additive Manufacturing AM): General overview, Introduction to reverse engineering, Traditional manufacturing v/s AM, Computer aided design (CAD) and AM. Different AM processes and relevant process physics AM process chain, Application level: Direct processes Rapid Prototyping, Rapid Tooling, Rapid Manufacturing; Indirect Processes Indirect Prototyping, Indirect Tooling, Indirect Manufacturing. 2. Materials science for AM : Discussion on different materials used for AM. Use of multiple materials, maltifunctional and graded materials in AM. Role of solidification rate. Evolution of nonequilibrium structure. Structure property relationship. Grain structure and microstructure. 3. AM technologies: Powderbased AM processes involving sintering and melting (selective laser sintering, laser engineered net shaping, electron beam melting, high energy beam involvement). Printing processes (droplet based 3D printing) Solidbased AM processes extrusion based fused deposition modeling (FDM), Laminated object manufacturing(LOM) Stereolithography. Microand nanoadditive manufacturing process. 4. Mathematical models for AM: Transport phenomena models: temperature, fluid flow and composition, buoyancy driven flow, surface tension driven free surface flow (study of molten pool). Case studies: Numerical Modeling of fusion based AM process, Powder bed melting based process, Droplet based printing process. Residual stress, part fabrication time, part fabrication cost, optimal orientation and optimal layer thickness. Defect in AM and role of transport phenomena on its formation. Simulations (choice of parameter, experimental data and comparison between simulation and experiments) Model validation for different aspects. **References/Text Books:** 1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010. 2. Andreas Gebhardt, Undeerstanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011. 3. J.D. Majumdar and I. Manna, Laserassisted fabrication of materials, Springer Series in Material Science, eISBN: 9783642283598. 4. L. Lu, J. Fuh and Y. S. Wong, Laserinduced materials and processes for rapid prototyping, Kluwer Academic Press, 2001. 5. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titatium alloy, InTech, 2012. 6. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications/ 3rd Edition, World Scientific, 2010.	ADDITIVE MANUFACTURING
ME671	3-0-0--4		**Course Contents:** Strain Gauge, strain rosettes and transducer applications. Photoelasticity,materials and their selection. Introduction to 3D photoelasticity. Brittle coatingmethods, Moire method of strain analysis and nondestructive testing using xraysand ultrasonic devices. **References/Text Books:**	EXPERIMENTAL STRESS ANALYSIS
ME673	3-0-0-0-4		**Course Contents:** I. Fundamentals: REV, Mass, momentumand energy transport, Darcy and NonDarcy equations,equilibrium and nonequilibrium conditions, species transport, radioactive decay. 2. Effective medium approximation: equivalent thermal conductivity, viscosity, dispersion. 3. Exact solutions: Flow over a flat plate, flow past a cylinder, boundarylayers, reservoir problems. 4. Special topics: Field scale and stochastic modeling, Turbulent flow, compressible flow, multiphase flow, numerical techniques, hierarchical porous media, multiscale modeling. 5. Engineering applications: Groundwater, waste disposal, oil and gas recovery, regenerators, energy storage systems. 6. Experimental techniques: Flow visualization, quantitative methods,	FLOW, HEAT & MASS TRANSFER THROUGH POROUS MEDIA

			inverse parameter estimation. **References/Text Books:** 1. Principles of Heat Transfer in Porous Media, by M. Kaviany, Springer New York(1995).2. Transport Phenomena in Porous Media, Volumes 1111, edited by D. R. Ingham and LPop, Elsevier, New York (19982005).3. Dynamics of Fluids in Porous Media, J. Bear, Dover (1988).4. Introduction to Modeling of Transport Phenomena in Porous Media, J. Bear and Y.Bachmat, Kluwer Academic Publishers, London (1990).5. Enhanced Oil Recovery, L.W. Lake, GulfPublishing Co. Texas (1989).6. The Mathematics of Reservoir Simulation, R.E. Ewing, SIAM Philadelphia (1983).	
ME681	3-0-0--4		**Course Contents:** (I)Introduction. 1. Introduction to the course.(II) Linear Algebra. 1.Vector spaces: definition, linear independence of vectors, basis, inner product and inner product space, orthogonality, GramSchmidt procedure, subspaces. 2. Matrices: coordinatedependent linear transformations, null and range spaces. 3. Linear algebraic equations: existence and uniqueness of solution, elementary row/column operations, Gauss elimination and Gauss Jordon methods, Echelon form, pivoting, LU decomposition and Cholesky method, GaussSeidel and Jacobi iterative methods, condition number, minimum norm and least square error solutions. 4. Eigenvalues and eigenvectors of matrices: properties like multiplicity, eigenspace, spectrum and linear independence of eigenvectors, similarity transformation and Jordon canonical form, eigenvalues/eigenvectors of symmetric matrices: orthogonal diagonalization.5.Iterative methods to find eigenvalues/ eigenvectors of symmetric matrices: forward iteration and Mises power method, inverse iteration. (III) Tensor Algebra. 1. Index Notation and Summation Convention. 2.Tensor algebra: tensor as a linear vector transformation, dyadic representation, transformation of components, product of tensors, transpose, decomposition into symmetric and antisymmetric parts, invariants, decomposition into isotropic and deviatoric parts, inner product and norm, inverse, orthogonal tensors, eigenvalues and eigenvectors, squareroot, positive definite symmetric tensor, polar decomposition, tensors of higher order. **References/Text Books:** 1.Advanced Engineering Mathematics by E. Kreyszig, John Wiley and Sons, International 8th Revised Edition, 1999,2.Applied Mathematical Methods by B. Dasgupta, Pearson Education, 2006.	MATHEMATICS FOR ENGINEERS
ME681A	3-0-0-0-9		**Course Contents:** (I)Introduction. 1. Introduction to the course.(II) Linear Algebra. 1.Vector spaces: definition, linear independence of vectors, basis, inner product and inner product space, orthogonality, GramSchmidt procedure, subspaces. 2. Matrices: coordinatedependent linear transformations, null and range spaces. 3. Linear algebraic equations: existence and uniqueness of solution, elementary row/column operations, Gauss elimination and Gauss Jordon methods, Echelon form, pivoting, LU decomposition and Cholesky method, GaussSeidel and Jacobi iterative methods, condition number, minimum norm and least square error solutions. 4. Eigenvalues and eigenvectors of matrices: properties like multiplicity, eigenspace, spectrum and linear independence of eigenvectors, similarity transformation and Jordon canonical form, eigenvalues/eigenvectors of symmetric matrices: orthogonal diagonalization.5.Iterative methods to find eigenvalues/ eigenvectors of symmetric matrices: forward iteration and Mises power method, inverse iteration. (III) Tensor Algebra. 1. Index Notation and Summation Convention. 2.Tensor algebra: tensor as a linear vector transformation, dyadic representation, transformation of components, product of tensors, transpose, decomposition into symmetric and antisymmetric parts, invariants, decomposition into isotropic and deviatoric parts, inner product and norm, inverse, orthogonal tensors, eigenvalues and eigenvectors, squareroot, positive definite symmetric tensor, polar decomposition, tensors of higher order. **References/Text Books:** 1.Advanced Engineering Mathematics by E. Kreyszig, John Wiley and Sons, International 8th Revised Edition, 1999,2.Applied Mathematical Methods by B. Dasgupta, Pearson Education, 2006.	MATHEMATICS FOR ENGINEERS
ME682	3-0-0-0-4		**Course Contents:**	DIFFERENCE EQUATIONS

			1. Introduction and Some Applications of Difference Equations in Engineering (1 lecture)2. Preliminaries in algebra and analysis (3 lectures)3. Analogies between differential and difference equations (1 lecture)4. Elementary Difference Operations. The Difference and shift operators (3 lectures)5. The Difference Calculus. Summation (3 lectures)6. Interpolation, Extrapolation (1 lecture)7. Generating functions (2 lectures)8. Linear difference equations, First order equations (2 lectures)9. Higher Order Difference Equations (1 lecture)10. Linear difference equations with constant coefficients (2 lectures)11. Linear difference equations with variable coefficients (2 lectures)12. Method of undetermined coefficients and variation of parameters (2 lectures)13. Limiting behavior of solutions (1 lecture)14. Systems of Linear difference equations and application (1 lecture)15. The ztransform and its applications (2 lectures)16. The Sturmian theory and Fourier analysis (3 lectures)17. Nonlinear difference equations and boundary value problems (1 lecture)18. Asymptotic methods (1 lecture)19. Stability theory and relevance to dynamical systems (1 lecture)20. Partial Difference Equations (2 lectures)21. Lagrangian and Hamiltonian Formalism for Difference Equations. Symmetry (2 lectures)22. Difference Equations with Continuous Time, Differentialdifference equations (1 lecture)23. Discrete Mechanics (1 lecture)24. Open problems (1 lecture) **References/Text Books:** 1. An Intoduction to Difference Equations, S. N. Elaydi (Springer) (textbook)2. Difference Equation, W. G. Kelley and A. C. Peterson (Academic Press)3. Finite Difference Equations. H. Levy and F. Lessman (MacMillan)4. A treatise on the Calculus of Finite Differences. G. Boole. (MacMillan)	FOR ENGINEERS
ME682A	3-0-0-0-9		**Course Contents:** 1. Introduction and Some Applications of Difference Equations in Engineering (1 lecture)2. Preliminaries in algebra and analysis (3 lectures)3. Analogies between differential and difference equations (1 lecture)4. Elementary Difference Operations. The Difference and shift operators (3 lectures)5. The Difference Calculus. Summation (3 lectures)6. Interpolation, Extrapolation (1 lecture)7. Generating functions (2 lectures)8. Linear difference equations, First order equations (2 lectures)9. Higher Order Difference Equations (1 lecture)10. Linear difference equations with constant coefficients (2 lectures)11. Linear difference equations with variable coefficients (2 lectures)12. Method of undetermined coefficients and variation of parameters (2 lectures)13. Limiting behavior of solutions (1 lecture)14. Systems of Linear difference equations and application (1 lecture)15. The ztransform and its applications (2 lectures)16. The Sturmian theory and Fourier analysis (3 lectures)17. Nonlinear difference equations and boundary value problems (1 lecture)18. Asymptotic methods (1 lecture)19. Stability theory and relevance to dynamical systems (1 lecture)20. Partial Difference Equations (2 lectures)21. Lagrangian and Hamiltonian Formalism for Difference Equations. Symmetry (2 lectures)22. Difference Equations with Continuous Time, Differentialdifference equations (1 lecture)23. Discrete Mechanics (1 lecture)24. Open problems (1 lecture) **References/Text Books:** 1. An Intoduction to Difference Equations, S. N. Elaydi (Springer) (textbook)2. Difference Equation, W. G. Kelley and A. C. Peterson (Academic Press)3. Finite Difference Equations. H. Levy and F. Lessman (MacMillan)4. A treatise on the Calculus of Finite Differences. G. Boole. (MacMillan)	DIFFERENCE EQUATIONS FOR ENGINEERS
ME685	3-0-0--4		**Course Contents:** MATLAB, Mathematical modeling, algorithms, Taylor series expansion, root finding,interpolation, extrapolation; Solution of linear algebraic systems, determinant, inverse:norms and condition number; Solution of nonlinear algebraic systems. Numericalintegration. R. K. Method, Solution of ODE and linear PDEs by finite differences. **References/Text Books:**	APPLIED NUMERICAL METHODS
ME685A	3-0-0-0-9		**Course Contents:** 1. Concepts of Algorithms and Programming; Revision of computer languages such as MATLAB, Fortran, and C++. 2. Introduction to Mathematical Modelling. 3. Taylor and Fourier series expansion. 4. Root finding. 5. Interpolation, splines, extrapolation. 6Regression and curve fitting. 7. Solution of simultaneous linear	APPLIED NUMERICAL METHODS

			algebraic systems; nonlinear algebraic equations. 8. igenvalues and eigenvectors. 9. Solution of simultaneous nonlinear algebraic systems. 10. Numerical integration, Simpsons rule, Gaussian quadrature. 11. Solution of ODE: R. K. Methods; PredictorCorrector methods; boundaryvalue problems. 12. Systems of ODEs; convergence and error studies. 13. Linear PDEs by finite differences. Programming projects based on mathematical modelling followed by an application of the numerical methods given above. **References/Text Books:** 1. Numerical Methods for Engineers; Steven C. Chapra and Raymond P. Canale, 7th2. Introduction to Numerical Analysis, S.S. Sastry; Prentice Hall of India, 2012. edition, McGrawHill, 2014.3. Numerical Methods for Engineers, Santhosh .K. Gupta, New Age International; 2012.4. Applied Numerical Methods for Digital Computation , M.L. James, G.M. Smith & J.C. Wolford, Harper Collins College Division; 4thedition, 1993.	
ME689	----4		**Course Contents:** MicroMechanical systems (MEMS), Micro Channels, Heat pipes, jets, valves,Heat Sinks, Solar cells, Bearings, Pumps, Heat pipes, Jets, valves, Heat sinks,Solar Cells, Bearings, Pumps, Flow Sensors and actuators, Fins, Drug deliverysystems, Mass, Momentum, Heat and charge transport equations, CharacteristicNondimensional parameters, Microscale Heat conduction, Heat transport in thinfilms and at solidsolid interfaces, Convective diffusion phenomena, Enzymesubstratereactions, channel flow with soluble or rapidly reacting walls, solutionsof electrolytes, Electric double layer, Electrokinetic phenomena, electroosmosis,Electroosmotic pumps, Surface tension driven flows, Coating flows,Thermocapillary flows, Molecular dynamics simulations. **References/Text Books:**	MICROSCALE THERMAL ENGINEERING
ME689A	----9		**Course Contents:** MicroMechanical systems (MEMS), Micro Channels, Heat pipes, jets, valves,Heat Sinks, Solar cells, Bearings, Pumps, Heat pipes, Jets, valves, Heat sinks,Solar Cells, Bearings, Pumps, Flow Sensors and actuators, Fins, Drug deliverysystems, Mass, Momentum, Heat and charge transport equations, CharacteristicNondimensional parameters, Microscale Heat conduction, Heat transport in thinfilms and at solidsolid interfaces, Convective diffusion phenomena, Enzymesubstratereactions, channel flow with soluble or rapidly reacting walls, solutionsof electrolytes, Electric double layer, Electrokinetic phenomena, electroosmosis,Electroosmotic pumps, Surface tension driven flows, Coating flows,Thermocapillary flows, Molecular dynamics simulations. **References/Text Books:**	MICROSCALE THERMAL ENGINEERING
ME690	3-0-0--4		**Course Contents:** Combustion and Fuels, Combustion process in SI and CI engines, Petroleum basedliquid fuels and refining, Liquid alternative Fuels, Advantages, potential,problems associated with utilization, Vegetable oils, Biodiesel, Emulsified fuels,Effect on Lubricating oils, Gaseous Alternative Fuels, Hydrogen, CompressedNatural Gas, Liquified petroleum Gas, Dimethyl ether, Hythane, Multifuelengines, Modern developments in IC Engines, EGR, MPFI, GDI, HCCI, Turbochargedengines, Optical Measurement techniques, Fuel atomization and spray visualizationtechniques, Laser doppler Anemometry, Particle image velocimetry, 3D andHolographic PIV, optical engines, sources and Nature of various types ofpollutants: Pollution monitoring instruments and techniques, Control measures,emission legislations. **References/Text Books:**	ALTERNATIVE FUELS & ADVANCE IN IC ENGINES
ME690A	3-0-0-0-9		**Course Contents:** Combustion and Fuels, Combustion process in SI and CI engines, Petroleum basedliquid fuels and refining, Liquid alternative Fuels, Advantages, potential,problems associated with utilization, Vegetable oils, Biodiesel, Emulsified fuels,Effect on Lubricating oils, Gaseous Alternative Fuels, Hydrogen,	ALTERNATIVE FUELS & ADVANCE IN IC ENGINES

			CompressedNatural Gas, Liquified petroleum Gas, Dimethyl ether, Hythane, Multifuelengines, Modern developments in IC Engines, EGR, MPFI, GDI, HCCI, Turbochargedengines, Optical Measurement techniques, Fuel atomization and spray visualizationtechniques, Laser doppler Anemometry, Particle image velocimetry, 3D andHolographic PIV, optical engines, sources and Nature of various types ofpollutants: Pollution monitoring instruments and techniques, Control measures,emission legislations. **References/Text Books:**	
ME691	3-0-0--4		**Course Contents:** 1. Introduction (1)2. Diesel Engine management: cylinder charge control systems, basic principles of diesel fuel injection, mixture distribution, fuel injection parameters, various designs and overview of diesel fuel injection systems, fuel supplysystems to the low pressure stage, governors and control systems for inline fuel injection pumps, distributor fuel injection pump systems, helix and port controlled distributor injection pumps, overview of discrete cylinder systems,single plunger fuel injection pumps, unit injector systems, and unit pump systems, common rail systems, injection nozzles, minimizing emissions inside the engine, electronic diesel control (EDC), electronic control unit (ECU). (25)3. Gasoline Engine Management: cylinder charge control systems, fuels supply, manifold fuel injection, gasoline direct injection, operation of gasoline engine on natural gas, ignition system, inductive ignition systems, ignition coils, spark plugs, sensors: temperature sensors, engine speed sensors, hall effect phase sensors, hot film air mass sensors,piezoelectric knock sensor, micromechanical pressure sensor, high pressure sensor, twostep lambda sensor,Electronic control unit, operating conditions, design and data processing. (15) **References/Text Books:** 1. Internal Combustion engine fundamentals: J B Heywood, McGraw Hill Publications.2. Gasoline Engine Management: Robert Bosch GMBH3. Diesel Engine Management: Robert Bosch GMBH4. The Internal combustion Engine in theory and practice: C F Taylor, MIT Press, Cambridge.5. Internal Combustion Engines and Air Pollution: E FObert, lntext Educational Publishers, NY.6. Advanced Engine Technology: Heinz Heisler ISBN 0340568224, SAE Publications.	ENGINE MANAGEMENT
ME691A	3-0-0-0-9		**Course Contents:** 1. Introduction (1)2. Diesel Engine management: cylinder charge control systems, basic principles of diesel fuel injection, mixture distribution, fuel injection parameters, various designs and overview of diesel fuel injection systems, fuel supplysystems to the low pressure stage, governors and control systems for inline fuel injection pumps, distributor fuel injection pump systems, helix and port controlled distributor injection pumps, overview of discrete cylinder systems,single plunger fuel injection pumps, unit injector systems, and unit pump systems, common rail systems, injection nozzles, minimizing emissions inside the engine, electronic diesel control (EDC), electronic control unit (ECU). (25)3. Gasoline Engine Management: cylinder charge control systems, fuels supply, manifold fuel injection, gasoline direct injection, operation of gasoline engine on natural gas, ignition system, inductive ignition systems, ignition coils, spark plugs, sensors: temperature sensors, engine speed sensors, hall effect phase sensors, hot film air mass sensors,piezoelectric knock sensor, micromechanical pressure sensor, high pressure sensor, twostep lambda sensor,Electronic control unit, operating conditions, design and data processing. (15) **References/Text Books:** 1. Internal Combustion engine fundamentals: J B Heywood, McGraw Hill Publications.2. Gasoline Engine Management: Robert Bosch GMBH3. Diesel Engine Management: Robert Bosch GMBH4. The Internal combustion Engine in theory and practice: C F Taylor, MIT Press, Cambridge.5. Internal Combustion Engines and Air Pollution: E FObert, lntext Educational Publishers, NY.6. Advanced Engine Technology: Heinz Heisler ISBN 0340568224, SAE Publications.	ENGINE MANAGEMENT
ME698A	3-0-0-0-9		**Course Contents:** Multiobjective optimization, Robust design techniques (variation reductiontechniques), Optimal control, stochastic programming. Role of Optimization inCAD: Why optimization? OptimizationGeometric	INTRODUCTION HYDRODYNAMIC STABILITY

			modelingAnalysis.Implementation Issues: computational time versus accuracy, Interfacing withgeometric modelling and analysis softwares, Graphics interfacing, Choice ofHardware platform. Application to engineering design problems, comparison withexisting solutions. **References/Text Books:**	
ME699	-0-0--		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
ME699.	0-0-0--9		**Course Contents:** M TECH THESIS (FOR DUAL DEGREE ONLY) **References/Text Books:**	M TECH THESIS (FOR DUAL DEGREE ONLY)
ME720	3-0-0-0-4		**Course Contents:** 1. Foundations of continuum thermodynamics1.1 Geometry of continuous bodies: kinematics; singular surfaces; strain compatibility (3)1.2 Balance of mass and momentum; the concept of stress (1)1.3 The first law of thermodynamics: energy; work; heat (1)1.4 The second law of thermodynamics: temperature; entropy; the ClausiusDuhem inequal ity (4)1.5 Constitutive theory1.5.1 Material frame indifference and material symmetry (1)I1.5.2 Equilibrium response (1)1.5.3 Dynamic response: linear irreversible thermodynamics (Onsanger 's relations) ; dissipation potential; maximum dissipation principle (3)1.6 Thermodynamic equilibrium; stability (4)2. Rigidconductors2.1 Constitutive equations; Fourier 's law (2)2.2 Boundary value problems (2)3. Thermoelasticity3.1 Constitutive equations; linear thermoelasticity (2)3.2 Boundary value problems (2)3.3 Thermoelastic stability: buckling of beams and plates (2)4. Thermoplasticity4.1 Constitutive equations: simple phenomenological models with work hardening (3)4.2 Onedimensional problems: adiabatic shear bands (4)5. Thermodynamics of surfaces5.1 Gibbs' treatment of surfaces (1)5.2 Surface energy, surface tension, and surface stress; capillarity (2)5.3 CalmHilliard type of theories for diffusive interfaces (2)5.4 Problems (can be from different sources, for e.g. adiabatic shock waves, phase transformations, grain growth, membrane mechanics) (4) **References/Text Books:** (i) The Mechanics and Thermodynamics of Continuous :tvledia, M. Silhavy, Springer , 1997.(ii) An Introduction to Thermomechanics, H. Ziegler, NorthHolland, 1983.(iii) The Mechanics and Thermodynamics of Continua, M. E. Gurtin, E. Fried, and L. Anand Cambridge, 2010.(iv) Theory of Thermal Stresses, B. A. Boley and J. H. Weiner , Dover , 1997.(v) The Physics and Mathematics of Adiabatic Shear Bands, T. W. Wright , Cambridge, 2002. (vi) Statistical Thermodynamics of Surfaces, Interfaces, and Membranes, S. A. Safran, Addison Wesley, 1994.	THERMODYNAMICS OF CONTINUOUS MEDIA
ME721	3-0-0--4		**Course Contents:** Yield surfaces. Deformation and flow theories; Theory of plastic constitutiveequations; Axisymmetric and spherically symmetric problems; Slipline theory andapplication to problems of extrusion, drawing and indentation; Wave propagationin plastic materials. **References/Text Books:**	THEORY OF PLASTICITY
ME721A	3-0-0-0-9		**Course Contents:** Yield surfaces. Deformation and flow theories; Theory of plastic constitutiveequations; Axisymmetric and spherically symmetric problems; Slipline theory andapplication to problems of extrusion, drawing and indentation; Wave propagationin plastic materials. **References/Text Books:**	THEORY OF PLASTICITY

ME723	3-0-0--4		**Course Contents:** Waves in infinite and semiinfinite elastic media. Reflection and refraction atplane interface. Dispersion of waves in bounded solids. Waves in rods and plates.Solution of transient problems. Rayleigh waves. Waves in anisotropic materials.Introduction to waves in viscoelastic and plastic media. **References/Text Books:**	WAVE PROPAGATION IN SOLIDS
ME723A	3-0-0-0-9	ME321A	**Course Contents:** Waves in infinite and semiinfinite elastic media. Reflection and refraction atplane interface. Dispersion of waves in bounded solids. Waves in rods and plates.Solution of transient problems. Rayleigh waves. Waves in anisotropic materials.Introduction to waves in viscoelastic and plastic media. **References/Text Books:**	WAVE PROPAGATION IN SOLIDS
ME724	3-0-0-0-4		**Course Contents:** 1. Organisation of Animal cells : Structure and function of cell membrane. Roll of fluid lipid bilayers in cell functionality. Discussion on the experimental methods of study membranes.2. A brief review of diffrential geometry concepts.3. Development of the electicity models of membranes. Applications of the theory to the determination of the stable equibilirium shapes of red blood cells. Application of the theory to equilibrium shapes of phase separated fluid lipid bilayers.4. A discussion on the adhesion of vecicles and cells. Role of membrane elasticity to adhesion.5. Interplay between membrane elasticity and protein binding via a combined mechanical and thermodynamic model. **References/Text Books:** 1. B Albert at zl.; Molecular biology of the cell. Garland Science, NY, 2002 (fourth edition).2. J. N. Israelachvili, Intermolecular and Surface Forces: With Applications to Colloidal and Biological Systems. Academic Press, 1992 (second edition).3. R. Lipowsky and E. Sackmann, Structure and Dynamics of Membranes, Handbook of Biological Physics Vol. 1, Elsevier, Amsterdam, 1995.4. S. A. Safran, Statistical Thermodynamics of Surfaces, Interfaces, and Membranes, Westview Press, 2003.	MECHANICS OF BIOLOGICAL MEMBRANES
ME724A	3-0-0-0-9		**Course Contents:** 1. Organisation of Animal cells : Structure and function of cell membrane. Roll of fluid lipid bilayers in cell functionality. Discussion on the experimental methods of study membranes.2. A brief review of diffrential geometry concepts.3. Development of the electicity models of membranes. Applications of the theory to the determination of the stable equibilirium shapes of red blood cells. Application of the theory to equilibrium shapes of phase separated fluid lipid bilayers.4. A discussion on the adhesion of vecicles and cells. Role of membrane elasticity to adhesion.5. Interplay between membrane elasticity and protein binding via a combined mechanical and thermodynamic model. **References/Text Books:** Course Reference : 1. B Albert at zl.; Molecular biology of the cell. Garland Science, NY, 2002 (fourth edition).2. J. N. Israelachvili, Intermolecular and Surface Forces: With Applications to Colloidal and Biological Systems. Academic Press, 1992 (second edition).3. R. Lipowsky and E. Sackmann, Structure and Dynamics of Membranes, Handbook of Biological Physics Vol. 1, Elsevier, Amsterdam, 1995.4. S. A. Safran, Statistical Thermodynamics of Surfaces, Interfaces, and Membranes, Westview Press, 2003.	MECHANICS OF BIOLOGICAL MEMBRANES
ME725	3-0-0-0-4		**Course Contents:** 1. Introduction: Defects in continua, their properties and characterization (1 lecture).2. Review of linear elastostatics. Defects. Eigenstrains. Static Green's functions. Superposition principle. (2 lectures)3. Conservation laws. Ni::iether's theorem. (4 lectures)4. Application to linear elastostatics. The Eshelby tensor: physical interpretation, invariants, principal values. (6 lectures)5. Linear elasticity with defects. Holes, inclusions and dislocations. Interaction of defects. Equivalent macroscopic properties. (6 lectures)6. Inhomogeneous elastostatics. Anisotropic elastostatics. Equivalent macroscopic properties. Coupled	MICRO-MECHANICS

			problems: Thermoelasticity (6 lectures)7. Elastodynamics of defected solids. Vvave motion. (6 lectures)8. Dissipative systems: Viscoelasticity. Neutral action method. (5 lectures)9. Conservation principles in bars, shafts, beams and plates (6 lectures) **References/Text Books:** 1. R. Kienzler and G. Herrmann. Mechanics in material space, with application to defectand fracture mechanics. Springer.2. T. Mura. Micromechanics of defects in solids. Martinus Nijhoff.3. S. NematNasser and M. Hori. l!Iicromechanics: Overall properties of heterogeneousmaterials. NorthHolland.	
ME725A	3-0-0-0-9		**Course Contents:** 1. Introduction: Defects in continua, their properties and characterization (1 lecture).2. Review of linear elastostatics. Defects. Eigenstrains. Static Green's functions. Superposition principle. (2 lectures)3. Conservation laws. Ni::iether's theorem. (4 lectures)4. Application to linear elastostatics. The Eshelby tensor: physical interpretation, invariants, principal values. (6 lectures)5. Linear elasticity with defects. Holes, inclusions and dislocations. Interaction of defects. Equivalent macroscopic properties. (6 lectures)6. Inhomogeneous elastostatics. Anisotropic elastostatics. Equivalent macroscopic properties. Coupled problems: Thermoelasticity (6 lectures)7. Elastodynamics of defected solids. Vvave motion. (6 lectures)8. Dissipative systems: Viscoelasticity. Neutral action method. (5 lectures)9. Conservation principles in bars, shafts, beams and plates (6 lectures) **References/Text Books:** 1. R. Kienzler and G. Herrmann. Mechanics in material space, with application to defectand fracture mechanics. Springer.2. T. Mura. Micromechanics of defects in solids. Martinus Nijhoff.3. S. NematNasser and M. Hori. l!Iicromechanics: Overall properties of heterogeneousmaterials. NorthHolland.	MICROMECHANICS
ME726	3-0-0--4	ME652/ESO206	**Course Contents:** Part 1a Some relevant definitions and results in the theory of differentiable manifolds, smooth vector fields, differential forms,exterior) calcu lus (differentiation and integration using differential forms) ,differential equatio11s and their associated flow maps, Symplect.ic manifolds.Part 1b Brief review of Hamiltonian mechanics (Lagrange's vs Hamilton's Equations) , Canonical Transformation , Legendre T:raus forma!.ion , Symplect.ic TIansfonna!.ions, Some defi.nit.ions and :result.s in the t. heory of Cont.inuous Groups for Symmet.ries and Conserved quantities, PoincareCartan invariant , The HamiltonJacobi Partial Differential Equation. Integrable systems (simple examples).Part 2a Some basic notions of numerical algorithms (order conditions etc). Examples of Numerical methods, Symplectic Integra tors, and Geometric integTators. Applications to simple problems in particle dynamics and a two body problem.Part 2b Symplectic RungeKutta lVIethods, Generating Function for Symplectic Rm1geKutta Methods and Symplectic Ivlethods Based on it. Variational Integrators. Introduction to Hamiltonian Perturbation theory (if time permits). Discussion on some open problems in symplectic algorithms and a brief discussion on geometric numerical integration with some applications to mechanical systems. **References/Text Books:** 1. Arnold, V. I., 1989. lVIathematical Methods of Classical Mechanics. Springer. Second edition. [Te}..tbook: for part 1 only sections 18, 3241, 4448, for part 2 only sections 1317, 19].2. Leimkuhler, B., Reich, S. , 2004. Simulating Hamiltonian Dynamics. Cambridge University Press [Textbook: for part 2 chapters 1, 2, 47,9]. 3. Hairer, E., Lubich, C., vVa1mer, G., 2006. Geometric Numerical Integration: StructurePreserving Algorithms for Ordinary Differential Equations. Springer.	HAMILTONIAN MECHANICS AND SYMPLECTIC ALGORITHMS
ME726A	3-0-0-0-9	ME726A/ESO209A	**Course Contents:** Part 1a Some relevant definitions and results in the theory of differentiable manifolds, smooth vector fields, differential forms,exterior) calcu lus (differentiation and integration using differential forms) ,differential equatio11s and their associated flow maps, Symplect.ic manifolds.Part 1b Brief review of Hamiltonian mechanics (Lagrange's vs Hamilton's Equations) , Canonical Transformation , Legendre T:raus forma!.ion , Symplect.ic TIansfonna!.ions, Some defi.nit.ions and :result.s in the t. heory of Cont.inuous Groups for	HAMILTONIAN MECHANICS AND SYMPLECTIC ALGORITHMS

			Symmet.ries and Conserved quantities, PoincareCartan invariant , The HamiltonJacobi Partial Differential Equation. Integrable systems (simple examples).Part 2a Some basic notions of numerical algorithms (order conditions etc). Examples of Numerical methods, Symplectic Integra tors, and Geometric integTators. Applications to simple problems in particle dynamics and a two body problem.Part 2b Symplectic RungeKutta lVIethods, Generating Function for Symplectic Rm1geKutta Methods and Symplectic Ivlethods Based on it. Variational Integrators. Introduction to Hamiltonian Perturbation theory (if time permits). Discussion on some open problems in symplectic algorithms and a brief discussion on geometric numerical integration with some applications to mechanical systems. **References/Text Books:**	
ME727	3-0-0--4		**Course Contents:** Structures and method of preparation of fibres and fibre reinforced composites.Micromechanics and prediction of elastic constants; Strength of composites;Properties of laminated composites and their constitutive equations; Laminates;Interfacial mechanics and properties; Applications. **References/Text Books:**	COMPOSITE MATERIALS
ME727A	3-0-0-0-9		**Course Contents:** Structures and method of preparation of fibres and fibre reinforced composites.Micromechanics and prediction of elastic constants; Strength of composites;Properties of laminated composites and their constitutive equations; Laminates;Interfacial mechanics and properties; Applications. **References/Text Books:**	COMPOSITE MATERIALS
ME728	3-0-0--4		**Course Contents:** Fracture: Energy release rate, crack tip stresses and deformation fields, plasticzone, Elastoplastic fracture through Jintegral and CTOD, Dynamic fracture,Testing for Fracture. Toughness. Fatigue: Crack nucleation and growth, Fatiguelife prediction, Statistical analysis. **References/Text Books:**	FRACTURE AND FATIGUE
ME728A	3-0-0-0-9		**Course Contents:** Fracture: Energy release rate, crack tip stresses and deformation fields, plasticzone, Elastoplastic fracture through Jintegral and CTOD, Dynamic fracture,Testing for Fracture. Toughness. Fatigue: Crack nucleation and growth, Fatiguelife prediction, Statistical analysis. **References/Text Books:**	FRACTURE AND FATIGUE
ME729	3-0-0--4	ME621/ME321	**Course Contents:** Introduction, Homogenisation, Ductile Materials, Dislocations, single crystalplasticity, Size effects on mechanical properties, Thermodynamics of constitutivemodelling, Examples of constitutive models, Modelling of very small structures. **References/Text Books:**	MODELLING OF MECHANICAL PROPERTIES OF MATERIALS
ME741	3-0-0-0-4		**Course Contents:** Thermochemistry, Chemical Equilibrium, Kinetics; Laminar and Tarbulent Flamepropagation in SI Engines, Unburned and Burned Mixture States, Flame Quenching;Fuel Injection, Spray Atomization, Penetration and Evaporation, FuelAirMixingand Burning Rates in CI Engines; Pollutant Formation in Engines, ZeldovichMechanism, Soot Formation; Vehicle Emissions and standards; Emission controlTechnologies, Catalytic Control, Engine Design and Fuel effects,New Advances;Emission Measurement	COMBUSTION ENGINES & AIR POLLUTION

			References/Text Books:	
ME741A	3-0-0-0-9		**Course Contents:** Thermochemistry, Chemical Equilibrium, Kinetics; Laminar and Tarbulent Flamepropagation in SI Engines, Unburned and Burned Mixture States, Flame Quenching; Fuel Injection, Spray Atomization, Penetration and Evaporation, FuelAirMixing and Burning Rates in CI Engines; Pollutant Formation in Engines, Zeldovich Mechanism, Soot Formation; Vehicle Emissions and standards; Emission control Technologies, Catalytic Control, Engine Design and Fuel effects,New Advances; Emission Measurement. **References/Text Books:**	COMBUSTION ENGINES & AIR POLLUTION
ME742	0-0-0--4		**Course Contents:** Pool boiling: Nukiyama Experiment, theory of vapour bubble formation, Mechanismof CHF, various models and correlations. Flow Boiling, Homogeneous, andhetrogeneous models, Boiling enhancement techniques. Heat Pipes. Design ofboilers, Film and dropwise condensation. Nusselt's analysis of laminar filmcondensaion on vertical flat plate, single horizontal tube and vertical array oftubes. Laminarwavy and turbulent film condensation. Film condensation insidehorizontal tubes, condensation enhancement techniques, design of condensers,special topics: Computer simulation of boiling. **References/Text Books:**	BOILING & CONDENSATION
ME743	3-0-0-0-4		**Course Contents:** (approximate number oflectures in brackets)1. Fundamentals: Review of classical thermodynamics; introductory electrochemistry;principles of chemical and electrochemical kinetics; transport phenomena in electrochemical systems [14].2. Analyses of fuel cells: Classical thermodynamic analyses of fuel cell systems; analyses of fuel cell kinetics; quantification of fuel cell performance [14].3. Computational/experimental techniques: Conservation and rate equations; approximate analytical treatment of fuel cell systems; scope and limitations of onedimensional analyses; introduction to computational fluid mechanics of fuel cell systems; measurement of fuel cell performance; lab visits; introduction to electrochemical impedance spectroscopy [10].4. Special topics: Direct methanol fuel cell; microbial fuel cell; hydrogen generation and storage; limitations, recent advances and challenges in fuel cell research [4]. **References/Text Books:** 1. Fuel Cell Systems Explained, J. Larminie and A. Dicks (John Wiley & Sons, 2003, USA)2. Fuel Cell Fundamentals, R. O'Hayre, SW. Cha, W. Colella, F. B. Prinz (John Wiley and Sons, 2005, USA)3. Fuel Cell Engines, M. M. Mench (John Wiley and Sons, 2008, USA)4. Fuel Cells: From Fundamental to Applications, S. Srinivasan (Springer, 2006, USA)5. Principles of Fuel Cells, X. Li (CRC Press, 2005, USA)6. Fuel Cells: Principles and Applications, B. Viswanathan and M.A. Scibioh (Universities Press, 2006, India)7. PEM Fuel Cells: Theory and practice, F. Barbir (Elsevier Academic Press, 2005, USA)8. HighTemperature Solid Oxide Fuel Cells: Fundamental, Design and Applications, S. C.Singhal, K. Kendall (Elsevier Science, 2004, USA)9. Transport Phenomena in Fuel cells, Ed. B. Sunden and M. Faghri (WIT Press, 2005, UK)10. Fundamentals of Electrochemistry, V. S. Bagotsky (John Wiley & Sons, 2006, USA	FUEL CELLS
ME744	3-0-0-0-4		**Course Contents:** (approximate number of lectures in brackets):I. Thermodynamic idealization of reacting, and hightemperature systems: classical and statistical thermodynamics review [6]2. Chemical kinetics, heterogeneous chemistry, kinetics of hydrocarbon fuels, kinetics of pollutant formation, sensitivity analysis [6]3. Review of multicomponent mass transfer, radiation in participating media [5]4. Coupling of thermodynamics, kinetics, and transport for idealized reactors [3]5. Approximate modeling of reacting systems; Numerical solution of coupled, stiff differential equations; computer simulation of reacting systems; laminar premixed and diffusion flames, chemical vapor deposition, hydrocarbon reforming processes, porous media reactor, membrane reactor [8]6. Thermal decomposition, ignition, and detonation [2]7. Ignition and combustion of solid propellant; approximate modeling of laser and plasma Ignition] (8. Environmental impact; pollutant	Combustion and Reacting Flow

			formation and control; exergybased analysis [3]9. Experimental techniques, theories of spectroscopy and mass spectrometry [3]I0. Futuristic technologies and advanced topics; possible topics: biogas reforming and combustion, coal combustion, lean combustion, flameless combustion, oxyfuel combustion, chemical looping combustion, carbon nanotube synthesis, burner design [3] **References/Text Books:** I. Fundamentals of Combustion, D. P. Mishra (PrenticeHall India, 2008)2. Combustion, Glassman, Yetter (Associated Press, 2008)3. Irreversible phenomena, K. Terao. (Springer, 2007)4. Combustion, Warnatz, Mass, Dibble (Springer, 2006)5. Combustion physics, C. K. Law (Cambridge, 2006)6. Dynamics of Combustion Systems, A. K. Oppenheim (Springer, 2006)7. Chemical kinetics and reaction dynamics, S. K. Upadhyay (Springer, 2006)8. Chemically Reacting Flow, Kee, Coltrin, Glarborg (WileyInterscience, 2003)9. An Introduction to Combustion, S. R. Turns (McGrawHill, 2000, international edition)I 0. Combustion theory, F. A. Williams (Benjamin/Cummings 1985)	
ME751	3-0-0--4		**Course Contents:** Methodology of interactive, graphical, engineering design; Discretization,optimization, simulation in CAED. Design of curves and surfaces. Applicationsin conveyor systems, sheet metal working, tool design, pumps etc. Design ofvolumes. Intersection of surface and interference of volumes. **References/Text Books:**	COMPUTER AIDED ENGINEERING DESIGN
ME751A	3-0-0-0-9		**Course Contents:** Methodology of interactive, graphical, engineering design; Discretization,optimization, simulation in CAED. Design of curves and surfaces. Applicationsin conveyor systems, sheet metal working, tool design, pumps etc. Design ofvolumes. Intersection of surface and interference of volumes. **References/Text Books:**	COMPUTER AIDED ENGINEERING DESIGN
ME752	3-0-0--4		**Course Contents:** Classical optimization methods, unconstrained minimization; Univariate, conjugatedirection, gradient and variable metric methods, constrained minimization,Feasible direction and projections. Integer and Geometric programming, geneticalgorithms, simulated annealing techniques, design applications. **References/Text Books:**	OPTIMIZATION METHODS IN ENGINEERING DESIGN
ME752A	3-0-0-0-9		**Course Contents:** Classical optimization methods, unconstrained minimization; Univariate, conjugatedirection, gradient and variable metric methods, constrained minimization,Feasible direction and projections. Integer and Geometric programming, geneticalgorithms, simulated annealing techniques, design applications. **References/Text Books:**	OPTIMIZATION METHODS IN ENGINEERING DESIGN
ME756	3-0-0--4		**Course Contents:** Factors affecting level of vibration, vibration reduction at the source, vibrationcontrol by structural design, selection of materials. Vibration control by additivedamping; Dynamic vibration absorbers, vibration and shock isolators, Activecontrol. **References/Text Books:**	VIBRATION CONTROL
ME756A	3-0-0-0-9		**Course Contents:** Factors affecting level of vibration, vibration reduction at the source, vibrationcontrol by structural design, selection of materials. Vibration control by additivedamping; Dynamic vibration absorbers, vibration and	VIBRATION CONTROL

			shock isolators, Activecontrol. **References/Text Books:**	
ME757	3-0-0--4		**Course Contents:** Rotorbearing interaction. Flexural vibration, critical speeds of shafts, Effectsof anisotropic bearings, unbalanced response of an assymetric shaft. Gyroscopiceffects. Aerodynamic effects. Equivalent discrete system. Geared and branchedsystems. Fluid film bearings: Steady state characteristics of bearings. Rigidand flexible rotor balancing. Measurement techniques. **References/Text Books:**	DYNAMICS OF ROTATING MACHINERY
ME757A	3-0-0-0-9		**Course Contents:** Rotorbearing interaction. Flexural vibration, critical speeds of shafts, Effectsof anisotropic bearings, unbalanced response of an assymetric shaft. Gyroscopiceffects. Aerodynamic effects. Equivalent discrete system. Geared and branchedsystems. Fluid film bearings: Steady state characteristics of bearings. Rigidand flexible rotor balancing. Measurement techniques. **References/Text Books:**	DYNAMICS OF ROTATING MACHINERY
ME759	3-0-0-0-4		**Course Contents:** A brief review of nontraditional machining processes, Analysis of mechanical,thermal and Electrochemical type nontraditional machining processes. Analysisof micromachining processes. Tool design for selected nontraditional machiningprocesses. Modeling and simulation of selected processes. A comparative studyof various processes. Application of CNC concepts to nontraditional machiningprocesses machines. Computer aided process planning of nontraditional processes. **References/Text Books:**	ADVANCED TOPICS IN NON TRADITINAL MACHINING PROCESS
ME761	3-0-0--4		**Course Contents:** Direct numerical control (DNC) and computer numerical control (CNC): adapativecontrol of manufacturing processes. Manufacturing system concepts. Computerprocesses monitoring and control, offline use of computers. Computer aideddesign. Computerprocess interface; programming, introduction to FMS. **References/Text Books:**	COMPUTER AIDED MANUFACTURING
ME761A	3-0-0-0-9		**Course Contents:** Direct numerical control (DNC) and computer numerical control (CNC): adapativecontrol of manufacturing processes. Manufacturing system concepts. Computerprocesses monitoring and control, offline use of computers. Computer aideddesign. Computerprocess interface; programming, introduction to FMS. **References/Text Books:**	COMPUTER AIDED MANUFACTURING
ME762	3-0-0--4		**Course Contents:** Types of Robots. Spatial transformation and kinematics of open chain linkages.Mobile robots, Actuators, sensors, programming and control. Applications motion planning, grasping and industrial automation. **References/Text Books:**	INTRODUCTION TO ROBOTICS
ME762A	3-0-0-0-9		**Course Contents:** Types of Robots. Spatial transformation and kinematics of open chain linkages.Mobile robots, Actuators, sensors, programming and control. Applications motion planning, grasping and industrial automation.	INTRODUCTION TO ROBOTICS

			References/Text Books:	
ME763	3-0-0--4		**Course Contents:** Review of robot manipulators. Manipulator kinematics, dynamics and control.Singularity and workspace analysis. Introduction to manipulator design. **References/Text Books:**	ROBOT MANIPULATORS: DYNAMICS AND CONTROL
ME763A	3-0-0-0-9		**Course Contents:** Review of robot manipulators. Manipulator kinematics, dynamics and control.Singularity and workspace analysis. Introduction to manipulator design. **References/Text Books:**	ROBOT MANIPULATORS: DYNAMICS AND CONTROL
ME765	3-0-0--4		**Course Contents:** Automation strategies, flow lines, automated assembly systems, transfersystems; Vibratory bowl feeders, nonvibratory feeders. Part orienting, feedtrack, part placing and part escapement systems; Programmable automation,industrial robotics; Flexible manufacturing systems; Automation equipment. **References/Text Books:**	MANUFACTURING AUTOMATION
ME765A	3-0-0-0-9		**Course Contents:** Automation strategies, flow lines, automated assembly systems, transfersystems; Vibratory bowl feeders, nonvibratory feeders. Part orienting, feedtrack, part placing and part escapement systems; Programmable automation,industrial robotics; Flexible manufacturing systems; Automation equipment. **References/Text Books:**	MANUFACTURING AUTOMATION
ME766	3-0-0--4		**Course Contents:** Configuration spaces of mobile vehicles and manipulators, Geometric modellingand sensor based map building. Path planning and obstacle avoidance. Objectmanipulation and grasping. Design of user interfaces and simulation. Algorithmsfor assembly and biological aspects of motion and intelligence. **References/Text Books:**	ROBOT MOTION PLANNING
ME766A	3-0-0-0-9		**Course Contents:** Configuration spaces of mobile vehicles and manipulators, Geometric modellingand sensor based map building. Path planning and obstacle avoidance. Objectmanipulation and grasping. Design of user interfaces and simulation. Algorithmsfor assembly and biological aspects of motion and intelligence. **References/Text Books:**	ROBOT MOTION PLANNING
ME767	3-0-0--4		**Course Contents:** Traditional optimization methods. Simple genetic algorithms reproduction,crossover and mutation. Analysis of GAoperators; Deception; Multimodel andmultiobjective optimization; Engineering applications. Introduction withapplications for Evolution strategy and Simulated annealing. **References/Text Books:**	EVOLUTIONARY ALGORITHMS IN SEARCH & OPTIMIZATION
ME769A	3-0-0-0-9		**Course Contents:** Advanced techniques of kinematics and dynamics of mechanical systems. Parallelactuated and closedloop manipulators. Redundant manipulators. Mobile robotes and path planning. Complaint motion and grasping. Sensing and vision. Nonlinerar control of robots. Any other relevant topic.	ADVANCED TOPICS IN ROBOTICS

			References/Text Books:	
ME770	3-0-0--4	#	**Course Contents:** The evolution of engineering materials; Materials and the design process;Functional requirements of engineering materials; Materials selection based onproperties alone; Materials selection based on properties & shape; Processing,materials & design; Materials property data. Latest developments in the useof materials; New materials; Case studies. **References/Text Books:**	MATERIALS SELECTION IN MECHANICAL DESIGN
ME770A	3-0-0-0-9		**Course Contents:** The evolution of engineering materials; Materials and the design process;Functional requirements of engineering materials; Materials selection based onproperties alone; Materials selection based on properties & shape; Processing,materials & design; Materials property data. Latest developments in the useof materials; New materials; Case studies. **References/Text Books:**	MATERIALS SELECTION IN MECHANICAL DESIGN
ME771	3-0-0-0-4		**Course Contents:** Materials for both actuation and sensing: Piezoelectric Materials, MagnetostrictiveMaterials, Materials for actuation: Shape Memory alloys Magnetic shape memorymaterial, Electro/Magneto rheological fluids; Materials for sensing: Optical fibre;Composite smart materials and micromodelling related issues; Energy basedapproach: HellingerReissner Principle, Variational Formulation, Finite ElementsModelling of Vibration of smart Laminates; state space based analysis & designof smart controllers, Concepts of Controllability & observability; Pole placementTechniques; Intelligent system with integrated sensors & actuators; Selfsensingactuators; Placement of Smart Actuators/Sensors Vibration damping. **References/Text Books:**	SMART MATERIALS AND STRUCTURE
ME771A	3-0-0-0-9		**Course Contents:** Materials for both actuation and sensing: Piezoelectric Materials, MagnetostrictiveMaterials, Materials for actuation: Shape Memory alloys Magnetic shape memorymaterial, Electro/Magneto rheological fluids; Materials for sensing: Optical fibre;Composite smart materials and micromodelling related issues; Energy basedapproach: HellingerReissner Principle, Variational Formulation, Finite ElementsModelling of Vibration of smart Laminates; state space based analysis & designof smart controllers, Concepts of Controllability & observability; Pole placementTechniques; Intelligent system with integrated sensors & actuators; Selfsensingactuators; Placement of Smart Actuators/Sensors Vibration damping. **References/Text Books:**	SMART MATERIALS AND STRUCTURE
ME773	3-0-0-0-4		**Course Contents:** 1. Introduction to granular materials: Illustrative examples.2. Revision of continuum mechanics.3. :Materials with yield strength: I IohrCoulolllb and DruckerPrager materials.4. Statics: Coulomb's, J ansseu's and Walker 's method. Volume averaging.5. Application: Hoppers, Dmns, Landslides alld Ast.eroids.6. Micromechanical behavior: Particleparticle interaction. Meanfield theory.7. Other features: Closepacking, Crystallization, Force chains, Shear banding.8. Slow dense flow: Plasticity theory.9. Application: Flows in Hoppers and Buukers.10. Rapid granular flow: Smooth inelastic part icles.11. Examples: Plane Couette flow , Inclined cbntes.12. Rapid granular flow: Rough inelastic particles.13. Mixing and segregation: Brazilnut effect, Rotating drum and Avalanches.14. Effect of air: Porous beds. Barchau d 111H, ,; .. ud Homglasses.15. Introduction to computational modeling. **References/Text Books:**	GRANULAR MATERIALS
ME773A	3-0-0-0-9		**Course Contents:**	GRANULAR MATERIALS

			1. Introduction to granular materials: Illustrative examples.2. Revision of continuum mechanics.3. :Materials with yield strength: I IohrCoulolllb and DruckerPrager materials.4. Statics: Coulomb's, J ansseu's and Walker 's method. Volume averaging.5. Application: Hoppers, Dmns, Landslides alld Ast.eroids.6. Micromechanical behavior: Particleparticle interaction. Meanfield theory.7. Other features: Closepacking, Crystallization, Force chains, Shear banding.8. Slow dense flow: Plasticity theory.9. Application: Flows in Hoppers and Buukers.10. Rapid granular flow: Smooth inelastic part icles.11. Examples: Plane Couette flow , Inclined cbntes.12. Rapid granular flow: Rough inelastic particles.13. Mixing and segregation: Brazilnut effect, Rotating drum and Avalanches.14. Effect of air: Porous beds. Barchau d 111H, ,; .. ud Homglasses.15. Introduction to computational modeling. **References/Text Books:**	
ME774	3-0-0-0-4		**Course Contents:** Introduction to BioMEMS and Microsystems technology, Biochips/ biosensors and introduction to device fabrication, Introduction to Cell biology, DNA & Protein chemistry, Microfluidics, Biochip Sensors & detection methods, potential of Microfluidics and introductory continuum mechanics at small scales, Microarrays andLabonchip devices, Introduction to MEMS Design. Microfluidics: Continuum mechanics at small scales, Basics of microfluidics, Gas flows, liquid flows, boundary conditions, low Reynold's no. flows, entrance effects, surface tension, electrokinetic techniques like electrophoresis, electroosmosis and dielectrophoresis, microfluid'cs for internal flow eontrol (micropumps and microvalves, cfevice building and characterization), **References/Text Books:** 1. Fundamentals ofMicrofabrication (Second Edition), Marc J. Madou, CRCpress Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300,Boca Raton, FL334872724, 2002.2. BioMEMS Technologies and Applications, Edited by Wanjun Wang, StevenA. Soper, CRC press Taylor and Francis Group, 6000 Broken Sound ParkwayNW, Suite 300, Boca Raton, FL334872724, 2006.3. Biomolecular sensing, processing and analysis, Rashid Bashir, Steve T.Werely, Mauro Ferrari, Springer Science and Business Media LLC, 233Spring Street, New York, NY10013, USA, 2006.	BIOMEMS AND MICROSYSTEMS TECHNOLOGY
ME774A	3-0-0-0-9		**Course Contents:** Introduction to BioMEMS and Microsystems technology, Biochips/ biosensors and introduction to device fabrication, Introduction to Cell biology, DNA & Protein chemistry, Microfluidics, Biochip Sensors & detection methods, potential of Microfluidics and introductory continuum mechanics at small scales, Microarrays andLabonchip devices, Introduction to MEMS Design. Microfluidics: Continuum mechanics at small scales, Basics of microfluidics, Gas flows, liquid flows, boundary conditions, low Reynold's no. flows, entrance effects, surface tension, electrokinetic techniques like electrophoresis, electroosmosis and dielectrophoresis, microfluid'cs for internal flow eontrol (micropumps and microvalves, cfevice building and characterization), **References/Text Books:** 1. Fundamentals ofMicrofabrication (Second Edition), Marc J. Madou, CRCpress Taylor and Francis Group, 6000 Broken Sound Parkway NW, Suite 300,Boca Raton, FL334872724, 2002.2. BioMEMS Technologies and Applications, Edited by Wanjun Wang, StevenA. Soper, CRC press Taylor and Francis Group, 6000 Broken Sound ParkwayNW, Suite 300, Boca Raton, FL334872724, 2006.3. Biomolecular sensing, processing and analysis, Rashid Bashir, Steve T.Werely, Mauro Ferrari, Springer Science and Business Media LLC, 233Spring Street, New York, NY10013, USA, 2006.	BIOMEMS AND MICROSYSTEMS TECHNOLOGY
ME778	3-0-0--4		**Course Contents:** Wave propagation in solids and fluids. Admittance and impedance concepts forinfinite and finite acoustic waveguides. Sound radiation from vibrating structures:Measurement of radiated power, elementary radiators, sound radiation frombending waves. Passive attenuation of structureborne sound : Damping models,effect of elastic interlayers, blocking masses, changes of material and crosssection.Active control of structureborne	ENGINEERING ACOUSTICS AND ITS CONTROL

			sound : Elements of frequency domaincontrol system analysis and synthesis, wave absorbing controllers for rods,beams, and plates. **References/Text Books:**	
ME778A	3-0-0-0-9		**Course Contents:** Wave propagation in solids and fluids. Admittance and impedance concepts forinfinite and finite acoustic waveguides. Sound radiation from vibrating structures:Measurement of radiated power, elementary radiators, sound radiation frombending waves. Passive attenuation of structureborne sound : Damping models,effect of elastic interlayers, blocking masses, changes of material and crosssection.Active control of structureborne sound : Elements of frequency domaincontrol system analysis and synthesis, wave absorbing controllers for rods,beams, and plates. **References/Text Books:**	ENGINEERING ACOUSTICS AND ITS CONTROL
ME779	3-0-0--4	#	**Course Contents:** Importance and overView ofRapid Protbtyping ario Manufacturing; Process Chain; Solid modeling;Data. formats, conversion, checking, repairing and transmission; Part Slicing and Build orientation;Classification of Rapid prototyping (RP), tooling (RT) and manufacturing (RM) processes;Materials for RP/RTIRM; Operating principles and chara.cteristics qf current and developing rapid prototyping, tooling and manufacturing processes; Use of rapid prototypes and tools in product design, development and service; Selection of rapid prototyping and tooling systems based on product requirements; Case studies. **References/Text Books:** Chua, C.K., Leong, K.F., and Lim, C.S., 2003, Rapid Prototyping Principles and Applications,World Scientific. (second edition).Jacobs, P.F., 1992, Rapid Prototyping and Manufacturing Fundamentals of StereoLithography, Society of Manufacturing Engineers.Lu, L., Fuh, J., and Wong, Y.S., 2001, LaserInduced Materials and Processes for Rapid Prototyping, KLuwer. /Gebhardt, A., 2003, Rapid Prototyping; Hanser. ' .Pham, D.T., and Demov, S.S., 2001, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, SpringerVerlag.Pique, A., and Chrisey, D.B., 2002, DirectWrite Techno ogies for Rapid PrototypingApplications: Sensors, Electronics and Integrated Power Sources, Academic Press.Vcnuvinod, P.K., and Ma, W., 2004, Rapid Prototyping Laser Based and Other Technologies,Kluwer.	RAPID PROTOTYPING & TOOLING TECH.
ME781	3-0-0-0-4		**Course Contents:** This course is an introduction to approximate mathematical methods in engineering. These methods provide powerful tools with which to approximately analyze omplicated/intractable engineer ing/scientific models. These approximate solutions are often very accurate and also provide insight into the underlying physics in an accessible manner. Finally, these approximate methods play a symbiotic role to computational analyses; these latter techniques typically falter near singularities, which is where approximate methods are most useful.1. Introduction to asymptotic approximat_ions (2lectures): Asymptotic relations; Convergent/divergen power series; Asymptotic series; Error estimates; Subdominance; Stokes'phenomenon.2. Asymptotic analysis of integrals (11 lectures): Integration by parts; Laplace's method; Watson's lemma; Method of stationary phase; Method of steepest descent; Application.3. Introducti0n to perturbation theory (4 lectures): Algebraic equations; Iteration and expan sion; Method of dominant balance; Regular and singular perturbation problems; J;lescaling; Nonintegral powers.4. Eigenvalue problems (4 lectures): First and second order perturbation; Iviultiple roots; Degenerate roots; Application.5. Summation of series (3 lectures): Improvement of convergence; Divergent series; Pade approximation; Application.6. Boundary layer theory (7 lectures): Introduction to boundary layers; Formal procedure;In ner, outer and intermediate layers; Asymptotic matching; Higherorder theory; Distinguished limits; Application.7. vVKB Theory (4 lectures): Formal procedure; Patched asymptotic approximation; Turning point problems. Application8. Multiplescale analysis (6 lectures): Resonance and secular behavior; Formal procedure; Reduction to WKB and boundary layer theory; Mathieu equation; Application.	APPROXIMATE METHODS IN ENGINEERING MATHEMATICS

			References/Text Books: 1. Bender, C. M. and S. 0. Orszag, 1999. Advanced Mathematical Methods for Scientists andEngineers, SpringerVerlag: New York, USA.2. Hinch, E. J., 1991. Perturbation Methods, Cambridge U. Press: Cambridge, U.K.	
ME781A	3-0-0-0-9		**Course Contents:** This course is an introduction to approximate mathematical methods in engineering. These methods provide powerful tools with which to approximately analyze omplicated/intractable engineer ing/scientific models. These approximate solutions are often very accurate and also provide insight into the underlying physics in an accessible manner. Finally, these approximate methods play a symbiotic role to computational analyses; these latter techniques typically falter near singularities, which is where approximate methods are most useful.1. Introduction to asymptotic approximat_ions (2lectures): Asymptotic relations; Convergent/divergen power series; Asymptotic series; Error estimates; Subdominance; Stokes'phenomenon.2. Asymptotic analysis of integrals (11 lectures): Integration by parts; Laplace's method; Watson's lemma; Method of stationary phase; Method of steepest descent; Application.3. Introducti0n to perturbation theory (4 lectures): Algebraic equations; Iteration and expan sion; Method of dominant balance; Regular and singular perturbation problems; J;lescaling; Nonintegral powers.4. Eigenvalue problems (4 lectures): First and second order perturbation; Iviultiple roots; Degenerate roots; Application.5. Summation of series (3 lectures): Improvement of convergence; Divergent series; Pade approximation; Application.6. Boundary layer theory (7 lectures): Introduction to boundary layers; Formal procedure;In ner, outer and intermediate layers; Asymptotic matching; Higherorder theory; Distinguished limits; Application.7. vVKB Theory (4 lectures): Formal procedure; Patched asymptotic approximation; Turning point problems. Application8. Multiplescale analysis (6 lectures): Resonance and secular behavior; Formal procedure; Reduction to WKB and boundary layer theory; Mathieu equation; Application. **References/Text Books:** 1. Bender, C. M. and S. 0. Orszag, 1999. Advanced Mathematical Methods for Scientists andEngineers, SpringerVerlag: New York, USA.2. Hinch, E. J., 1991. Perturbation Methods, Cambridge U. Press: Cambridge, U.K.	APPROXIMATE METHODS IN ENGINEERING MATHEMATICS
ME799	-0-0--		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
ME850	3-0-0-0-4		**Course Contents:** 1. Elementary review of dynamic systems. Equations of motion. Numerical solution of ODEs. Linearization.Stability. (5 lectures)2. Laplace transforms and inverse Laplace transforms. Block diagrams. Transfer functions. Feedback loops.Poles and zeros. Transient responses. Stability. The RouthHu rwitz criterion. Nonminimum phase systems and their transient responses. Steady state responses. (7 lectures)3. Root locus plots. Nyquist plots. Bode plots. Implications for transient responses. (5 lectures)4. Compensators. Lead and lag compensators. PID controllers. Tuning rules. (4 lectures)5. Stabilization using a stable controller: motivation and sample problems. (3 lectures)6. Discrete time systems. Stability. (2 lectures)7. State space. Standard form for an LTI system. General solution. Controllability and observability. Pole placement. Connections with classical control. (8 lectures)8. Introduction to optimal control. The linear quadratic regulator. (2 lectures)9. Introduction to timedelayed control. (2 lectures)10. Simulations of nonlinear systems with linearization based controllers. Case studies from the literature as time permits. (41ectures)In addition, the course will have a designoriented project which requires a level of maturity appropriate for a postgraduate class. **References/Text Books:** 1. K. Ogata. Modern Control Engineering. (PHI}2. F. Golnaraghi and B. C. Kuo. Automatic Control Systems. (Wiley)	BASIC CONTROL SYSTEMS FOR MECHANICAL ENGINEERS

ME850A	3-0-0-0-9		**Course Contents:** 1. Elementary review of dynamic systems. Equations of motion. Numerical solution of ODEs. Linearization.Stability. (5 lectures)2. Laplace transforms and inverse Laplace transforms. Block diagrams. Transfer functions. Feedback loops.Poles and zeros. Transient responses. Stability. The RouthHu rwitz criterion. Nonminimum phase systems and their transient responses. Steady state responses. (7 lectures)3. Root locus plots. Nyquist plots. Bode plots. Implications for transient responses. (5 lectures)4. Compensators. Lead and lag compensators. PID controllers. Tuning rules. (4 lectures)5. Stabilization using a stable controller: motivation and sample problems. (3 lectures)6. Discrete time systems. Stability. (2 lectures)7. State space. Standard form for an LTI system. General solution. Controllability and observability. Pole placement. Connections with classical control. (8 lectures)8. Introduction to optimal control. The linear quadratic regulator. (2 lectures)9. Introduction to timedelayed control. (2 lectures)10. Simulations of nonlinear systems with linearization based controllers. Case studies from the literature as time permits. (41ectures)In addition, the course will have a designoriented project which requires a level of maturity appropriate for a postgraduate class. **References/Text Books:** 1. K. Ogata. Modern Control Engineering. (PHI}2. F. Golnaraghi and B. C. Kuo. Automatic Control Systems. (Wiley)	BASIC CONTROL SYSTEM FOR MECHANICAL ENGINEERS
ME851	3-0-0-0-4		**Course Contents:** Genesis of compliant mechanisms; glimpse of applications of compliant mechanisms; mobilityanalysis; large deformation analysis: continuum and discrete perspectives: finite element analysis,pseudo rigidbody analysis, and lumped analysis using springlever and springmasslever models;design of compliant mechanisms based on linkage synthesis methods, selectionbased methods, and structural optimizationbased methods; kinetoelastic maps and understanding limits of compliant mechanisms; static balancing of compliant mechanisms; applications in microsystems, precision engineering, biomedical, automotive, product design, etc. **References/Text Books:**	COMPLIANT MECHANISMS
ME851A	3-0-0-0-9		**Course Contents:** Genesis of compliant mechanisms; glimpse of applications of compliant mechanisms; mobilityanalysis; large deformation analysis: continuum and discrete perspectives: finite element analysis,pseudo rigidbody analysis, and lumped analysis using springlever and springmasslever models;design of compliant mechanisms based on linkage synthesis methods, selectionbased methods, and structural optimizationbased methods; kinetoelastic maps and understanding limits of compliant mechanisms; static balancing of compliant mechanisms; applications in microsystems, precision engineering, biomedical, automotive, product design, etc. **References/Text Books:**	COMPLIANT MECHANISMS
NT611	3-0-0--4		**Course Contents:** Types of nuclear reactors. Heat generation in fuel elements and temperaturedistributions. Heat removal, Reactor coolants. Single phase and two phase heattransfer. Boiling and flow regimes. Heat transfer and fluid flow correlations.Pressure drops due to friction and pumping power. Reactor core **References/Text Books:**	NUCLEAR POWER ENGINEERING I
NT642	3-0-0-0-4		**Course Contents:** Introduction, various NDE techniques ultrasonics, eddy current, magnetic fluxleakage, radiography, optical, tomographic extensions of classical NDE/NDT methodsRadon inversion, data collection mechanisms, applications in industrial situations.	NON-DESTRUCTIVE EVALUATION

			References/Text Books:	
SE381	3-0-0-0-4		**Course Contents:** Introduction: Micro ElectroMechanical Systems (MEMS), Micro channels, Heatpipes, Jets, Valves, Heat sinks, Solar cells, Bearings, Pumps, Flow sensors andactuators, Fins, Drug delivery systems; Transport Equations: Mass, Momentum,Heat and Charge transport equations, Multicomponent systems, CharacteristicNondimensional parameters; Microscale Heat Conduction: Microscale energytransport in solids, Heat transport in thin films and at solidsolid interfaces,Heat conduction in semiconductor devices and interconnects; Convective diffusionPhenomena: Enzymesubstrate reactions, External flow, Internal flow, Channelflow with soluble or rapidly reacting walls, Flow past reacting flat plate; Solutionsof Electrolytes: Electric double layer of Debye sheath, Electrokinetic phenomena,Electro osmosis, Electroosmotic microchannel systems, Electroosmotic Pumps;Surface Tension Driven Flows: Coating flows, Themocapillary flows, Thermocapillary pump, Diffusocapillary flows, Marangoni convection and instability;Modeling: Continuum model, Molecular model, Introduction to molecular dynamicssimulations and direct simulation Monte Carlo method (DSMC); Assorted JournalPapers. **References/Text Books:**	MICROSCALE THERMAL SCIENCES
SE394	3-0-0-0-4	ESO204	**Course Contents:** Vectors and Tensors; Stress, principal stresses, invariants, deviatoric stresses,plane stress, simplified theory; Strains and Deformation, rotation, material andspatial derivatives, deformation tensor, spin and rate of deformation, finitestrain and deformation, rotation and stretch tensors, compatibility conditions;General principles, continuity equation and momentum principles, transporttheorems, virtual work, basic thermodynamics for solids; Constitutive equations,Rational mechanics approach, Classical elasticity, Generalized Hookes law,isotropy, hyperelasticity, thermal stresses, ideal frictionless fluids, Newtonianfluids, Stokes condition. **References/Text Books:**	INTRODUCTION TO CONTINUUM MECHANICS
TA201B	1-0-3-0-6		**Course Contents:** Introduction to manufacturing; Evolution of manufacturing; Importance ofdesign in manufacturing; Conventional material removal processes: chip formation, tooldynamics, practical machining and finishing operations; CNC machining; Unconventionalmachining; Introduction to microfabrication, layered manufacturing, and metrology.Specialized Infrastructure requirement:equipment.Unconventional machining demonstration **References/Text Books:**	MANUFACTURING PROCESSES
TA202A	1-0-3-0-6		**Course Contents:** Engineering materials; Microstructureprocessing relationship; Solidificationprocesses: molding and casting; Joining processes: welding, brazing, and soldering; Deformationprocesses: hot and cold working, bulk and sheet forming; Powder metallurgical processing:powder production, sintering; FeC phase diagram and heat treatment; Surface modificationtechniques: carburization, CVD, PVD.Specialized Infrastructure requirement:Rolling Mill, Pressure Die Casting Unit **References/Text Books:**	MANUFACTURING PROCESSES II
TA202N	1-0-3--3		**Course Contents:** Engineering materials; Microstructureprocessing relationship; Solidificationprocesses: molding and casting; Joining processes: welding, brazing, and soldering; Deformationprocesses: hot and cold working, bulk and sheet forming; Powder metallurgical processing:powder production, sintering; FeC phase diagram and heat treatment; Surface modificationtechniques: carburization, CVD, PVD.Specialized Infrastructure	MANUFACTURING PROCESSES

			requirement:Rolling Mill, Pressure Die Casting Unit **References/Text Books:**	
***** Department of MME *****				
ESO214	3-1-3-1-5		**Course Contents:** Importance of structure, visavis, property with examples, periodic patterns in 2D/3D,symmetry, point and space groups, Bravais Lattices. Crystallographic planes and directions.Glasses, polymers, concept of glass transition temperature. Crystal defects and their importance.Basic characterization techuiques (Xrays and optical microscopy). Evolution of microstructure,phase diagrams, diffusion and phase transformation, application to microstructure design.Mechauical properties: stressstrain curves, elastic modulus, plastic deformation, slip, dislocationmotion, critical resolved shear stress, strengthening mechauisms. Introduction to fatigue andcreep properties of materials. Electrical and magnetic properties of materials, Distinctionbetween conductors, semiconductors and insulators, Brief summary of Free electron theory andBand Theory, Relation of electrical properties with structure and microstructure with suitableexamples, Dielectric Materials with a brief introduction to ferroelectrics, Magnetic materials andstructure relations e.g. texture. **References/Text Books:** 1. V. Raghavan, Materials Science and Engineering: A first course.2. L. H. VanVlack, Elements of Materials Science3. W. D. Callister, Jr., Materials Science and Engineering: An futroduction4. M.F. Ashby and DRH Jones, Engineering Materials!: An introduction to their propertiesand applications.5. M.F. Ashby and DRH Jones, Engineering Materials 2: An introduction to microstructuresprocessing and design.6. Wulff series (Vol.l4), Science and Properties of Materials7. WF Smith, Principles of Materials Science and Engineering8. B.G. Streetman, Solid State Electronic Devices (Chapter upto 4)	NATURE AND PROPERTIES OF MATERIALS
MME100	2-0-0-0-0		**Course Contents:** Historical aspects of various materials, including some landmarks; Naturalresources of materials; Cost, economics, energy, environmental and politicalissues relating to materials industry and applications; Importance of materialsand their properties, performance and manufacturing processes in the developmentand growth of automotive, aerospace and railway sectors, electrical, electronicand telecommunication equipment/systems, energy sector, military hardware,structural and general engineering applications, biomedical/implant materialsetc.; Demonstrations/film shows related to selected materials and theircharacterization, properties and processing. **References/Text Books:**	INTRODUCTION TO PROFESSION
MME200	3-1-0-0-4		**Course Contents:** Heterogeneous and homogeneous systems, extensive and intensive properties,simple equilibrium; First Law of thermodynamics, constant volume and constantpressure processes; Spontaneous processes, entropy and quantification ofirrversibility, properties of heat engines, thermodynamic temperature scale,Second Law of thermodynamics, criterion for equilibrium, Entropy and disorder,most probable microstate, configurational entropy and thermal entropy; auxiliaryfunctions, Maxwells relations, GibbsHelmholtz equation; Third Law ofthermodynamics; variation of Gibbs energy with temperature and pressure,ClausiusClapeyron equation; thermodynamic properties of mixtures of ideal andimperfect gases; reactions in gas mixtures; reactions of pure condensed phaseswith gas mixtures standard Gibbs energy of reactions, Ellingham diagrams;Raoulfs and Henrys Law, activity of a component, GibbsDuhem equation, nonidealsolutions, regular solutions, quasichemical model of solution, activity andalternative standard states; reaction equilibrium in condensed system, Gibbsphase rule, binary systems involving compound formation, solubility of gasesin metals, formation of oxide phases of variable composition; relation betweenchemical and electrical driving forces, Nernst equation, concentration andformation cells, Pourbaix diagrams; thermodynamics of Point Defects. **References/Text Books:**	THERMODYNAMICS OF MATERIALS

MME210	3-1-0-0-4		**Course Contents:** Thermodynamics vs. kinetics, homogeneous and heterogeneous reactions;Chemical Reaction Controlrate equation, reaction rate constant, reaction order,nonelementary reactions; Solid State Diffusion Ficks Law, mechanism ofdiffusion, uphill diffusion, Kirkendall effect, steady and transient diffusion;External Mass Transfer fluid flow and its relevance to mass transfer, generalmass transport equation, concept of mass transfer coefficient, models of masstransfer film theory and Higbies penetration theory; Internal Mass TransferOrdinary and Knudsen diffusion, Mass transfer with reaction; Adsorption physicaladsorption vs. chemisorption, adsorption isotherms; Langmuir, BET, adsorptionas the rate limiting step; gasification of C by CO2, dissolution of N2 in moltensteel, porous solids, specific surface area and pore size distribution; ReactorDesign batch vs. continuous reactors, ideal stirred tank and plug flow reactors,mass balance in ideal reactors, residence time distribution; models of industrialreactors; Electrochemical Kineticsconcept of polarization, activation over potential,ButlerVolmer and Tafels equation, applications in electrodeposition and corrosion,concentration overpotential, limiting current; electrowinning and corrosion. **References/Text Books:**	METALLURGICAL KINETICS
MME250	3-0-3-0-5		**Course Contents:** Chemical bonding, fundamentals of crystallography, reciprocal lattice, structuresin metals, inorganic compounds, polymers, silicates and glasses, stereographicprojections; Production, characterization, and interaction of Xrays with matter,Braggs Law and Laues equations, Ewalds construction, diffraction techniquesand applications; Optical principles of microscopy resolution, magnification,depth of focus; electron diffraction, imaging (various contrasts), determinationof crystal structure, burgers vector, electron beamspecimen interactions andother applications of Transmission Electron Microscopy; Applications of ScanningElectron Microscopy and, Electron Probe Micro Analyser; Principles of QuantitativeMicroscopy: volume density, surface density, length density, numerical density,particle and grain size; Overview of other characterization techniques such asAuger electron spectroscopy, Scanning Tunneling Microscopy, Atomic ForceMicroscopy. **References/Text Books:**	MATERIALS CHARACTERIZATION
MME310	3-1-0-0-5		**Course Contents:** Stress tensor and stress transformation equations, Principal stresses; Straintensor and strain transformation equations; Isotropic and anisotropic elasticity,elastic strain energy; Yield criteria and constitutive relationships; Work hardening,plastic instability and its significance; Crystallographic aspects of plasticdeformation; Dislocation theory edge, screw and mixed dislocations, resistanceto dislocation motion and elastic properties of dislocations, dislocation interactions,multiplication and dissociation; Strengthening mechanisms; Creep characteristicsof creep curve and steadystate creep, mechanisms and creep mechanism maps,creep under complex stressstates, prediction of long time properties; Fracturetoughness and fatigue Griffiths crack theory, energy release rate analysis,modes of loading, stress analysis of cracks, fracture toughness, Low and Highcyclefatigue, Fatigue crack initiation and propagation, structural aspects offatigue, fatigue under complex stressstates, environmental assisted crackingand fatigue; Some case studies related to design. **References/Text Books:**	MECHANICAL BEHAVIOUR OF MATERIALS
MME320	3-1-0-0-4		**Course Contents:** History and importance of metal extraction; Introduction of mineral dressing:Communition, Tabling, Jigging and flotation; Metallurgical fuels and the energyscenario; Pyrometallurgical operations roasting, agglomeration, smelting, refiningand secondary refining; Principles of Hydro Metallurgy; Principles of ElectroMetallurgy Aqueous solution and fused salts; Flow sheet design of importantnon ferrous metals based on materials and heat balance. **References/Text Books:**	PRINCIPLES OF METAL EXTRACTION AND REFINING

MME330	3-1-0-0-5		**Course Contents:** Phase rule, lever rule and Free energy of phase mixtures; Binary isomorphoussystems Equilibrium solidification, nonequilibrium solidification, dendriticgrowth, coring, CuNi alloys and Zone refining; Binary Eutectic and PeritecticSystems solidification of eutectic, hypoeutectic, and hypereutectic alloys;solidification of peritectic, hypoperitectic, and hyperperitectic alloys;morphologies of eutectic systems, Binary Monotectic and Syntectic Systems;Stability of regular solution and miscibility gas, intrinsic stability of solutionand spinodal; HumeRothery rules and intermediate phases e.g., laves, sigma,electron compounds; Binary eutectoid, peritectoid, metatectic and monotecticsystems; Ironcarbon phase diagram and microstructures of plain carbon steeland cast iron: nonequilibrium structures; Binary ceramics systems: SiO2AbOa,NiOMnO, etc.; Ternary phase diagrams Gibbs triangle, isothermal and verticalsections, polythermal projections, twophase equilibrium, concept of tie lines,rules for construction of tie lines, three phase equilibrium, concept of tietriangle,four phase equilibria; Multicomponent alloy systems: Stainless steels,highspeed steels, Hadfield steels, superalloys, light metal alloys, refractorysystems, (AbOaSiO2MgO) , sialanes. **References/Text Books:**	PHASE EQUILIBRIA IN MATERIALS
MME331	0-0-3-0-2		**Course Contents:** Laboratory techniques of temperature and flow rate measurement and calibration:Experiments on Mineral Engineering, Metallurgical Thermodynamics and Kinetics,Fuels and Furnaces, Iron making, steelmaking, pyro, hydro, electrometallurgyin extraction of nonferrous metals and metallurgical analysis. **References/Text Books:**	PROCESS METALLURGY LAB.
MME340	3-0-0-0-4		**Course Contents:** Thermodynamic order of transformations; Theory of nucleation Kinetics ofhomogeneous, transient and heterogeneous nucleation; Theory of ThermallyActivated Growth: Interface controlled growth, Diffusion controlled growth,Interface instability and Widmanstatten growth, Eutectoid growth, Discontinuousprecipitation, Massive transformation; Transformation Kinetics JohnsonMehlequation, Avrami model, Transformation kinetics in diffusioncontrolledtransformations, Isothermal and continuous cooling transformation diagrams;Precipitation and Particle Coarsening; Kinetics of recrystallization, Theory ofgrain growth, Effect of second phase particles; Martensitic transformation Nature of martensitic transformations, Bain distortion, Nucleation, and growthof martensite, Athermal, isothermal and burst transformations, Thermoeleasticmartensitie; Spinodal Decomposition Diffusion equation in spinodal region,Effect of gradient energy and elastic strain energy; Solidification Nature andgrowth of solidliquid interfaces, Rapid solidification, Glass transition, metallicglasses; Heat Treatment IT and CCT Diagrams in steels, quench hardening andtempering of martensite, hardenability of steels, surface hardening processes,tool steels and their heat treatments, heat treatment of cast irons, heattreatment of Nibase superalloys and Ti alloys, Thermomechanical treatments. **References/Text Books:**	PHASE TRANSFORMATIONS IN MATERIALS
MME350	3-1-0-0-4		**Course Contents:** Refractories for iron and steel; Design and profile of an iron blast furnace andits auxiliaries; Performance evaluation of bast furnace Iron ore reduction, fuelrate calculations, BF aerodynamics and hot metal quality control; Energy andmaterials balance calculations in steelmaking processes; Physical chemistry ofsteelmaking and secondary steelmaking deoxidation, ladle and tundish metallurgy,ingot and continuous casting of steel; Emerging trends in iron and steelmaking. **References/Text Books:**	IRON AND STEELMAKING
MME370	3-0-0-0-4		**Course Contents:** Overview of various processing methods for materials; microstructural evolutionduring solidification and effect of cooling rate on cast microstructures, microandmacrosegregation in alloys, directional solidification,	FUNDAMENTALS OF MATERIALS PROCESSING

			rapid solidification;Elements of casting mold design solidification shrinkage and its role in riserdesign, fluid flow fundamentals and metal fluidity, elements of mold design;Fundamentals of deformation processing State of stress during various metalworking operations, friction and its role in bulk metal forming operations,microstructural evolution during deformation processing, workability of metals,superplastic forming; Metal flow and aspects of design during bulk formingoperations, elementary load calculations during various bulkmetal workingoperations; Sheet metal forming State of stress during sheet metal formingprocesses, forming limit diagram, ehancement of sheet metal formability;Fundamentals of powder processing Basics of metal and ceramic powderproductions and characterization, design aspects during powder consolidation;solid and liquid state sintering, driving force and mechanism of si ntering ,selection of sintering atmosphere for different systems, characterization ofsintered products, full density processing. **References/Text Books:**	
MME390	0-0-0-0-0		**Course Contents:** Visit to industries in and around Kanpur or elsewhere primarily of interest toMaterials and Metallurgical Engineering. **References/Text Books:**	INDUSTRIAL TOUR
MME410	3-0-0-0-4		**Course Contents:** DC conductivity of metals, Hall effect and magnetoresistance, AC conductivityof metals, thermal conductivity and specific heat of metals, Thermopower ofmetals; Review of quantum mechanics and free electron theory, failures of freeelectron theory and introduction to the role of lattice; Review of reciprocal lattice,Brilouin zone, Free electron band diagrams, potential in a crystal, electrondynamics and concept of holes, conductivity in relation to band structure, bandstructures of metals and semiconductors; empirical estimates of conductivityin metals and alloys; Semiconductors band diagrams, direct and indirect bandgap, applications of semiconductors; Degenerate and non degeneratesemiconductors, intrinsic and extrinsic semiconductors, determination of dopantlevels and mobility measurements; Ionic conduction review of defect equilibriumand diffusion mechanisms, theory of ionic conduction, conduction in glasses,effect of stoichiometric and extrinsic defects on conduction, applications insensors and batteries; Dielectric Materials Dielectric constant and polarization,linear dielectric materials, capacitors and insulators, polarization mechanisms,nonlinear dielectrics pyro, piezo and ferroelectric properties, hysterisis andferroelectric domains and applications; Optical Materials electronholerecombination, solidstate LEDs, lasers and IR detectors, band gap engineering;Light interaction with materials transparency, translucency and opacity, refractionand refractive index, reflection, absorption and transmission; Magnetic field,flux density, susceptibility and permeability; Orbital and spin, permanentmagnetic moment of atoms, diamagnetism, paramagnetism and Pauliparamagnetism,ferro, antiferro and ferri magnetism, Fe, Co and Ni and alloyadditions, ferrites, magnetic hysterisis, soft and hard magnet materials. **References/Text Books:**	ELECTRONIC & MAGNETIC PROPERTIES OF MATERIALS
MME415	0-0-3-0-2		**Course Contents:** Laboratory techniques for studying phase transformations in materials,recrystallization and grain growth, eutectoid transformations in steels,hardenability, tempering of martensite; resistivity of metals, conductivity ofsemiconductors, conduction in ionic solids, dielectric measurements in $BaTiO_3$,reflection, absorption and transmission measurement on various metals. **References/Text Books:**	PHYSICAL METALLURGY LAB
MME420	3-0-0--4		**Course Contents:** Mining, Smelting, Alloying (mainly copper tin), Metal forming : forging, castingOrigins of metallurgy in Balkans, Near and Middle East ; Metallurgy in PrehistoricWorld, Iron and Steel, Silver, Lead, Brass, Zinc, Gold and Platinum, Decoration,Plating, Metal Fakes and Forgeries, Surface Treatment, Metallurgy of	HISTORY OF SCIENCE AND TECHNOLOGY OF METALLURGY

			India,Metallurgy in Asia, Metallurgy of Greece and Rome, Metallurgy in Europe andthe Middle East, Metallurgy of the Americas and Africa. **References/Text Books:**	
MME424	3-0-0--4		**Course Contents:** Brief review of fundamentals of steel making processes: Brief review offundamentals of transport processes: Mathematical modeling fundamentals:Successful modeling examples. **References/Text Books:**	MODELLING OF STEELMAKING PROCESSES
MME425	3-0-0--4		**Course Contents:** Identification of process flow sheet: Preliminary estimate of resources andfacilities: Materials and energy balance, detailed plant flow sheet: Equipmentselection and specification, economic selection and specification: environmentalimpact analysis: Report presentation, case studies of typical metallurgical plantoperation. **References/Text Books:**	PROCESS PLANT DESIGN FOR METT. ENGG. OPERATIONS
MME430	3-0-0--4		**Course Contents:** Definition and classification of furnaces; Principles of heat generation in fuelfired furnaces and combustion, Flame temperature, Burners for liquid andgaseous fuels, Movement of gases in furnaces, ducts and chimneys, Heatgeneration in electric furnaces, resistance, induction, are, plasma etc. Metallicand nonmetallic heating elements. Furnaces, resistence, induction, are, plasmaetc. Metallic and nonmetallic heating elements. Furnace construction materials:Manufacture and uses of different types of refractories and insulators, criticalinsulation thickness, criteria of section of refractory material. Heat balanceof a furnace and thermal efficiency, Waste heat recovery systems and theirdesigns, Atmosphere in furnaces. Fuel economy measures in furnaces.Constructional, operational and design features of different types of furnaceslike soaking pits, pusher type, walking beams, forging furnaces etc. **References/Text Books:**	FURNANCE TECHNOLOGIES
MME441	3-0-0--4	MME250	**Course Contents:** Hierarchy in structure nanoto macroscale, structural defects and structuralproperty correlations, overview of characterization need and challenges.Physical phenomena and basic concepts: Waves particle beams, radiationmatterinteractions, concepts likes resolution, lens defects, depth of focus, depth offield, detection limits etc. Neutron diffraction. XRD, electron diffraction. ESBDand their applications. Principles of microscopic techniques like TEM, HRTEM, SEM,OIM, SPM etc., and their applications. Nanometer scale design and fabrication usingSTM and AFM. Fundamentals of EPMA, ESCA, AES, SIMS, EELS etc., and applications.Case studies: Super alloys, HSLA, FGM, device structure, structural ceramics,high Tc superconductor, CNT, polymeric LB films. **References/Text Books:**	STRUCTURAL CHARACTERZATION TECHNIQUES & THEIR APPLICATION
MME467	3-0-0--4		**Course Contents:** Semiconductor fundamentals, band structure, indirect and direct band gap,optical properties, carrier statistics, semiconductor material purification andcrystal growth, epitaxy, CVD and MBE, PN Junction, Schottky and MaS devicestructures, specific material requirements, Doping by implantation and diffusion,dielectric and insulators, ohmic and barrier contacts, band edge behaviour,empirical rule, alloy design. **References/Text Books:**	MATERIALS FOR SEMICONDUCTOR INDUSTRY
MME480	2-0-0-0-2		**Course Contents:**	MATERIALS

			Types of processes leading to degradation of materials, viz Oxidation Corrosion,Wear, Creep and fatigue review of basics of thermodynamics and kinetics relatedto oxidation and corrosion studies, Pourbaix diagram, Polarization, Mixedpotential theory, Passivity Characteristics of passivation ; Various types ofdegradation : atmospheric galvanic, intergranular, dealloying, crevice and pittingcorrosion, microbiological, stress corrosion cracking, hydrogen damage, radiationdamagte; Oxidation and hot corrosion of materals at high temperatures ; Wearof materials, analytical models of wear; Prevention of meaterials degradation alloying, environment conditioning design modification cathodic and anodicprotection, metallic coating inorganic coating organic coating, inhibitors andpassivators wear resistant materials structural modifications, wear resistantcoatings. **References/Text Books:**	DEGRADATION & ITS PREVENTION
MME482	3-0-0-0-4		**Course Contents:** Hardenability, Selection and specification of steels: New technology such asthermochemical and thermo mechanical and thermocycling treatments:Quantitative approach to heattreatment: Failure analysis of heat treatedproducts: Applications tailoring and computer harmonizing techniques. **References/Text Books:**	ADVANCES IN HEAT TREATMENT TECHNOLOGY
MME498	0-0-4-0-3		**Course Contents:** PROJECT I **References/Text Books:**	PROJECT I
MME499	0-0-10-0-4		**Course Contents:** PROJECT II **References/Text Books:**	PROJECT II
MME601	3-0-0-0-4		**Course Contents:** Contents: Overview of display industry, information capacity of displays, introduction to different flat panel display technologies, applications and comparison; Characterization and performance of displays: Concepts of luminance and brightness, color, contrast and gradation, directional visibility,driving power, efficiency, speed, memory and storage, degradation, resolution, addressability,physiological factors, and measurement instrumentation; Basic concepts of cathode ray tube (CRT); Luminescence and luminescent materials: Physical processes and interactions leading to emission of light, processes responsible for the transfer of energy in luminescent materials,chemistry and preparation of luminescent materials, and emission properties of the prepared materials; Technical discussion of display technologies: Light Emitting Diodes (LEDs),Organic LightEmitting Diodes (OLEOs), Electroluminescent Displays (ELs): Plasma Displays (PDs): FieldEmission Displays (FEDs): Vacuum Fluorescent Displays (VFDs): Liquid Crystal Displays (LCDs): **References/Text Books:**	DISPLAY MATERIALS & TECHNOLOGIES
MME603	3-0-0-0-4		**Course Contents:** Introduction to nonequilibrium processing; Thermodynamics and kinetics of metastable phase formation; Rapid solidification: Under cooling, Phase diagram of metastable states, Methods of rapid solidification, Microstructure t:ormation by rapid solidification, Application of rapid solidification; Mechanical alloying: Process of mechanical alloying, Mechanism of alloying, Energy criteria for mechanical alloying, Synthesis of nonequilibrium phases,Application of mechanical alloying; Metallic glass: Understanding of glass formation, thermal stability and glass forming ability, structure of metallic glass, crystallization behavior, properties of metallic glass, application. Special nonequilibrium processing and phase transformations **References/Text Books:**	NON EQUILIBRIUM PROCESSING OF MATERIALS

			1.Nonequilibrium processing of Materials Edited by C. Suryanarayana, Pergamon, I 999.Phase Transformation in Metals and Alloys D.A. Porter and K.E. Sterling, Van Nostrand Reinhold,Wokingham, YK (1981).2.Solid state phase transformations V. Raghavan, Prentice Hall of India Pvt. Ltd. I 987.3.Fundamentals of Solidification W. Kurz and D.J. Fisher, 3rd edn, Trans Tech Publications, Switzerland,19894.Elements of rapid solidification Edited by M.A.Otooni, Springer I 998.5.Mechanical alloying and milling C. Suryanarayana, Marcel Dekker, 2004.6.Rapid solidification processing Loren A. Jacobson and Joanna McKittrick, Materials Science and Engineering R, I I (1994) 355408.7.Metallic glasses: production, properties and applications Edited by T.R. Anantharaman, Trans Tech publications I 984.	
MME605	3-0-0-0-4		**Course Contents:** Surface Chemistry/Interaction (surface charge, dipoles, energies, interfacial chemical reactions), Surface Phonons/Plasmons (Quantisation of plasma, light and, sound, Brillioun Zones), Elastic/Inelastic scattering, Electromagnetic scattering (Compton, Rayleigh, Rutherford, Thomson), Crystal structure and Reciprocal Lattice, Brillouim Zone, Surface Diffusion (Fick's law, intergraular/amorphous layer formation), Surface Energy/Young's Equation (Capillary/surface tension in fluids), Surface Sensitive Properties : Pussivation/Adsorption (Forces/Chemical bonds on surface), Interfacial wetting (formationof interfaces, contact angle in wetting surfaces), Density functional theory of atomic equilibrium, Case Studies: FeB49system, and Al2O3carbon nanotube, Surface Modification/UnctionalizationNanostructures: Self Assembly (adding molecules to surface), Distribution of phase : Voronoi and Dirichlet Tessellation, Molecular Sieves (Molecular filters : purification of gases/chemicals etc). **References/Text Books:** I. Materials Science and Tedmology. Ed. R.W. Kahn, P. Hassen, E.J. Kramer, Vol. 2n/2b, Wiley YCII (2005).2. Physics of Atoms and Molecules. B.H. Bransden, and C.J. Joachain, Longman (1996).3. Surface Analysis Methods in Materials Science, D. J. O'Connors, B.A. Sexlon, and R. St. C. Smart, Springer (2003).4. The Physics and Chemistry of Materials, J. I. (Gersten, F. W. Smith. Wiley (2001).5. Elementary Solid State Physics. M. A, Omar, AddisonWesley {2001).6. Course materials wlll be supplememed with hundouts, and journal publications.	SURFACE PHENOMENA AND CHARACTERIZATION
MME607	3-1-0--5		**Course Contents:** Fortran fundamentals: Applications of regression analysis and curve fittingtechniques, computer calculations of phase diagrams: Numerical of partialdifferential equations pertinent to heat, mass and momentum transfer: Computerapplications in solidification, potential energy diagrams and experiment inmetallurgy. **References/Text Books:**	COMPUTING APPLICATIONS IN METALLURGY
MME613	3-0-0--4		**Course Contents:** Thermodynamic of electrolyte, electrochemical potential, conduction of ions insolution, overpotential, absorption, phase formation: Economics of an electrolyticprocess, principles of cell design, Electrochemical technology: Elactowinning, electrorefining and metal electroforming, electrochemical machining, electroplating,anodizing, pickling, electrophoretic painting, electrochemical treatment of minerals,batteries and fuel cells, water treatment and environmental protection. **References/Text Books:**	ELECTROCHEMICAL TECHNOLOGY IN MATERIALS PROCESSING
MME626	3-1-0--5		**Course Contents:** Review of the basic concepts in heat,mass and momentum transfer: Advancedtopics in convective heat and heat transfer: Radiative heat transmission.Simultaneous heat and mass transfer: Selected topics in metallurgical engineering,Reaction kinetics. **References/Text Books:**	HEAT AND MASS TRANSFER
MME630	3-0-0--4		**Course Contents:**	ADVANCES IN IRON AND

			Recent trends in iron and steel making: Gassolid and slagmetal reaction: Spongeiron making: Continuous steel making: Continuous casting: Vacuum degassingand electroslag remelting: Advances in agglomeration, blast furnace and steelmaking, analysis of iron and steel making processes and reactors: Deoxidationand impurity control: Emphasis on application of physical chemistry and transportphenomena. **References/Text Books:**	STEEL MAKING
MME646	3-0-0--4		**Course Contents:** Elemental compound and alloy crystals, modes of bonding, crystal types, densityof packing, atomic stacking, inter atomic voids, coordination polyhedra,Paulings rules, symmetry elements, space and point groups, group theoreticalformulation, diffraction or radiation. **References/Text Books:**	X-RAY CRYSTALLOGRAPHY - I
MME650	3-0-0--4		**Course Contents:** Concepts and language of stereology; geometrical probability; fundamentaloperations in stereology; averaging with respect to orientation; basic stereologicalparameters on true 2D sections and thick sections; topological parameters ofmicrostructure; error analysis; applications of analysis of optical, scanning andtransmission electron micrographs; numerical density and size distribution ofparticles and grains of various shapes and sizes; stereological analysis ofanisotropic microstructures; fractal description of various microstructures;fractal dimensions and its significance; applications to characterization ofmartensitic, polycrystalline and other structures and fracture surfaces. **References/Text Books:**	FUNDAMENTALS OF STEREOLOGY & APPLICATIONS TO MICROSTRUTURAL ANALYSIS
MME655	3-0-0--4		**Course Contents:** Limitation of conventional metal forming methods: Powder rolling and its variousvariants, spray rolling, direct strip process: Powder, spray, rotary and isothermalforging: Hydrostatic and powder extrusion: Conform process: Applications ofthese processes for making conventional and speciality products. **References/Text Books:**	MODERN TRENDS IN METAL FORMING PROCESESS
MME658	3-0-0-0-4		**Course Contents:** Overview of defects in Materials: (point, line, planar and volume defects) and their classification. Overview of plastic deformation mechanisms. Point defects: interaction and distributions, statistical thermodynamics, role in diffusion and deformation. Basic understanding of dislocations using physical and computer models: the Volterra cut, Burgers vector and the Burgers circuit, the line vector, edge, screw and mixed locations, Role of dislocations in weakening the crystal and in plasticity. Elasticity theory of dislocations: Stress, strain and displacement fields and energy of a dislocation, Forces on dislocations (including image force) Interaction between dislocations, Core of a dislocation. Motion of dislocations: The Peierls stress, role of the core structure, interaction of dislocations with other defects (including yield point phenomenon); kinks; jogs; crossslip; climb, Temperature and strainrate dependence of flow stress, Dislocation dynamics and the tensile stressstrain curve. Dislocations in FCC Metals: Partial dislocations (Shockley and Frank partials) stacking faults, Thompson's tetrahedron, LomerCotrell sessile dislocation. Overview of dislocations in other crystal structures: HCP metals, BCC metals, ionic crystals, superlattices, covalent crystals. Origin and multiplication of dislocations: dislocations in freshly grown crystals, nucleation of dislocations, multiplication of dislocations (by FrankRead sources, cross slip and climb), Grain boundary sources, Recovery and recrystallization. Geometrically/structurally necessary dislocations: lowangle & general grain boundaries, indentation, interfacial dislocations, Twinning including incoherent twins. Specific examples of role of dislocations and case studies:Dislocations in nanocrystals, The HallPetch relation and the Inverse HallPetch Effect (IHPE), Dislocations in epitaxial systems, Severe Plastic deformation, Role of dislocations in Creep, Fatigue and Fracture.	DISLOCATIONS AND PLASTICITY

			References/Text Books: 1. Introduction to Dislocations, D. Hull and D.J. Bacon, Pergamon Press, Oxford, 1984.2. Theory of Dislocations, J.P. Hirth and J. Lothe, MeGrawHill, New York, 1968.3. Crystal Defects and Crystalline Interfaces, W. Bollmann, SpringerVerlag, Berlin, 1970.4. Elementary Dislocation Theory, J. Weertmen and J. Weertman, The MacMillian Company, New York, 1964.5. http://www.if.unikiel.de/matwis/amat/defenl	
MME667	3-0-0--4		**Course Contents:** Overview of the design process: concepts and stages of engineering design anddesign alternatives to develop materials with tailored properties; Performanceindices of materials; function, objective and constraints in design, specificstiffnesslimited and strengthlimited design for maximum performance,Performance indices for thermal, mechanical, thermomechanical applications,damage tolerant designs for structural applications; Basic concepts of materialsscience: processingstructurepropertyperformance correlation; overview ofconventional and advanced materials; Brief overview of the elements of chemicalbonding, crystal structure, defect structure of different material classes, Briefintroduction to the manufacturing processes for metals, polymers, ceramics,glasses and composite materials; design for manufacturability, Ashbys materialproperty charts; Decision matrices and decision matrix techniques in materialsselection, relationship between materials selection and processing; Case studies:designing of Metals and alloys, ceramics and glasses, composite materials (MMC,CMC and PMC/ FRC) for specific applications. **References/Text Books:**	SELECTION AND DESIGNING WITH ENGINEERING MATERIALS
MME668	3-0-0--4		**Course Contents:** Introduction to basic concepts of Materials Science; Salient properties of important material classes; Property requirement of biomaterials; Concept of biocompatibility; cellmaterial interactions and foreign body response; assessment of biocompatibility of biomaterials,Important biometallic alloys: Tibased, Stainless steels, CoCrMo alloys; Bioinert, Bioactive and bioresorbable ceramics; Processing and properties of different bioceramic materials with emphasize on hydroxyapatite; Synthesis of biocompatible coatings on structural implant materials; Microstructure and properties of glassceramics; biodegradable polymers; Design concept of developing new materials for bioimplant applications. **References/Text Books:** 1. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratnes, Hoffman, Schoet and Lemons,Second Edition: Elsevier Academic Press, 2004.2. Comprehensive structural Interity, Vol.9: Bioengineering3.Editors: Mithe, Ritchie and Karihaloo, Elsevier Academic Press, 2003.3. Biomaterials Science and Biocompatibility, Frederick H. Silver and David L.Christiansen, Piscataway, Springer, New Jersey.4. Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981.5. Basic Cell Culture: A Practical Approach, Edited by J.M. Davis, IRL Press, Oxford University Press, New York, 1994.	MATERIALS FOR BIOMEDICAL APPLICATIONS
MME670	3-0-0-0-4		**Course Contents:** Introduction; Thermodynamics of solidification; Nucleation and growth ; Pure metalsolidification: GibbsThomson effect ; Alloy Solidification: Mathematical Analysis ofredistribution of solute during solidification, Constitutional undercooling, ullinsSekerka instability; Single phase solidification: Cellular and Dendritic growth;Multiphase solidification: eutectic, peritectic and monotectic; Modelling of solidification;Case studies. **References/Text Books:** 1. Solidification Processing; Fleming, M.C., McGrawHill, N.Y., 19742. Solidification of Casting; Ruddle, R.W., Institute of Metals, 19573. Solidification and Casting, Davies, G.J., John Wiley and Sons, 19734. Science and Engineering of Casting Solidification; Stefanescu, D.M., KluwarPublications, 20025. Fundamentals of Solidification by Kurz, W. and Fisher, D.J., TransTech Publications,Switzerland, 19896. Theory of Solidification; Davis, Stephen, H. Cambridge University Press, 2001	SOLIDIFICATION PROCESSING

MME672	3-0-0-4-4		**Course Contents:** 1. Fundamentals of Material Properties and the importance of Ceramic materials (2L)2. Glass and glassceramics (3L)3. Processing and properties of different ceramic monoliths: (12L) Fundamental Sintering mechanismsVarious advanced sintering techniques, like Hot Isostatic Pressing, SparkPlasma Sintering, Microwave sintering4. Mechanical behavior of Structural ceramics: (12L) Brittleness of ceramicsConcept of fracture toughness and different toughness measurement techniquesElastic modulusStrength measurement and Weibull theory of strength variabilityConcept of various toughening mechanisms5. Processing and Properties of ceramic composites: (6L)Examples of toughened particle reinforced compositesWhisker reinforced compositesFiber reinforced composites6. Recent advances in Structural Ceramics: (3L)Functionally graded ceramic compositesBioceramics and composites **References/Text Books:** o W.D. Kingery, H.K. Bowen, D.R. Uhlmann, Introduction to Ceramics, 2nd ed. (John Wiley and Sons,NY, 1976).o R. W. Davidge; Mechanical behavior of ceramics; Cambridge University Press, 1989. o M.N. Rahaman, Ceramic Processing and Sintering, (Marcel Dekker, NY, 1995).o Y. M. Chiang, D. P. .Birnie and W. D. Kingery; Physical Ceramics, John Wiley & Sons. o J.B. Wachtman, Mechanical Properties of Ceramics. (John Wiley and Sons, NY, 1996).o B.R. Lawn, Fracture of Brittle Solids., 2nd ed. (Cambridge University Press, Cambridge, UK, 1993).o D.J. Green, An Introduction to the Mechanical Properties of Ceramics (Cambridge University, UK,1998)o R.W. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials., 3rd ed. (John Wiley & Sons, NY, 1983).	Advanced Structural Ceramics
MME674	3-0-0--4		**Course Contents:** Factors affecting designmaterials and geometry: Specific design of productslike permeable materials, structural parts, bearings and cutting tool materials:conditioning of metal powders to influence processing parameters: Productproperties evaluation and their standardization. **References/Text Books:**	DESIGN OF SINTERED PRODUCTS
MME680	3-0-0--4		**Course Contents:** 1. Grain boundary structure: Geometrical aspects, Degrees of freedom, Principles governing grain shape and size and their orientation. Theoretical formulations: Structural units model, Plane matching model, 0 Lattice model, Special boundaries, CSL and DSC Lattice(6 hours)2. Boundary energy and equilibria, Grain Boundary types, GB mobility and boundarysolute interactions. GB structure and Properties: mechanical strength, wear, creep, magnetic, electrical etc., Simulation and Modelling (7 hours)3. Grain boundary engineering strategy: Deformation, thermomechanical treatment, trace additions, Magnetic Field etc. GB descriptors: Connectivity, density, junction distribution, Character Distribution (8 hours)4. Boundary Characterization Tools: Xray, EBSDOIM, CTEM, AEM, HRTEM, etc.Macrotexture analysis: Pole figure measurement, Xray diffraction, neutron diffraction methods. Microtexture analysis: Automated EBSD,Kikuchi pattern, Hough's transform, SEMOIM based, TEM based, Schemes for representation of Data (12 hours)5. Prospective applications: Superplasticity, Creep resistance, Corrosion Resistance,Superconductivity, Electronic ceramics **References/Text Books:**	GRAIN BOUNDARY ENGINEERING
MME681	3-0-0-0-4		**Course Contents:** 1. Introduction to the course. 2. Solar Spectrum. 3. Available solar energy technologies.4. Solar Thermal Energy Conversion. a. Fundamentals. b. Materials and Technologies.c. Applications. d. Present status. 5. Photovoltaic Devices and their fundamentals. 6. Solar Electricity Conversion or Solar Photovoltaics. a. Technologies _b. Materials, devices and issues, 1. First generation technologies Si based.u. Second generation technologies (low cost) thinfilms (aSi, CdTe, CIGS); solarconcentratorsm. Third generation (high efficiency and low cost) Organic solar cells, multijunction,quantum dotsc. Device Characterizationd. Comparative Performance7. PV Processing with emphasis on migration from solar cells to modules to	SOLAR ENERGY TECHNOLOGIES AND MATERIALS

			systems8. Present status and Future outlook **References/Text Books:** 1. Thin Films Solar Cells, K.L. Chopra, McGraw Hill2. Physics and Technology of Solar Energy, H. P. Garg, M. Dayal, G. Furlan (1987)a. Volume 1: Solar Thermal Applicationsb. Volume II: Photovoltaic And Solar Energy Materials)l r._c1'L/3. The Physics of Solar Cells (Properties ofSemiconductor Materials) , Jenny Nelson4. Third Generation Photovoltaics: Advanced Solar Energy Conversion (Springer Series inPhotonics) by M.A. Green5. Flexible Solar Cells by Mario Pagliaro, Giovanni Palmisano, and Rosaria Cirirninna (HardoverDec 10, 2008)6. Physics of Solar Cells: From Basic Principles to Advanced Concepts (Physics Textbook) byPeter W?rfel (Paperback April 13, 2009)	
MME685	3-0-0--4		**Course Contents:** Surface science; experimental techniques to study surfaces; kinetics of surfaceprocesses impingement of atoms, scattering, adsorption, sticking coefficient;Film nucleation and growth mechanisms, critical radius of nuclei, computersimulation of film growth, microstructure evolution; Film growth by evaporation,sputtering, chemical vapour deposition, atomic layer epitaxy, liquid phaseepitaxy, solgel technique etc, Electrical, optical, magnetic and mechanicalproperties of thin films and their applications. **References/Text Books:**	THIN FILM PHYSICS & APPLICATIONS
MME686	3-0-0-0-4		**Course Contents:** contents: Review of semiconductor physics, carrier statistics, generationrecombination and carrier transport. Devices: PN junctions, Schottky barrier diodes, MOS capacitors, field effect transistors.Planar technology and process flows for PN junctions and Schottky diodes. Oxidation, diffusion (oxidation enhanced diffusion, transient enhanced diffusion), ionimplantation, deposition (chemical and physical vapour techniques), etching; Lithography; Device and process integration, withMOSFET as an example. **References/Text Books:** I . Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects, D.Michael Ashby, Paulo Ferreira. Daniel L. Schodek , ButterworthHeinemann, 2009.2. Handbook ofNanophase and Nanostructured i!Jaterials (in jour volume.). Ed: Z.L. Wang, Y.Liu, Z. Zhang, Kluwer Academic/Plenum Publishers, 2003.3. Encyclopedia ofNanoscience and Nanotechnology, Ed.: Hari Singh Nalwa, AmericanScientific Publishers, 2004.4. Handbook ojNanoceramics and their Based Nanodevices (Vol. 2) Edited by T eungYuenTyeng and Hari Singh NahFa, American Scientific Publishers.	SEMI CONDUCTOR DEVICES AND PROCESSING
MME688	3-0-0-4-4		**Course Contents:** 1. Fundamental Properties of various primary material classes (Metals, ceramics and Polymers) (8L)2. Definition and Classification ofNanomaterials (2L)3. Size dependent properties and various characterization techniques ofNanomaterials (5L)4. Synthesis/Consolidation routes to produce Nanomaterials (10 L)4.1 Mechanochemical synthesis to produce nanosized precursor powders4.2. Various routes to produce Nanometallic alloys (Rapid solidification)4.3 Challenges in processing bulk ceramic nanomaterials4.4. Various densification routes for nanoceramics and nanoceramic composites5. Processingstructureproperties of important bulk nanomaterials (10 L)5.1 Mechanical Properties5.2 Thermal Properties5.3 Tribological Properties5.4 Biological Properties (Biomedical applications)6. Applications of bulk nanomaterials (3L)7. Critical issues related to understanding the properties of nanomaterials (2L) **References/Text Books:** o Nanomaterials Synthesis, Properties and Applications, Edited by A. S. Edelstein and R. Cammarata, Institute of Physics Publishing, London, 1998 (paper back Edition).o Physics and Chemistry ofNanostructured Materials; Shihe Yang and Ping Shen (Taylor & Francis,. 2000)o Handbook of Nanostructured Materials and Nanotechnology, Edited by H. S. Nalwa Vols. 15,Academic Press (2000).	Nanomaterials: Processing and Properties
MME690	-0-0--0		**Course Contents:**	SEMINAR PARTICIPATION

			SEMINAR PARTICIPATION **References/Text Books:**	
MME690.	0-0-0--0		**Course Contents:** SEMINAR PARTICIPATION **References/Text Books:**	SEMINAR PARTICIPATION
MME691	-0-0--0		**Course Contents:** SEMINAR PRESENTATION **References/Text Books:**	SEMINAR PRESENTATION
MME693	3-0-0-0-4		**Course Contents:** Introduction to basic concepts of DNA and proteins: structure, their role in life sciencesand their application as nanotechnology tools; Microfabrication techniques forapplications in life sciences including bionanosensors and microfluidic devices;Fabrication and analysis of Labonachip devices; Concept of biocompatibility; SelfAssembled Monolayers (SAMs); Biofunctionalization of nanomaterials; Drug deliverytechniques using nanomaterials; Characterization techniques used in life sciences:Fluorescence microscopy, Quantum dots, Single molecule detection techniques, andAtomic Force Microscopy; Applications of Materials Science in Life Sciences including:Sensing, BioMEMS devices, Drug delivery, and Biomedical devices. **References/Text Books:** 1. B. Alberts eta!. , Essential Cell Biology. (Garland Publishing Inc. , New York, ed.Third, 2009).2. C. S. S. R. Kumar, Biofimclionalization qfNanomalerials. C. S. S. R. Kumar, Ed.,Nanotechnologies for the life sciences (WileyVCH, Weinheim, 2006), vol. 1, pp.366.3. C. S. S. R. Kumar, Nanomaterialsfor biosensors. C. S. S. R. Kumar, Ed. ,Nanotechnologies for the life sciences (WileyVCH, Weinheim, 2006), vol. 8.	MATERIALS SCIENCE TECHNOLOGIES FOR APPLICATIONS IN LIFE SCIENCES
MME694	3-0-0-0-4		**Course Contents:** Overview of Nanostructures and Nanomaterials: classification (Dimensionality, Morphology/ shape/structure of nanoentities, New Effect/ Phenomena). Crystallinenanomaterials and defects therein. Hybrid nanomaterials. Effect of size, structure,mechanism, and property on material performanc?. Multiscale hierarchical structures built out of nanosized building blocks (nano to macro). Eucledian, Hyperbolic and Spherical space structures. Nanostructures: Carbon Nanotubes, Fullerenes, Nanowires, Graphene, Quantum Dots. Thermodynamics of Nanomaterials. Configurational entropy and Gibbs free energy of nanocrystals. Wulff reconstruction. Surface reconstruction and reconfiguration. Adsorption and Absorption. **References/Text Books:** 1. Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects, D.Michael Ashby, Paulo Ferreira, Daniel L. Schodek, ButterworthHeinemann, 2009.2. Handbook of Nanophase and Nanostructured Materials (in four volumes), Eds: Z.L. Wang, Y. Liu, Z.Zhang, Kluwer Academic/Plenum Publishers, 2003.3. Encyclopedia of Nanoscience and Nanotechnology, Ed.: Hari Singh Nalwa, American ScientificPublishers, 2004.4. Handbook of Nanoceramics and their Based Nanodevices (Vol. 2} Edited by TseungYuen Tseng andHari Singh Nalwa, American Scientific Publishers.5. Introduction to Nanoscience, G.L. Hornyak, J. Dutta, H. F. Tibbals, A.K. Rao, CRC Press (2008).	NANOSTRUCTURES AND NANOMATERIALS: CHARACTERIZATION AND PROPERTIES
MME695	3-0-0-0-4		**Course Contents:** Importance of Smfacc Characterization. Present status sensitivity and resolution achievable.Diffraction Techniques: Revicv.,: of basic diffraction theory; Various Small Angle Xray Scattering techniques, EXAFS. SEXAFS!NEXAFS and its applications; electron cliftl'action,LEED and RHEED. Properties of neutron radiation: neutron sources: Small angle neutron scattering; lllustrative analysis using diffraction techniques	DiiTraction and Spectroscopy Techniques for Surface

			Spectroscopy: Basic principles of Spectroscopy. Principles of XPS, Instrumentation, XPSpatterns, Quantitative analysis. Chemical effect, Chemical shilL XPS imaging; Auger electron generation: Principle of AES. Chemical e1Tect, Quantitative analysis, Depth profiling,Applications; Static and Dynamic SlMS, Common modes of analysis, quantitative and Qualitative analysis; Case studies on the spectroscopic analysis of surfaces. **References/Text Books:** l. Encycleopedia ofMateria!s Characterisation, C. R. Brunelle. C. A. Evans and S. Vilson,ButterworthHennmann, 1992. Boston.2. Characterisation ofMaterials Volume 2. Editor:E.N. Kaufmann, Wileylnterscience. 2003.New Jersey.3. Surface Anctvsis kfethods in ;Hateria!s Science. D. J. oconnors, B.A. Sexton. and R. St. Smart, Springer (2003).4. Materials Charocterization. published in 1986 as Volume l 0 of the 9th Edition MetalsHandbook, ASM International. 1986 (Fifth printing 1998).	
MME698	----		**Course Contents:** SEMINAR PARTICIPATION **References/Text Books:**	SEMINAR PARTICIPATION
MME699	-0-0--		**Course Contents:** M TECH THESIS **References/Text Books:**	M TECH THESIS
MME799	-0-0--		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
***** Department of MS *****				
MS601	3-0-0--4		**Course Contents:** Crystal structure, Bonding of atoms, Crystal chemistry, Equilibrium thermodynamics,Phase equilibria, Phase transformations, Dia, Para, Ferro, Ferri and Antiferromagnetism,Magnetic domains, Anisotropy effects, Magnetostriction, Measurementof magnetic properties, Soft and hard magnetic materials and their technology. **References/Text Books:**	STRUCTURAL & MAGNETIC PROPERTIES OF MATERIALS
MS601A	3-0-0-0-9		**Course Contents:** Crystal structure, Bonding of atoms, Crystal chemistry, Equilibrium thermodynamics,Phase equilibria, Phase transformations, Dia, Para, Ferro, Ferri and Antiferromagnetism,Magnetic domains, Anisotropy effects, Magnetostriction, Measurementof magnetic properties, Soft and hard magnetic materials and their technology. **References/Text Books:**	STRUCTURAL & MAGNETIC PROPERTIES OF MATERIALS
MS602	3-0-0--4		**Course Contents:** Metallic conduction, Energy bands, Brillouin zones, Temperature dependence ofmetallic conductivity, Impurity contributions, Semiconductor materials, Dopingeffects, Law of mass action, Electrical resistivity and Hall effect measurements,Recombination Processes, pn junctions, MOS field effect transistors, Semiconductortechnology, Point defects, Diffusion phenomenon, Ionic conduction, Temperatureand (aliovalent) impurity effects, Superionic conductors and devices, Di, piezoandferroelectric materials,	ELECTRICAL AND DIELECTRIC MATERIALS

			Mechanisms of polarization, Dielectric parametersand their measurements. **References/Text Books:**	
MS602A	3-0-0-0-9		**Course Contents:** Metallic conduction, Energy bands, Brillouin zones, Temperature dependence of metallic conductivity, Impurity contributions, Semiconductor materials, Doping effects, Law of mass action, Electrical resistivity and Hall effect measurements, Recombination Processes, pn junctions, MOS field effect transistors, Semiconductio technology, Point defects, Diffusion phenomenon,Ionic conduction, Temperature and (aliovalent) impurity effects, Superionic conductors and devices, Di, piezo and ferroelectric materials, Mechanisms of polarization, Dielectric parameters and their measurements. **References/Text Books:**	ELECTRICAL AND DIELECTRIC MATERIALS
MS603	3-0-0-1-5		**Course Contents:** Stress and strain tensors, Elastic constants, Effect of structure on elasticbehaviour, Elastic stress distributions, Viscosity and viscoelasticity in polymers,Yielding criteria, Dislocations and plastic deformation of metals and ceramics,Strengthening mechanisms, Creep, Brittle fracture in ceramics and glasses,Toughening of ceramics and composites, Fatigue, Mechanical testing, Strengthand engineering design with brittle solids, Heat treatment, Powder processing. **References/Text Books:**	MECHANICAL PROPERTIES OF MATERIALS
MS603A	3-0-0-0-9		**Course Contents:** Stress and strain tensors, Elastic constants, Effect of structure on elastic behaviour,Elastic stress distributions, Viscosity and viscoelasticity in polymers,Yielding criteria, Dislocations and plastic deformation of metals andceramics, Strengthening mechanisms, Creep, Brittle fracture in ceramics andglasses, Toughening of ceramics and composites, Fatigue, Mechanicaltesting, Strength and engineering design with brittle solids, Heattreatment, Powder processing. **References/Text Books:**	MECHANICAL PROPERTIES OF MATERIALS
MS604	3-0-1--5		**Course Contents:** Crystallography, Reciprocal lattice, Diffraction methods, Electron microscopy,Metallography, Thermal analysis, Chemical analysis, Spectroscopic techniques,Laboratory sessions. **References/Text Books:**	CHARACTERIZATION OF MATERIALS
MS604A	3-0-1-0-10		**Course Contents:** Crystallography, Reciprocal lattice, Diffraction methods, Electron microscopy, Metallography, Thermal analysis, Chemical analysis, Spectroscopic techniques,Laboratory sessions. **References/Text Books:**	CHARACTERIZATION OF MATERIALS
MS605	3-0-0--4		**Course Contents:** Solidification, Powder processing, Crystal growth, Heat treatment andmicrostructures, Non destructive evaluation, Processing of glasses and polymers,Novel processing methods, Thin films, Surface phenomena and corrosion. **References/Text Books:**	MATERIALS ENGINEERING
MS605A	3-0-0-0-9		**Course Contents:** Solidification, Powder processing, Crystal growth, Heat treatment andmicrostructures, Non destructive	MATERIALS ENGINEERING

			evaluation, Processing of glasses and polymers,Novel processing methods, Thin films, Surface phenomena and corrosion. **References/Text Books:**	
MS606	3-0-0--4		**Course Contents:** Classification, Crystal growth techniques, Wafer processing, Doping methods,Formation of oxide layer, CVD, MOCVD and MBE, Metallic contacts and interconnects,Lithography, Processing integration.Photonic materialssolar cells, photodetectors, light emitting diodes, Superlatticestructures, Materials for high frequency and high temperature devices, Applicationof linear and nonlinear dielectric materials, Electrooptic ceramics, Materialsfor signal processing, transducers and digital data storage, Superconductingmaterials and applications. **References/Text Books:**	ELECTRONIC MATERIALS
MS606A	3-0-0-0-9		**Course Contents:** Classification, Crystal growth techniques, Wafer processing, Doping methods, Formation of oxide layer, CVD, MOCVD and MBE, Metallic contacts and interconnects, Lithography, Processing integration. Photonic materialssolar cells, photodetectors, light emitting diodes, Superlattice structures, Materials for high frequency and high temperature devices, Application of linear and nonlinear dielectric materials, Electrooptic ceramics, Materials for signal processing, transducers and digital data storage, Superconducting materials and applications. **References/Text Books:**	ELECTRONIC MATERIALS
MS611	3-0-0--4	#	**Course Contents:** Characteristics of solar radiation, Basic features of solar cells, Various junctionconfigurations, p n homojunction, Schottky barrier, Heterojunction, Photoelectrochemicalcells, Desired material properties, Promising semiconductormaterials, Various fabrication techniques, Solid state diffusion, Vacuumevaporation, Sputtering, Thermal oxidation, Chemical displacement, Plasmadeposition, Energy storage devices. **References/Text Books:**	MATERIALS FOR ENERGY CONVERSION & STORAGE
MS614	3-0-0--4		**Course Contents:** Classification and structure of polymers, Glass transition, Linear viscoelasticity,Stress relaxation and dynamic experiments, Mechanical models, Superpositionprinciples, Effect of structure on mechanical properties, Rubber elasticity, Yieldand fracture. **References/Text Books:**	ENGINEERING POLYMERS
MS617	3-0-0-0-4		**Course Contents:** Effects of confinement and finite sizezero, one and two dimensional nanostructures(concepts of surface and interfacial energies), Intermolecular andinterfacial forces in organic, polymeric, biological and aqueous systemsVan derWaals, electrostatic, double layer, acid base, depletion interactions, hydrophobicforce, layering, mesoscale thermodynamics, Gibbs treatment of interfaces,mesoscale fluid dynamics, thin soft films, mesoscale phenomena in soft matterand applications: adhesion, wetting, nucleation, Nanofabrication: patterning ofsoft materials by self organisation and other techniques, chemical self assembly,artificial multilayers, cluster fabrication, LangmuirBlodget growth, Nanolithography,Scanning probe lithography, Micro contact printing, Synthesis of nanoparticlesand films: solgel, hydrothermal, freeze drying, intercalation, attrition, ionimplantation, Gas phase condensation, Chemical vapour deposition,Nanosuspensionsferrofluids, Compaction of nanocrystlline materials, Carbonnanotubes, short and long term applications and perspectives, Demonstrationof some techniques in preparation and	INTRODUCTION TO NANOMATERIALS AND NANOTECHNOLOGY

			characterization of nanomaterials. **References/Text Books:**	
MS617A	3-0-0-0-9		**Course Contents:** Effects of confinement and finite sizezero, one and two dimensional nanostructures(concepts of surface and interfacial energies), Intermolecular andinterfacial forces in organic, polymeric, biological and aqueous systemsVan derWaals, electrostatic, double layer, acid base, depletion interactions, hydrophobicforce, layering, mesoscale thermodynamics, Gibbs treatment of interfaces,mesoscale fluid dynamics, thin soft films, mesoscale phenomena in soft matterand applications: adhesion, wetting, nucleation, Nanofabrication: patterning ofsoft materials by self organisation and other techniques, chemical self assembly,artificial multilayers, cluster fabrication, LangmuirBlodget growth, Nanolithography,Scanning probe lithography, Micro contact printing, Synthesis of nanoparticlesand films: solgel, hydrothermal, freeze drying, intercalation, attrition, ionimplantation, Gas phase condensation, Chemical vapour deposition,Nanosuspensionsferrofluids, Compaction of nanocrystlline materials, Carbonnanotubes, short and long term applications and perspectives, Demonstrationof some techniques in preparation and characterization of nanomaterials. **References/Text Books:**	INTRODUCTION TO NANOMATERIALS AND NANOTECHNOLOGY
MS698	----0		**Course Contents:** Graduate Seminar **References/Text Books:**	GRADUATE SEMINAR
MS698A	0-0-0-0-0		**Course Contents:** Graduate Seminar **References/Text Books:**	GRADUATE SEMINAR
MS699	----		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
MS799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
***** Department of MSE *****				
ESO205A	3-1-3-0-14		**Course Contents:** Examples of materials highlighting StructureProcessingPropertyperformancerelations. 14 space lattices, unit cells, cubic and HCP structures, Miller indices,Packing, interstitials, different ceramic structures; Noncrystalline/nanocrystallinematerialsdefinitions, concept of Tg, local order, different polymerstructures.LTPD[C]3131[5]LTPD[C]3101[4]26Structure determination using Xray diffraction (Braggs diffraction and structurefactor for cubic lattices); Point defects, edge and screw dislocationstheirnotation and concepts, energy of a dislocation, stacking fault, grains and grainboundaries, bulk defects;PHASE EVOLUTION: Definition of diffusivity, concept of activation energy,examples of diffusion process; Definition of a phase, phase rule, unary andbinary (eutectic, eutectic with terminal solid solutions) systems and examples,phase diagrams of important metal and ceramic systems, Nucleation and	NATURE AND PROPERTIES OF MATERIALS

			growth(homogeneous and heterogeneous), Introduction to TTT curves, examples ofvarious transformations; **References/Text Books:**	
MSE100	2-0-0-0-0		**Course Contents:** Historical aspects of various materials, including some landmarks; Naturalresources of materials; Cost, economics, energy, environmental and politicalissues relating to materials industry and applications; Importance of materialsand their properties, performance and manufacturing processes in the developmentand growth of automotive, aerospace and railway sectors, electrical, electronicand telecommunication equipment/systems, energy sector, military hardware,structural and general engineering applications, biomedical/implant materialsetc.; Demonstrations/film shows related to selected materials and theircharacterization, properties and processing. **References/Text Books:**	INTRODUCTION TO PROFESSION
MSE200	3-1-0-0-4		**Course Contents:** Heterogeneous and homogeneous systems, extensive and intensive properties,simple equilibrium; First Law of thermodynamics, constant volume and constantpressure processes; Spontaneous processes, entropy and quantification ofirrversibility, properties of heat engines, thermodynamic temperature scale,Second Law of thermodynamics, criterion for equilibrium, Entropy and disorder,most probable microstate, configurational entropy and thermal entropy; auxiliaryfunctions, Maxwells relations, GibbsHelmholtz equation; Third Law ofthermodynamics; variation of Gibbs energy with temperature and pressure,ClausiusClapeyron equation; thermodynamic properties of mixtures of ideal andimperfect gases; reactions in gas mixtures; reactions of pure condensed phaseswith gas mixtures standard Gibbs energy of reactions, Ellingham diagrams;Raoulfs and Henrys Law, activity of a component, GibbsDuhem equation, nonidealsolutions, regular solutions, quasichemical model of solution, activity andalternative standard states; reaction equilibrium in condensed system, Gibbsphase rule, binary systems involving compound formation, solubility of gasesin metals, formation of oxide phases of variable composition; relation betweenchemical and electrical driving forces, Nernst equation, concentration andformation cells, Pourbaix diagrams; thermodynamics of Point Defects. **References/Text Books:**	THERMODYNAMICS OF MATERIALS
MSE201A	3-1-0-0-11		**Course Contents:** I. .Introduction Introduction, Thermodynamics terminology2. First law First law of thermodynamics and its applications3. Second Law Second law of thermodynamics and itsconsequences, Combined statement of first andsecond laws4. Statistical Statistical interpretation of entropy, entropy andInterpretations disorder5. Thermodynamic Auxiliary functions: Helmholtz free energy,functions Gibbs free energy, Chemical potential,Maxwell's relations, GibbsHelmholtz equations.6. Third law Third law of thermodynamics7. Phase equiliblia in Phase equilibria in onecomponent systems:single component system variation of Gibbs free energy with temperatureand pressure, ClausiusClapeyron equation, PTdiagram8. Solutions Thermodynamics_ of solutions: Raoult's andHenry's Law, activity of a component, Regularsolutions, GibbsDuhem equation and itsapplication, nonideal solutions, Sievert's Law,activity and altemative standard states, dilutesolutions and interaction ___mtrameters.9. Reaction Equilibria Equilibrium constant, Reaction equilibria for (a)homogeneous reactions consisting of gasmixtures, (b) heterogeneous reactions consistingof condensed phases and gas mixtures,Ellingham Diagram.I0. Phase rules Phase rules and its applications, Lever Rulell. Electrochemical cells Them1odynamics of electrochemical cells:Relation between chemical and electrical drivingforces, Nemst equation, Concentration andformation cells, thennodynamics of aqueoussolutions.Fundamentals of Free energycomposition12. Free energy diagram for binary systems. Examples ofcomposition diagram common binary Free energycompositiondiagrams: Eutectic, Eutectoid, Peritectic etc.13. Phase diagrams Study of some common phase diagrams, such asFeC, CuZn, AlCu, Fe0Si02 and evolution ofequilibrium microstructure on cooling. **References/Text Books:**	THERMODYNAMICS & PHASE EQUILIBRIA

			I. Thermodynamics of Solids: Richard A. Swalin2. Introduction to Thermodynamics of Materials: David R. Gaskell3. Physical Chemistry of Metals: L.Darken and R.W.Gury4. Problems in Metallurgical Thermodynamics and Kinetics: G. S. Upadhyayaand R. K. Dube5. Phase Equilibria in Materials: S.P.Gupta6. Phase Transformation: Porter and Esterling.	
MSE202A	3-1-0-0-11		**Course Contents:** 1 Introduction to Fluid flow2. Introduction to heat transfer3. Introduction to mass transfer4. Mass transfer with Chemical reaction5. Introduction to Heterogeneous Reaction Kinetics6. Simultaneous Heat and Mass Transfer with Chemical reactions7. Introduction to Electrochemical Kinetics **References/Text Books:** 1. Engineering in Process Metallurgy: R. Guthrie, Oxford Scientific Publications 2. Transport Phenomena in Metallurgy: GH Geiger and DR Poirier; TMS publication 3. Kinetic and metallurgical processes: Fathi Habashi 4. Mass transport in solids and fluids: DS Wilkinson, Cambridge solid state science series.	RATE PROCESSES
MSE203A	3-0-0-0-9		**Course Contents:** 1. Introduction 2. Crystalline State 3. Noncrystalline state 4. Microstructures 5. Xray Diffraction 6.Electron diffraction 7.Optical microscopy 8.Scanning electron microscope 9.Transmission electron microscope 10.Surface analysis technique **References/Text Books:** 1. Elements of Xray diffraction, B.D. Cullity and S.R. Stocks, AddisonWeiley Publishing Co. 2. Introduction to solids, L.V. Azaroff, McGrawHill Book Company3. Elementary Crystallography by M.J. Buerger4. The structure of materials, S.M. Allen and E. L. Thomas, John Wiley and Sons, 19985. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 20066. Fundamentals of Materials Sciencethe microstructureproperty relationship using metals as model systems, E.J. Mittemeijer, Springer, 20107. Microstructural Characterization of Materials D. Brandon and W.D. Kaplan, John Wiley and Sons, 2008	STRUCTURE & CHARACTERIZATION OF MATERIALS
MSE204A	2-0-0-0-6		**Course Contents:** 1. Introduction to Biomaterials 2. Classification of biomaterials 3. StructureProperty correlation 4. Processing and properties of biocompatible materials 5.Surface engineering & casestudies **References/Text Books:** * Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoen and Lemons, Second Edition: Elsevier Academic Press, 2004. * Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981.	INTRODUCTION OF BIOMATERIALS
MSE210	3-1-0-0-4		**Course Contents:** Thermodynamics vs. kinetics, homogeneous and heterogeneous reactions;Chemical Reaction Controlrate equation, reaction rate constant, reaction order,nonelementary reactions; Solid State Diffusion Ficks Law, mechanism ofdiffusion, uphill diffusion, Kirkendall effect, steady and transient diffusion;External Mass Transfer fluid flow and its relevance to mass transfer, generalLTPD[C]3100[4]LTPD[C]3100[4]LTPD[C]2000[0]278mass transport equation, concept of mass transfer coefficient, models of masstransfer film theory and Higbies penetration theory; Internal Mass TransferOrdinary and Knudsen diffusion, Mass transfer with reaction; Adsorption physicaladsorption vs. chemisorption, adsorption isotherms; Langmuir, BET, adsorptionas the rate limiting step; gasification of C by CO2, dissolution of N2 in moltensteel, porous solids, specific surface area and pore size distribution; ReactorDesign batch vs. continuous reactors, ideal stirred tank and plug flow reactors,mass balance in ideal reactors, residence time distribution; models of industrialreactors; Electrochemical Kineticsconcept of polarization, activation over potential,ButlerVolmer and Tafels equation, applications in electrodeposition and corrosion,concentration overpotential, limiting current; electrowinning and corrosion. **References/Text Books:**	METALLURGICAL KINETICS

MSE250	3-0-3-0-5		**Course Contents:** Chemical bonding, fundamentals of crystallography, reciprocal lattice, structuresin metals, inorganic compounds, polymers, silicates and glasses, stereographicprojections; Production, characterization, and interaction of Xrays with matter,Braggs Law and Laues equations, Ewalds construction, diffraction techniquesand applications; Optical principles of microscopy resolution, magnification,depth of focus; electron diffraction, imaging (various contrasts), determinationof crystal structure, burgers vector, electron beamspecimen interactions andother applications of Transmission Electron Microscopy; Applications of ScanningElectron Microscopy and, Electron Probe Micro Analyser; Principles of QuantitativeMicroscopy: volume density, surface density, length density, numerical density,particle and grain size; Overview of other characterization techniques such asAuger electron spectroscopy, Scanning Tunneling Microscopy, Atomic ForceMicroscopy. **References/Text Books:**	MATERIALS CHARACTERIZATION
MSE300A	0-0-0-2-2		**Course Contents:** * Importance of professional/technical communication: * Domains: Thesis/Report writing, Paper writing, Business letters, job letters, rsum, etc. * Plagiarism: Importance, what is it and how to keep a check * Projects/Assignments: Oral talks, Group discussions, Preparing report, Presentation skills, and time management (on selecting contents, highlighting novelty, using visual aids and providing illustrations) **References/Text Books:**	PROFESSIONAL & TECHNICAL COMMUNICATION
MSE301A	2-0-0-0-6		**Course Contents:** 1. Introduction 2. Gibbs free energy change calculations 3. Interfaces 4. Nucleation 5. Growth 6. Transformation kinetics 7. Precipitation 8. Recrystallisation and grain growth 9. Martensitic Transformation 10. Isothermal and continuous cooling transformations 11. Spinodal decomposition 12. Solidification **References/Text Books:** 1.Phase Transformations in Materials by R. C. Sharma, CBS Publishers, New Delhi 2. Solid State Transformations by V. Raghavan, PrenticeHall of India, New Delhi	PHASE TRANSFORMATIONS
MSE302A	3-0-0-0-9		**Course Contents:** 1. Elasticity 2. Plasticity 3. Dislocations 4. Applications **References/Text Books:** Suggested text books:1. Mechanical Behaviour of Materials, M.A. Meyers and K.K. Chawla2. Introduction to Dislocations, Hull and BaconReference Material:3. Mechanical Metallurgy, G.E. Dieter4. Mechanical Behavior of Materials, Courtney5. Theory of Elasticity, Timoshenko6. An Introduction to Mechanics of Solids, S.H. Crandall and N.C. Dahl7. Deformation and Fracture Mechanics, R.W. Hertzberg8. Mechanical Testing, Metals Handbook9. Recrystallization and Related Annealing Phenomena, F.J. Humphreys	MECHANICAL BEHAVIOUR OF MATERIALS
MSE303A	3-0-0-0-9		**Course Contents:** 1.Introduction to electronic structure 2. Electronic structure in crystalline materials 3. Electron Dynamics 4.Semiconductors 5. Ionic conductors 6. Dielectric materials 7. Magnetic materials 8. Optical materials **References/Text Books:** 1. Electronic Properties of Materials: An Introduction for Engineers, Rolf E. Hummel, Springer Verlag, 19852. Physical Properties of Semiconductors, Charles M. Wolfe, Nick Holonyak and Gregory E. Stillman, Prentice Hall, 19893. Solid State Physics, Neil W. Ashcroft and N. David Mermin, Sauders College, Philadelphia, USA, 19764. Advanced Theory of Semiconductor Devices, Karl Hess, Prentice Hall, 19885. Advanced Semiconductor Fundamentals, Robert F. Pierret as part of Modular Series on Solid State Devices Vol. 6, Addison Wesley, 19896. Introduction to Solid State Physics, Charles Kittel, John Wiley & Sons 19917. Electrical Properties of Materials, L. Solymar and D. Walsh, Oxford University press, 1998.8. Physics	ELECTRONIC & MAGNETIC PROPERTIES OF MATERIALS

			of Solids, C. A. Wert and R.M. Thomson, McGrawHill Book Company, 1970 or later9. Physics of Semiconductor Devices by JP Colinge and C. A. Colinge, Kluwer Academic Pub. 200210. Electronic Properties of Materials by R. E. Hummel, Springer, 2011	
MSE304A	2-0-0-0-6		**Course Contents:** 1. Thermodynamics and Kinetics in metals extraction and refining 2. Principles of Mineral Beneficiation 3. Principles of Pyrometallurgy 4. Principles of Electrometallurgy 5. Principles of Hydrometallurgy 6. General issues related to metal extraction 7. Refining of Metals **References/Text Books:** 1. DR Gaskel: An Introduction to Metallurgical Thermodynamics, McMillan Publishing Co., 1992 2. Barry Willis: Mineral Processing Technology, Elsevier 3. T.A.Engh: Principles of metal refining, Oxford Scientific Publications;1992 4. JJ More: Chemical Metallurgy, Butterworth, 1990 5. Terkel Rosenqvist: Principles of Extractive Metallurgy, 2nd Edition, Tapiar Academic Press	PRINCIPLES OF METAL EXTRACTION & REFINING
MSE305A	2-0-0-0-6		**Course Contents:** 1. Solidification Processing 2. Mechanical Working 3. Metal and Ceramic Powder Processing 4. ThinFilm and Coating Techniques **References/Text Books:** 1. R.W. Heine, C.R. Loper, and P.C. Rosenthal, Principles of Metal Casting, 2nd ed., 1967.2. A. Upadhyaya, G.S. Upadhyaya: Powder Metallurgy Science, Technology and Materials (2011)3. Donald Leonard Smith "Thinfilm deposition: principles and practice", McGraw Hill4. J.N. Harris, Mechanical Working of Metals Theory & Practice, Pergamon Press, Exeter, UK, 1983.	MATERIALS PROCESSING
MSE310	3-1-0-0-5		**Course Contents:** Stress tensor and stress transformation equations, Principal stresses; Straintensor and strain transformation equations; Isotropic and anisotropic elasticity,elastic strain energy; Yield criteria and constitutive relationships; Work hardening,plastic instability and its significance; Crystallographic aspects of plasticdeformation; Dislocation theory edge, screw and mixed dislocations, resistanceto dislocation motion and elastic properties of dislocations, dislocation interactions,multiplication and dissociation; Strengthening mechanisms; Creep characteristicsof creep curve and steadystate creep, mechanisms and creep mechanism maps,creep under complex stressstates, prediction of long time properties; Fracturetoughness and fatigue Griffiths crack theory, energy release rate analysis,modes of loading, stress analysis of cracks, fracture toughness, Low and Highcyclefatigue, Fatigue crack initiation and propagation, structural aspects offatigue, fatigue under complex stressstates, environmental assisted crackingand fatigue; Some case studies related to design. **References/Text Books:**	MECHANICAL BEHAVIOUR OF MATERIALS
MSE311A	0-0-3-0-3		**Course Contents:** 1 Metallographic specimen preparation 2 Optical microscopy of illustrative Ferrous samples 3 Optical microscopy of NonFerrous samples 4 Optical microscopy of Ceramic samples: Colour metallography and phase contrast microscopy of nonmetallic materials 5 Quantitative metallography and image analysis 6 Xray powder diffraction in materials analysis 7 Study of nucleation and growth in eutectoid steel 8 Carburization of Steel and Hardenability of steel 9 Recovery and Recrystallisation 10 Thermal analysis using DSC to study phase transformations 11 Bubble raft experiments 12 Stereographic projections **References/Text Books:**	PHYSICAL METALLURGY LABORATORY
MSE312A	0-0-3-0-3		**Course Contents:** 1Ionic conductivity Conductivity measurement as a function of temperature for different samples2Dielectric and ferroelectric/piezoelectric materials Measurement of dielectric constant Hysteresis loop3Optical behavior	FUNCTIONAL MATERIALS LABORATORY

			of Liquid Crystals Measure response to applied field Measure the transmittance Measure threshold voltage4Fabrication of organic light emitting diodes Partial fabrication of organic polymer light emitting diodes Characterization of an OLED5Magnetic materials Magnetoresistance MH curves6Semiconductor characterization Semiconductors resistivity Hall measurement Bandgap measurement7&8Solar cell fabrication and characterization Fabrication of organic photovoltaic cells (PV) cells Characterization of solar cells9Processing of biomaterials Fabricate biomaterials using(i) compression molding (for entire component), and(ii) electrostatic spraying (for coatings)10Tribology of biocoatings Tribology of two samples: (i) polymer with modifier (ii) polymer without modifier for comparison purpose. Comparison with metallic substrates (demo).11Biomimetics/ Surface modification22Effect of surface energy on wetting of surfaces Samples prepared by the students measuring the contact angle. Role of surface roughness/ chemistry on affecting the wettability of surface.12Effect of surface modification on Bacteria/ Cell growth Effect of surface modification/functionalization characterized by comparing cell growth/proliferation on treated versus pristine surfaces. One or more of the following will be performed by students to learn cell response:(i) Role of surface chemistry (hydrophobic/ hydrophilic and hydrophobic/ hydrophilic + modifier)(ii) Role of surface roughness **References/Text Books:**	
MSE313A	0-0-3-0-3		**Course Contents:** 1.Determination of tensile properties of different classes of materials 2.Principles of Hardness Testing: comparison of different hardness measurement techniques 3.Impact Testing of Materials: Charpy Impact Test 4.Creep Testing of Materials 5.Fatigue Testing 6.Strain Ageing and Yield Point Phenomenon 7.Observation of dislocations by using the etch pitting technique 8.Effect of WorkHardening on Tensile Properties of Metals. 9.Plastic Anisotropy 10Project **References/Text Books:**	MECHANICAL BEHAVIOUR LABORATORY
MSE314A	0-0-3-0-3		**Course Contents:** 1Measurement techniques 2Laminar fluid flow 3Macroscopic energy balance (Bernoulli"s equation) 4Steady and unsteady conduction heat transfer 5Convective heat transfer 6Radiation heat transfer 7Mass transfer 8Thermodynamics 9Kinetics 10Mineral processing 11Hydrometallurgy I 12Hydrometallurgy II 13Process metallurgy I 14Process metallurgy II 15Electrochemistry **References/Text Books:**	PROCESS ENGINEERING LABORATORY
MSE315A	0-0-3-0-3		**Course Contents:** 1Deformation Behavior of Metals during Rolling and study of the associated microstructural changes2Fluidity Measurement during Casting3Permanent mold casting and casting defect evaluation4Effect of MMAW and MIG Welding on the Microstructure and HAZ in Steels5TIG and OAW Welding of Aluminium Alloys6To Study Various Characteristics of Metal Powders and Evaluate the effect of particle size and shape on the green density, apparent density and green strength of coldcompacted powders7Conventional and Microwave Sintering of Particulate Compacts8PM Design of Engineering Components (CDBased Design Expt)9Structural NanoMaterials through ECAP10Spray Forming of Alloys and MMCs11MicroExtrusion of Alloys12Injection molding of thermoplastic polymers (e.g. PE, PP)133Dimensional Printing (3DP) of designed structures14Thin film deposition using evaporation technique **References/Text Books:**	MANUFACTURING PROCESSES LABORATORY
MSE320	3-1-0-0-4		**Course Contents:** History and importance of metal extraction; Introduction of mineral dressing:Communition, Tabling, Jigging and flotation; Metallurgical fuels and the energyscenario; Pyrometallurgical operations roasting, agglomeration, smelting, refiningand secondary refining; Principles of Hydro Metallurgy; Principles of ElectroMetallurgy Aqueous solution and fused salts; Flow sheet design of importantnon ferrous metals based	PRINCIPLES OF METAL EXTRACTION AND REFINING

			on materials and heat balance. **References/Text Books:**	
MSE330	3-1-0-0-5		**Course Contents:** Phase rule, lever rule and Free energy of phase mixtures; Binary isomorphoussystems Equilibrium solidification, nonequilibrium solidification, dendriticgrowth, coring, CuNi alloys and Zone refining; Binary Eutectic and PeritecticSystems solidification of eutectic, hypoeutectic, and hypereutectic alloys;solidification of peritectic, hypoperitectic, and hyperperitectic alloys;morphologies of eutectic systems, Binary Monotectic and Syntectic Systems;Stability of regular solution and miscibility gas, intrinsic stability of solutionand spinodal; HumeRothery rules and intermediate phases e.g., laves, sigma,electron compounds; Binary eutectoid, peritectoid, metatectic and monotecticsystems; Ironcarbon phase diagram and microstructures of plain carbon steeland cast iron: nonequilibrium structures; Binary ceramics systems: SiO2AbOa,NiOMnO, etc.; Ternary phase diagrams Gibbs triangle, isothermal and verticalsections, polythermal projections, twophase equilibrium, concept of tie lines,rules for construction of tie lines, three phase equilibrium, concept of tietriangle,four phase equilibria; Multicomponent alloy systems: Stainless steels,highspeed steels, Hadfield steels, superalloys, light metal alloys, refractorysystems, (AbOaSiO2MgO) , sialanes. **References/Text Books:**	PHASE EQUILIBRIA IN MATERIALS
MSE331	0-0-3-0-2		**Course Contents:** Laboratory techniques of temperature and flow rate measurement and calibration:Experiments on Mineral Engineering, Metallurgical Thermodynamics and Kinetics,Fuels and Furnaces, Iron making, steelmaking, pyro, hydro, electrometallurgyin extraction of nonferrous metals and metallurgical analysis. **References/Text Books:**	PROCESS METALLURGY LAB.
MSE340	3-0-0-0-4		**Course Contents:** Thermodynamic order of transformations; Theory of nucleation Kinetics ofhomogeneous, transient and heterogeneous nucleation; Theory of ThermallyActivated Growth: Interface controlled growth, Diffusion controlled growth,Interface instability and Widmanstatten growth, Eutectoid growth, Discontinuousprecipitation, Massive transformation; Transformation Kinetics JohnsonMehlequation, Avrami model, Transformation kinetics in diffusioncontrolledtransformations, Isothermal and continuous cooling transformation diagrams;Precipitation and Particle Coarsening; Kinetics of recrystallization, Theory ofgrain growth, Effect of second phase particles; Martensitic transformation Nature of martensitic transformations, Bain distortion, Nucleation, and growthof martensite, Athermal, isothermal and burst transformations, Thermoeleasticmartensitie; Spinodal Decomposition Diffusion equation in spinodal region,Effect of gradient energy and elastic strain energy; Solidification Nature andgrowth of solidliquid interfaces, Rapid solidification, Glass transition, metallicglasses; Heat Treatment IT and CCT Diagrams in steels, quench hardening andtempering of martensite, hardenability of steels, surface hardening processes,tool steels and their heat treatments, heat treatment of cast irons, heattreatment of Nibase superalloys and Ti alloys, Thermomechanical treatments. **References/Text Books:**	PHASE TRANSFORMATIONS IN MATERIALS
MSE349A	0-0-2-0-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UNDER GRADUATE PROJECT I
MSE350	3-1-0-0-4		**Course Contents:** Refractories for iron and steel; Design and profile of an iron blast furnace andits auxiliaries; Performance evaluation of bast furnace Iron ore reduction, fuelrate calculations, BF aerodynamics and hot metal quality	IRON & STEEL MAKING

			control; Energy andmaterials balance calculations in steelmaking processes; Physical chemistry ofsteelmaking and secondary steelmaking deoxidation, ladle and tundish metallurgy,ingot and continuous casting of steel; Emerging trends in iron and steelmaking. **References/Text Books:**	
MSE370	3-0-0-0-4		**Course Contents:** Overview of various processing methods for materials; microstructural evolutionduring solidification and effect of cooling rate on cast microstructures, microandmacrosegregation in alloys, directional solidification, rapid solidification;Elements of casting mold design solidification shrinkage and its role in riserdesign, fluid flow fundamentals and metal fluidity, elements of mold design;Fundamentals of deformation processing State of stress during various metalworking operations, friction and its role in bulk metal forming operations,microstructural evolution during deformation processing, workability of metals,superplastic forming; Metal flow and aspects of design during bulk formingoperations, elementary load calculations during various bulkmetal workingoperations; Sheet metal forming State of stress during sheet metal formingprocesses, forming limit diagram, ehancement of sheet metal formability;Fundamentals of powder processing Basics of metal and ceramic powderproductions and characterization, design aspects during powder consolidation;solid and liquid state sintering, driving force and mechanism of si ntering ,selection of sintering atmosphere for different systems, characterization ofsintered products, full density processing. **References/Text Books:**	FUNDAMENTALS OF MATERIALS PROCESSING
MSE390	0-0-0-0-0		**Course Contents:** Visit to industries in and around Kanpur or elsewhere primarily of interest toMaterials and Metallurgical Engineering. **References/Text Books:**	INDUSTRIAL TOUR
MSE398A	0-0-0-0-9		**Course Contents:** UP PROJECT (UGPII) **References/Text Books:**	UNDER GRADUATE PROJECT II
MSE410	3-0-0-0-4		**Course Contents:** DC conductivity of metals, Hall effect and magnetoresistance, AC conductivityof metals, thermal conductivity and specific heat of metals, Thermopower ofmetals; Review of quantum mechanics and free electron theory, failures of freeelectron theory and introduction to the role of lattice; Review of reciprocal lattice,Brilouin zone, Free electron band diagrams, potential in a crystal, electrondynamics and concept of holes, conductivity in relation to band structure, bandstructures of metals and semiconductors; empirical estimates of conductivityin metals and alloys; Semiconductors band diagrams, direct and indirect bandgap, applications of semiconductors; Degenerate and non degeneratesemiconductors, intrinsic and extrinsic semiconductors, determination of dopantlevels and mobility measurements; Ionic conduction review of defect equilibriumand diffusion mechanisms, theory of ionic conduction, conduction in glasses,effect of stoichiometric and extrinsic defects on conduction, applications insensors and batteries; Dielectric Materials Dielectric constant and polarization,linear dielectric materials, capacitors and insulators, polarization mechanisms,nonlinear dielectrics pyro, piezo and ferroelectric properties, hysterisis andferroelectric domains and applications; Optical Materials electronholerecombination, solidstate LEDs, lasers and IR detectors, band gap engineering;Light interaction with materials transparency, translucency and opacity, refractionand refractive index, reflection, absorption and transmission; Magnetic field,flux density, susceptibility and permeability; Orbital and spin, permanentmagnetic moment of atoms, diamagnetism, paramagnetism and Pauliparamagnetism,ferro, antiferro and ferri magnetism, Fe, Co and Ni and alloyadditions, ferrites, magnetic hysterisis, soft and hard magnet materials.	ELECTRONIC & MAGNETIC PROPERTIES OF MATERIALS

			References/Text Books:	
MSE415	0-0-3-0-2		**Course Contents:** Laboratory techniques for studying phase transformations in materials,recrystallization and grain growth, eutectoid transformations in steels,hardenability, tempering of martensite; resistivity of metals, conductivity ofsemiconductors, conduction in ionic solids, dielectric measurements in BaTiO3,reflection, absorption and transmission measurement on various metals. **References/Text Books:**	PHYSICAL METALLURGY LAB
MSE425	3-0-0--4		**Course Contents:** Identification of process flow sheet: Preliminary estimate of resources andfacilities: Materials and energy balance, detailed plant flow sheet: Equipmentselection and specification, economic selection and specification: environmentalimpact analysis: Report presentation, case studies of typical metallurgical plantoperation. **References/Text Books:**	PROCESS PLANT DESIGN FOR METT. ENGG. OPERATIONS
MSE425A	3-0-0-0-9		**Course Contents:** Identification of process flow sheet: Preliminary estimate of resources and facilities: Materials and energy balance, detailed plant flow sheet: Equipment selection and specification, economic selection and specification: Environmental impact analysis: Report presentation, case studies of typical metallurgical plant operation. **References/Text Books:**	PROCESS PLANT DESIGN FOR METT. ENGG. OPERATIONS
MSE449A	0-0-0-0-9		**Course Contents:** UG PROJECT (UGPIV) **References/Text Books:**	UNDER GRADUATE PROJECT IV
MSE467	3-0-0--4		**Course Contents:** Semiconductor fundamentals, band structure, indirect and direct band gap,optical properties, carrier statistics, semiconductor material purification andcrystal growth, epitaxy, CVD and MBE, PN Junction, Schottky and MaS devicestructures, specific material requirements, Doping by implantation and diffusion,dielectric and insulators, ohmic and barrier contacts, band edge behaviour,empirical rule, alloy design. **References/Text Books:**	MATERIALS FOR SEMICONDUCTOR INDUSTRY
MSE467A	3-0-0--9		**Course Contents:** Semiconductor fundamentals, band structure, indirect and direct band gap,optical properties, carrier statistics, semiconductor material purification andcrystal growth, epitaxy, CVD and MBE, PN Junction, Schottky and MaS devicestructures, specific material requirements, Doping by implantation and diffusion,dielectric and insulators, ohmic and barrier contacts, band edge behaviour,empirical rule, alloy design. **References/Text Books:**	MATERIALS FOR SEMICONDUCTOR INDUSTRY
MSE480	2-0-0-0-2		**Course Contents:** Types of processes leading to degradation of materials, viz Oxidation Corrosion,Wear, Creep and fatigue review of basics of thermodynamics and kinetics relatedto oxidation and corrosion studies, Pourbaix diagram, Polarization, Mixedpotential theory, Passivity Characteristics of passivation ; Various types ofdegradation : atmospheric galvanic, intergranular, dealloying, crevice and pittingcorrosion, microbiological, stress corrosion cracking, hydrogen damage, radiationdamagte; Oxidation and hot corrosion of materials at high temperatures ; Wearof materials, analytical models of wear; Prevention of meaterials degradation alloying,	MATERIALS DEGRADATION & ITS PREVENTION

			environment conditioning design modification cathodic and anodicprotection, metallic coating inorganic coating organic coating, inhibitors andpassivators wear resistant materials structural modifications, wear resistantcoatings. **References/Text Books:**	
MSE497A	3-0-0-0-9		**Course Contents:** UG PROJECT (UGPIII) **References/Text Books:**	UNDER GRADUATE PROJECT III
MSE498	0-0-4-0-2		**Course Contents:** PROJECT I **References/Text Books:**	PROJECT I
MSE499	0-0-10-0-5		**Course Contents:** PROJECT II **References/Text Books:**	PROJECT II
MSE603	3-0-0-0-4		**Course Contents:** Introduction to nonequilibrium proccsing Thermodynamics and kinetics ofmetastable phase formation ; Rapid solidification : Undercooling. Phase diagrammetastable states, Methods of rapid solidification, Mienrostruclure formationby rapid solidification, Application for rapid solidification ; Mechanical alloying:Process of mechanical alloying, Mechanism of alloying Energy criteria formechanical alloying, Synthesis of nonequilibrium phases, Application of mechanicalalloying, Metallic glass : Understanding of glass formation, thermal stability andglass forming ability, structure of metallic glass, crystallization behavior,properties of metallic glass, application, Special nonequilibrium processing andphase transformations **References/Text Books:**	NON EQUILIBRIUM PROCESSING OF MATERIALS
MSE604	3-0-0-0-4		**Course Contents:** 1. Introduction Introduction to device processing steps 4 Examples of various devices (with emphasis on solar cellsand MOSFETs) Need for miniaturizationThin Film Deposition2. Basics of thin film Brief review of kinetic theorygrowth Adsorption and desorption3 Film growth: nucletion and growth kinetics Epitaxy Thin film growth control3. PVD Processes Evaporation (Thermal and ebeam)5 Principles of glow discharge and various sputteringprocesses4. Chemical Growth Fundamentals of CVD growthProcesses 4 Modern variants: MOCVD, PECVD and ALD Spin Coating5. Basic Thin Film Thickness measurementCharacterization Phase analysis 1 Optical analysis Morphology analysisDevice Fabrication6. Substrate seiection Selection of substratesand preparation , Single crystal growth (Silicon)3 Role of substrate surface and contaminants Physical and chemical methods of substrate surfacepreparation7. Pattern fabrication Concepts of lithography Photoresists (Negative, Positive etc) Exposure Development 5 Masking Variants of lithography with emphasis on Photo and ebeam Precautionary steps8. Material Removal Wet (Chemical) and dry (Plasma, RIE etc.) etching 59. Jon implantation, Doping and ion ImplantationDoping, oxidation 6 Diffusion control of composition in devicesand heat treatment Oxidation and heat treatment10. Metallization and Adhesion and morphology issuesInterconnects Introduction to electromigration visavis metallization: 2Impact on device performance and methods of prevention11. Process Integration Example of process integration for a particular kind offor a particular case device e.g. Si Solar Cell, MOSFET, 111V solar cell devices 4(take the case of adevice) **References/Text Books:**	SCIENCE AND TECHNOLOGY OF THIN FILMS AND DEVICE FABRICATION

			VLSI Fabrication: S.K. Gandhi Si Processing (Volume I and II) Lou and Mayer Introduction to Microfabrication by Sami Fransilla (Wiley) Fundamentals ofMicrofabrication: The Science of Miniaturization by Marc Madou (CRC Press) Thin film deposition by Donald Smith (Me Graw Hill) Materials science of thin films by Milton Ohring (Academic Press) Pulsed Laser deposition of thin films by Chrisey and Hubler (Wiley Interscience)	
MSE604A	3-0-0-0-9		**Course Contents:** 1. Introduction Introduction to device processing steps 4 Examples of various devices (with emphasis on solar cellsand MOSFETs) Need for miniaturizationThin Film Deposition2. Basics of thin film Brief review of kinetic theorygrowth Adsorption and desorption3 Film growth: nucletion and growth kinetics Epitaxy Thin film growth control3. PVD Processes Evaporation (Thermal and ebeam)5 Principles of glow discharge and various sputteringprocesses4. Chemical Growth Fundamentals of CVD growthProcesses 4 Modern variants: MOCVD, PECVD and ALD Spin Coating5. Basic Thin Film Thickness measurementCharacterization Phase analysis 1 Optical analysis Morphology analysisDevice Fabrication6. Substrate seiection Selection of substratesand preparation , Single crystal growth (Silicon)3 Role of substrate surface and contaminants Physical and chemical methods of substrate surfacepreparation7. Pattern fabrication Concepts of lithography Photoresists (Negative, Positive etc) Exposure Development 5 Masking Variants of lithography with emphasis on Photo and ebeam Precautionary steps8. Material Removal Wet (Chemical) and dry (Plasma, RIE etc.) etching 59. Jon implantation, Doping and ion ImplantationDoping, oxidation 6 Diffusion control of composition in devicesand heat treatment Oxidation and heat treatment10. Metallization and Adhesion and morphology issuesInterconnects Introduction to electromigration visavis metallization: 2Impact on device performance and methods of prevention11. Process Integration Example of process integration for a particular kind offor a particular case device e.g. Si Solar Cell, MOSFET, 111V solar cell devices 4(take the case of adevice) **References/Text Books:** VLSI Fabrication: S.K. Gandhi Si Processing (Volume I and II) Lou and Mayer Introduction to Microfabrication by Sami Fransilla (Wiley) Fundamentals ofMicrofabrication: The Science of Miniaturization by Marc Madou (CRC Press) Thin film deposition by Donald Smith (Me Graw Hill) Materials science of thin films by Milton Ohring (Academic Press) Pulsed Laser deposition of thin films by Chrisey and Hubler (Wiley Interscience)	SCIENCE AND TECHNOLOGY OF THIN FILMS AND DEVICE FABRICATION
MSE605	3-0-0-0-4		**Course Contents:** Surface Chemistry/Interaction (surface charge, dipoles, energies, interfacial chemical reactions), Surface Phonons/Plasmons (Quantisation of plasma, light and, sound, Brillioun Zones), Elastic/Inelastic scattering, Electromagnetic scattering (Compton, Rayleigh, Rutherford, Thomson), Crystal structure and Reciprocal Lattice, Brillouim Zone, Surface Diffusion (Fick's law, intergraular/amorphous layer formation), Surface Energy/Young's Equation (Capillary/surface tension in fluids), Surface Sensitive Properties : Pussivation/Adsorption (Forces/Chemical bonds on surface), Interfacial wetting (formationof interfaces, contact angle in wetting surfaces), Density functional theory of atomic equilibrium, Case Studies: FeB49system, and Al2O3carbon nanotube, Surface Modification/UnctionalizationNanostructures: Self Assembly (adding molecules to surface), Distribution of phase : Voronoi and Dirichlet Tessellation, Molecular Sieves (Molecular filters : purification of gases/chemicals etc). **References/Text Books:** I. Materials Science and Tedmology. Ed. R.W. Kahn, P. Hassen, E.J. Kramer, Vol. 2n/2b, Wiley YCII (2005).2. Physics of Atoms and Molecules. B.H. Bransden, and C.J. Joachain, Longman (1996).3. Surface Analysis Methods in Materials Science, D. J. O'Connors, B.A. Sexlon, and R. St. C. Smart, Springer (2003).4. The Physics and Chemistry of Materials, J. I. (Gersten, F. W. Smith. Wiley (2001).5. Elementary Solid State Physics. M. A, Omar, AddisonWesley {2001).6. Course materials wlll be supplemened with hundouts, and journal publications.	SURFACE PHENOMENA AND CHARACTERIZATION
MSE605A	3-0-0-0-9		**Course Contents:**	SURFACE PHENOMENA

			Surface Chemistry/Interaction (surface charge, dipoles, energies, interfacial chemical reactions), Surface Phonons/Plasmons (Quantisation of plasma, light and, sound, Brillioun Zones), Elastic/Inelastic scattering, Electromagnetic scattering (Compton, Rayleigh, Rutherford, Thomson), Crystal structure and Reciprocal Lattice, Brillouim Zone, Surface Diffusion (Fick's law, intergraular/amorphous layer formation), Surface Energy/Young's Equation (Capillary/surface tension in fluids), Surface Sensitive Properties : Pussivation/Adsorption (Forces/Chemical bonds on surface), Interfacial wetting (formationof interfaces, contact angle in wetting surfaces), Density functional theory of atomic equilibrium, Case Studies: FeB49system, and Al2O3carbon nanotube, Surface Modification/UnctionalizationNanostructures: Self Assembly (adding molecules to surface), Distribution of phase : Voronoi and Dirichlet Tessellation, Molecular Sieves (Molecular filters : purification of gases/chemicals etc). **References/Text Books:** I. Materials Science and Tedmology. Ed. R.W. Kahn, P. Hassen, E.J. Kramer, Vol. 2n/2b, Wiley YCII (2005).2. Physics of Atoms and Molecules. B.H. Bransden, and C.J. Joachain, Longman (1996).3. Surface Analysis Methods in Materials Science, D. J. O'Connors, B.A. Sexlon, and R. St. C. Smart, Springer (2003).4. The Physics and Chemistry of Materials, J. I. (Gersten, F. W. Smith. Wiley (2001).5. Elementary Solid State Physics. M. A, Omar, AddisonWesley {2001).6. Course materials wlll be supplememed with hundouts, and journal publications.	AND CHARACTERIZATION
MSE607	3-1-0--5		**Course Contents:** Fortran fundamentals: Applications of regression analysis and curve fittingtechniques, computer calculations of phase diagrams: Numerical of partialdifferential equations pertinent to heat, mass and momentum transfer: Computerapplications in solidification, potential energy diagrams and experiment inmetallurgy. **References/Text Books:**	COMPUTING APPLICATIONS IN METALLURGY
MSE611A	3-0-0-0-9		**Course Contents:** Introduction to Corrosion and Oxidation; Review of basics of Thermodynamics and Kineticsrelated to corrosion and oxidation; Pourbaix diagram and its relation to aqueous corrosion; Basic electrochemistry related to corrosion and advanced theory of electrochemical kinetics and corrosion; Polarization; Mixed potential theory; Passivity; Various types of corrosion: Galvanic,Intergranular, Crevice, Pitting, Dealloying, Erosion corrosion, Stress corrosion and hydrogen embrittlement; Corrosion protection mechanism and methods; Oxidation and hot corrosion at high temperatures; Interaction between metals and different gases and Ellingham diagram; Wagner laws of oxidation; Oxide structure and oxidation; Oxidation protection mechanisms and methods; Coatings: Different types of Coatings, Coating methods and characteristics of Coating. **References/Text Books:** 1.Corrosion: L.L. Shreir, NewnesButterworths (London), 1976.2.Corrosion and Corrosion Control: HH Uhlig and W. Revie, Wiley, New York, 2007.30Corrosion Science and Technology. David Talbot, James Talbot, CRC Press, 1998.4.Corrosion Engineering By Mars. G. Fontana, Third ed. , TMH5.Environmental Degradation of Metals: UK Chatterjee, SK Bose and SK Roy, MarcelDekker, 2001.6.Oxidation of Metals and Alloys: 0. Kubaschewski and B.E. Hopkins, Butterworths(London) 1967.7.High Temperature Oxidation of Metals: P. Kofstad, John Wiley & Sons, Inc, 1966.8.Materials Degradation and Its Control by Surface Engineering: A. W. Batchelor, L.N.Lam and M Chandrasekharan, Imperial College Press, 2002	CORROSION AND OXIDATION OF METALS AND ALLOYS
MSE613	3-0-0--4		**Course Contents:** Thermodynamic of electrolyte, electrochemical potential, conduction of ions insolution, overpotential, absorption, phase formation: Economics of an electrolyticprocess, principles of cell design, Electrochemical technology: Elactowinning, electrorefining and metal electroforming, electrochemical machining, electroplating,anodizing, pickling, electrophoretic painting, electrochemical treatment of minerals,batteries and fuel cells, water treatment and environmental protection.	ELECTROCHEMICAL TECHNOLOGY IN MATERIALS PROCESSING

			References/Text Books:	
MSE613A	3-0-0-0-9		**Course Contents:** Thermodynamic of electrolyte, electrochemical potential, conduction of ions insolution, overpotential, absorption, phase formation: Economics of an electrolyticprocess, principles of cell design, Electrochemical technology: Elactowinning, electrorefining and metal electroforming, electrochemical machining, electroplating,anodizing, pickling, electrophoretic painting, electrochemical treatment of minerals,batteries and fuel cells, water treatment and environmental protection. **References/Text Books:**	ELECTROCHEMICAL TECHNOLOGY IN MATERIALS PROCESSING
MSE615	3-0-0-0-4		**Course Contents:** Basic crystallo2raphy and crystal structures (8 Lectures hour)Periodic patterns, Lattices, Motif, Unit cells, Crystal structure, Primitive and Non primitive cells 1, Symmetry elements and point group notations 1, Crystal systems and Bravais lattices 1, Crystallographic directions and planes, Miller indices and Weiss zone law 1, Streographic projections 1, Bonding in materials and atomic packing in metals, coordination number concepts 1, Covalent bonding, glasses and polymers 2,Crystal defects and their significance (12 Lectures hours)Point defects and their role in materials Processing, performance and failure 1, Ionically bonded structures: Pauling's rules and some examples 2, Point defects: thermodynamics, schottkey and Frenkel defect, KrogerVink notation, defect interactions 2, Dislocations, burgers vector, types of dislocations 1, Dislocation movement, slip systems, energetics of dislocations and their interactions 2, Planar defects: stacking faults, grain boundaries (low angle and high angle), antiphase 2 **References/Text Books:** 1. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 20062. Materials Science and Engineering W.D. Callister, Jr. Wiley India(P) Ltd., 20073. Materials Science and Engineering, G.S. Upadhyaya and Anish Upadhyaya, Viva books, 20104. Fundamentals of Materials Sciencethe microstructureproperty relationship using metals as model systems, E.J. Mittemeijer, Springer, 20105. Microstructural Characterization of Materials D. Brandon and W.D. Kaplan, John Wiley and Sons, 20086. Science of Microscopy, P.W. Hawkes and J.C.H. Spence, Springer, 20077. Scanning Electron Microscopy & XRay Microanalysis, J.Goldstein et.al, Springer, 20038. Transmission Electron Microscopy B.D.Williams & C.B.Carter, Springer, 20099. Surface Analysis methods in materials science, Editors: D.J.O'Connor, B.A. Sextton, R.St. C. Smart, Springer, 2003.10. Materials Characterisation Techniques, S. Zhang, Lin Li and Ashok Kumar, CRC Press, 2009	STRUCTURE AND CHARACTERIZATION OF MATERIALS
MSE615A	3-0-0-0-9		**Course Contents:** Basic crystallo2raphy and crystal structures (8 Lectures hour)Periodic patterns, Lattices, Motif, Unit cells, Crystal structure, Primitive and Non primitive cells 1, Symmetry elements and point group notations 1, Crystal systems and Bravais lattices 1, Crystallographic directions and planes, Miller indices and Weiss zone law 1, Streographic projections 1, Bonding in materials and atomic packing in metals, coordination number concepts 1, Covalent bonding, glasses and polymers 2,Crystal defects and their significance (12 Lectures hours)Point defects and their role in materials Processing, performance and failure 1, Ionically bonded structures: Pauling's rules and some examples 2, Point defects: thermodynamics, schottkey and Frenkel defect, KrogerVink notation, defect interactions 2, Dislocations, burgers vector, types of dislocations 1, Dislocation movement, slip systems, energetics of dislocations and their interactions 2, Planar defects: stacking faults, grain boundaries (low angle and high angle), antiphase 2 **References/Text Books:** 1. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 20062. Materials Science and Engineering W.D. Callister, Jr. Wiley India(P) Ltd., 20073. Materials Science and Engineering, G.S. Upadhyaya and Anish Upadhyaya, Viva books, 20104. Fundamentals of Materials Sciencethe microstructureproperty relationship using metals as model systems, E.J. Mittemeijer, Springer, 20105. Microstructural Characterization of Materials D. Brandon and W.D. Kaplan, John Wiley and Sons, 20086.	STRUCTURE AND CHARACTERIZATION OF MATERIALS

			Science of Microscopy, P.W. Hawkes and J.C.H. Spence, Springer, 20077. Scanning Electron Microscopy & XRay Microanalysis, J.Goldstein et.al, Springer, 20038. Transmission Electron Microscopy B.D.Williams & C.B.Carter, Springer, 20099. Surface Analysis methods in materials science, Editors: D.J.O'Connor, B.A. Sextton, R.St. C. Smart, Springer, 2003.10. Materials Characterisation Techniques, S. Zhang, Lin Li and Ashok Kumar, CRC Press, 2009	
MSE616	3-0-0-0-4		**Course Contents:** Thermodynamic systems and variables. 1First, second and third laws of thermodynamics. 7Statistical interpretation of entropy. 2Free energy functions and criteria for equilibrium. 2Thermodynamics of solutions. Ideal and nonideal solutions,Partial and molar quantities 2Quasichemical model and regular solutions, 2Polynomial expressions for excess Gibbs energy of mixing for binary and higher order solutions. Multicomponent dilute solutions and interaction parameters. 2Chemical reaction equilibrium, equilibrium constant; applications to materials and metallurgical systems.4Electrochemical systems, cell reactions and EMF, Formation and concentrations cells. 3Phase rule and binary phase diagrams 2Free energy composition diagrams 3Phase equilibrium calculations 5Introduction to ternary phase diagrams.1 **References/Text Books:**	THERMODYNAMICS OF MATERIALS
MSE616A	3-0-0-0-9		**Course Contents:** Thermodynamic systems and variables. 1 First, second and third laws of thermodynamics. 7Statistical interpretation of entropy. 2 Free energy functions and criteria for equilibrium. 2 Thermodynamics of solutions. Ideal and nonideal solutions,Partial and molar quantities 2 Quasichemical model and regular solutions, 2 Polynomial expressions for excess Gibbs energy of mixing for binary and higher order solutions. Multicomponent dilute solutions and interaction parameters. 2 Chemical reaction equilibrium, equilibrium constant; applications to materials and metallurgical systems.4 Electrochemical systems, cell reactions and EMF, Formation and concentrations cells. 3 Phase rule and binary phase diagrams 2Free energy composition diagrams 3Phase equilibrium calculations 5Introduction to ternary phase diagrams.1 **References/Text Books:**	THERMODYNAMICS OF MATERIALS
MSE617	3-0-0-0-4		**Course Contents:** 1 Introduction of functions, vectors, matrices2 Partial Differentiation (Total differentiation, Maximum and minimum: method of Lagrange multipliers, Change of variables: Legendre transformation, Differentiation of integral; Leibniz rule)3 Multiple Integration (Change of variable: Jacobian, Surface and volume integrals)4 Vectors (Geometry: Lines and planes, Directional derivative, gradients (fields, equipotential, grad, normal to surface, curl, div), Line integration (conservative fields, potential, exact differentiation), Green, Stokes, Div and Curl theorems5 Coordinate Transformation (Linear transform, Orthogonal transform, Eigenvalues: diagonalization of matrix)6 Ordinary differential equations (Linear first order, Second order: constant coefficient and zero right hand side, Second order: constant coefficient and non zero right hand side)7 Statisticsa. Introduction to random experiment, computing probability of an event **References/Text Books:**	MATHEMATICS AND COMPUTATIONAL METHODS
MSE617A	3-0-0-0-9		**Course Contents:** 1 Introduction of functions, vectors, matrices2 Partial Differentiation (Total differentiation, Maximum and minimum: method of Lagrange multipliers, Change of variables: Legendre transformation, Differentiation of integral; Leibniz rule)3 Multiple Integration (Change of variable: Jacobian, Surface and volume integrals)4 Vectors (Geometry: Lines and planes, Directional derivative, gradients (fields, equipotential, grad, normal to surface, curl, div), Line integration (conservative fields, potential, exact differentiation), Green, Stokes, Div and Curl theorems5 Coordinate Transformation (Linear transform, Orthogonal transform, Eigenvalues: diagonalization of matrix)6 Ordinary differential equations (Linear first order, Second order: constant coefficient and zero right hand side, Second order: constant coefficient and non zero right hand side)7	MATHEMATICS AND COMPUTATIONAL METHODS

			Statisticsa. Introduction to random experiment, computing probability of an event **References/Text Books:**	
MSE621	3-0-0-0-4		**Course Contents:** Solid surfaces, their structure and composition: Importance of the surfaces/ Surfaces in different materials/ Structural imaging/ Composition of surface selvedges; Practical detection and spatial limits; Chemical tste information; Techniques to probe electronic structure at surfaces. Xray Photoelectron SpectroscopyBasics: Principles; Instrumentation; Vacuum systems, Xray sources, synchrotron radiation, electron energy analyzers; Spectral information, chemical shifts and interpretations; Quantification, depth profiling, imaging. XPSApplications: Catalysis; polyments and organic materials; corrosion, passivation and oxidation; superconductor; semiconductors; metallurgy/ tribology; thin films; Biomaterials, Case studies and lab visit/demo. Auger Electron SpectroscopyBasics: Principles; Instrumentation; Vacuum requirements, Electron sources, electron energy analyzers; Spectral information and interpretation; Quantification, depth profiling, imaging. **References/Text Books:** 1. Surface and Thin Film Analysis, Editors; G. Friedbachaer and H. Bubert, WileyVCH, 2011. 2. Encyclopedia of Materials Characterisation, C.R. Brundle, C.A. Evans and S. Wilson, ButterworthHennmann, 1992, Boston. 3. Introduction to Photoelectron spectoscopy P.K. Ghosh, John Wiley and Sons, WileyIntersicence, 1978, New York. 4. Surface Analysis Methods in Materials Science, D.J. O'Connors, B.A. Sexton, and R. St. C. Smart, Springer (2003). 5. Photoelectron and Auger spectroscopy. Thomas A Carlson, Plenum, New York, 1975. 6. Topics in Current physics: Electron spectroscopy for surface analysis, Ed. H. Ibach, SpringerVerlag, Berlin, 1977. 7. Scanning Auger electron microscopy, Editors: M. PLrutton and Mohamed M. El Gomati, John Wiley & Sons, 2006. 8. Practial guide to surface science and spectroscopy. YipWah Chung, Academic Press, Boston, 2001.	XPS AND AES IN STUDY OF SURFACE AND THIN FILMS
MSE621A	3-0-0-0-9		**Course Contents:** Solid surfaces, their structure and composition: Importance of the surfaces/ Surfaces in different materials/ Structural imaging/ Composition of surface selvedges; Practical detection and spatial limits; Chemical tste information; Techniques to probe electronic structure at surfaces. Xray Photoelectron SpectroscopyBasics: Principles; Instrumentation; Vacuum systems, Xray sources, synchrotron radiation, electron energy analyzers; Spectral information, chemical shifts and interpretations; Quantification, depth profiling, imaging. XPSApplications: Catalysis; polyments and organic materials; corrosion, passivation and oxidation; superconductor; semiconductors; metallurgy/ tribology; thin films; Biomaterials, Case studies and lab visit/demo. Auger Electron SpectroscopyBasics: Principles; Instrumentation; Vacuum requirements, Electron sources, electron energy analyzers; Spectral information and interpretation; Quantification, depth profiling, imaging. **References/Text Books:** 1. Surface and Thin Film Analysis, Editors; G. Friedbachaer and H. Bubert, WileyVCH, 2011. 2. Encyclopedia of Materials Characterisation, C.R. Brundle, C.A. Evans and S. Wilson, ButterworthHennmann, 1992, Boston. 3. Introduction to Photoelectron spectoscopy P.K. Ghosh, John Wiley and Sons, WileyIntersicence, 1978, New York. 4. Surface Analysis Methods in Materials Science, D.J. O'Connors, B.A. Sexton, and R. St. C. Smart, Springer (2003). 5. Photoelectron and Auger spectroscopy. Thomas A Carlson, Plenum, New York, 1975. 6. Topics in Current physics: Electron spectroscopy for surface analysis, Ed. H. Ibach, SpringerVerlag, Berlin, 1977. 7. Scanning Auger electron microscopy, Editors: M. PLrutton and Mohamed M. El Gomati, John Wiley & Sons, 2006. 8. Practial guide to surface science and spectroscopy. YipWah Chung, Academic Press, Boston, 2001.	XPS AND AES IN STUDY OF SURFACE AND THIN FILMS
MSE626	3-1-0--5		**Course Contents:** Review of the basic concepts in heat,mass and momentum transfer: Advancedtopics in convective heat and heat transfer: Radiative heat transmission:Simultaneous heat and mass transfer: Selected topics in	HEAT AND MASS TRANSFER

			metallurgical engineering,Reaction kinetics. **References/Text Books:**	
MSE626A	3-0-0-0-9		**Course Contents:** I. Fluid dynamics : Introduction to Transport phenomena in materials processing, Newton's law of viscosity, equation of continuity, Navier Stokes equations, Macroscopic mass and energy balance ; Characteristics of industrial flows, Numerical problems on above topics of interest to metals and materials processing.2. Heat transfer : Fundamentals of conduction heat transfer; Laws and equations; Steady and unsteady heat, conduction Numerical problems on conductive heat transfer, Fundamentals of convective heat transfer; free and forced convective heat transfer, Convective, heat transfer rate laws and heat transfer coefficient Problems on Convective heat transfer, Fundamentals of Radiation heat transfer and rate laws; view factors, Problems on Radiation heat transfer, Application of heat transfer in: Heat treatment, solidification, cooling of slabs, heat flow, through refractory walls etc.3. Mass Transfer : Fundamentals of diffusion; rate laws, Uphill diffusion and Kirkendal's effect, steady and unsteady diffusion, Numericalgroblems on diffusion mass transfer, Fundamentals of convective mass transfer; free and forced convective mass transfer transfer, Convective mass transfer, rate laws and mass transfer coefficient, Problems on Convective mass transport, Application of mass transfer in: case hardening, doping of semi conductors, homogenization, oxidation, absorption/desorption of gases in liquid metals. **References/Text Books:** 1. Transport phenomena: D. R. Geiger and G. H. Poirier2. Transport phenomena: D. R. Gaskel3. Engineering in process metallurgy: R.Guthrie4. Mass transport in solids and fluids: D. S. WilkinsonRecommended Reference books:1. Diffusion in solids: P. G. Shewrnan2. Atom movements diffusion and mass transport in solids: J. Philibert3. Diffusion in solids: field theory, solidstate principles, and applications: M. E. Glicksman	TRANSPORT PHENOMENA
MSE626N	3-0-0-0-4		**Course Contents:** I. Fluid dynamics : Introduction to Transport phenomena in materials processing, Newton's law of viscosity, equation of continuity, Navier Stokes equations, Macroscopic mass and energy balance ; Characteristics of industrial flows, Numerical problems on above topics of interest to metals and materials processing.2. Heat transfer : Fundamentals of conduction heat transfer; Laws and equations; Steady and unsteady heat, conduction Numerical problems on conductive heat transfer, Fundamentals of convective heat transfer; free and forced convective heat transfer, Convective, heat transfer rate laws and heat transfer coefficient Problems on Convective heat transfer, Fundamentals of Radiation heat transfer and rate laws; view factors, Problems on Radiation heat transfer, Application of heat transfer in: Heat treatment, solidification, cooling of slabs, heat flow, through refractory walls etc.3. Mass Transfer : Fundamentals of diffusion; rate laws, Uphill diffusion and Kirkendal's effect, steady and unsteady diffusion, Numericalgroblems on diffusion mass transfer, Fundamentals of convective mass transfer; free and forced convective mass transfer transfer, Convective mass transfer, rate laws and mass transfer coefficient, Problems on Convective mass transport, Application of mass transfer in: case hardening, doping of semi conductors, homogenization, oxidation, absorption/desorption of gases in liquid metals. **References/Text Books:** 1. Transport phenomena: D. R. Geiger and G. H. Poirier2. Transport phenomena: D. R. Gaskel3. Engineering in process metallurgy: R.Guthrie4. Mass transport in solids and fluids: D. S. WilkinsonRecommended Reference books:1. Diffusion in solids: P. G. Shewrnan2. Atom movements diffusion and mass transport in solids: J. Philibert3. Diffusion in solids: field theory, solidstate principles, and applications: M. E. Glicksman	TRANSPORT PHENOMENA
MSE628	3-0-0-0-4		**Course Contents:** Electronic Device related characteristics of a semiconductor material Review: n and p type semiconductors, wafers, carrier mobility, conductivity, equilibrium carrier statistics, generationrecombination processes and carrier transport, traps and defect states {2)Characterization : {a) Doping density: Secondary lon Mass Spectroscopy {SIMS) {0.75){b) Resistivity: Fourpoint probe {0.75) {c) Charge carrier type, density,	ELECTRONIC DEVICES AND CHARACTERIZATION

			mobility: Hall effect {1}{d) Bandgap: UVVisible spectroscopy {0.75) {e) Absorption coefficient {0.5)2 Semiconductor semiconductor junction : {a) PN junction in thermal equilibrium, JV characteristics: qualitative {3) {b) PN junction's JV characteristics of an ideal device, origin of non idealities {4) {c) Diode variants: solar cell {JV with illumination and bias effect and PIN diode, LEOs {2.5) {d) Device measurement of a solarell (Light and dark JV, R5 , Rsh, Efficiency) {0.5) {e) BJTs: Principle and device measurement {2)3 Metal Semiconductor junction : (a} Schottky and Ohmic contacts, thermionicemission, Tunnelling, Schottky diodes (2} (b) Contact resistance: Two terminal; Four terminal technique (0. 5} 5 (c) Barrier height: From 1V, CV, Photocurrent; comparison ofthree (1) (d) Capacitance Voltage measurements: DopingDensity and majority carrier density profiling (1) (e) Bandoffset for a semiconductor semiconductor junction using CV technique (0.5} 4 Metalinsulatorsemiconductor junctions : (a} MOS capacitor, quantitative analysis of a flat band device, CV characteristics (4.5} (b) MOS capacitor: deviations from flat band conditions (2.5} (c) Oxide charges : fixed, mobile, trapped and interfacetrapped charges (1} (d) MOSFET (5} (e) FinFET MOSFET: Architecture for creating simple Boolean logic, memory Dopant density profiling using CV (already discussed in section 3 above} **References/Text Books:** (I) Semiconductor Material and Device Characterization, Dieter K. Schroder, January 2006,WileyIEEE Press(2) MetalSemiconductor Contacts (Electrical & Electronic Engineering Monographs), E. H.Rhoderick and R. H. Williams, Oxford University Press, USA; 2 edition (September I,1988)(3) Electronic Structure of MetalSemiconductor Contacts, Winfried Monch (Nov 30,I990)Springer; I edition (November 30, I990)(4) Optical Techniques for SolidState Materials Characterization, Rohit P. Prasankumar and Antoinette J. Taylor, CRC Press; I edition (July 5, 201I)(5) Semiconductor Device Fundamentals by Robert F. Pierret, Addison Wesley; 2nd edition(April 12, I 996)(6) Advanced Semiconductor Fundamentals (2nd Edition) by Robert F. Pierret, PrenticeHall; 2 edition (August 19, 2002)(7) Semiconductor Devices: Physics and Technology, Simon M. Sze, MingK wei Lee,Wiley; 3 edition (May I5 , 20I2)	
MSE628A	3-0-0-0-9		**Course Contents:** Electronic Device related characteristics of a semiconductor material Review: n and p type semiconductors, wafers, carrier mobility, conductivity, equilibrium carrier statistics, generationrecombination processes and carrier transport, traps and defect states {2)Characterization : {a) Doping density: Secondary lon Mass Spectroscopy {SIMS) {0.75){b) Resistivity: Fourpoint probe {0.75) {c) Charge carrier type, density, mobility: Hall effect {1}{d) Bandgap: UVVisible spectroscopy {0.75) {e) Absorption coefficient {0.5)2 Semiconductor semiconductor junction : {a) PN junction in thermal equilibrium, JV characteristics: qualitative {3) {b) PN junction's JV characteristics of an ideal device, origin of non idealities {4) {c) Diode variants: solar cell {JV with illumination and bias effect and PIN diode, LEOs {2.5) {d) Device measurement of a solarell (Light and dark JV, R5 , Rsh, Efficiency) {0.5) {e) BJTs: Principle and device measurement {2)3 Metal Semiconductor junction : (a} Schottky and Ohmic contacts, thermionicemission, Tunnelling, Schottky diodes (2} (b) Contact resistance: Two terminal; Four terminal technique (0. 5} 5 (c) Barrier height: From 1V, CV, Photocurrent; comparison ofthree (1) (d) Capacitance Voltage measurements: DopingDensity and majority carrier density profiling (1) (e) Bandoffset for a semiconductor semiconductor junction using CV technique (0.5} 4 Metalinsulatorsemiconductor junctions : (a} MOS capacitor, quantitative analysis of a flat band device, CV characteristics (4.5} (b) MOS capacitor: deviations from flat band conditions (2.5} (c) Oxide charges : fixed, mobile, trapped and interfacetrapped charges (1} (d) MOSFET (5} (e) FinFET MOSFET: Architecture for creating simple Boolean logic, memory Dopant density profiling using CV (already discussed in section 3 above} **References/Text Books:** (I) Semiconductor Material and Device Characterization, Dieter K. Schroder, January 2006,WileyIEEE Press(2) MetalSemiconductor Contacts (Electrical & Electronic Engineering Monographs), E. H.Rhoderick and R. H. Williams, Oxford University Press, USA; 2 edition (September I,1988)(3) Electronic Structure of MetalSemiconductor Contacts, Winfried Monch (Nov 30,I990)Springer; I edition (November 30, I990)(4) Optical Techniques for SolidState Materials Characterization, Rohit P. Prasankumar and Antoinette J. Taylor, CRC Press; I edition (July 5, 201I)(5) Semiconductor Device Fundamentals by Robert F. Pierret, Addison	ELECTRONIC DEVICES AND CHARACTERIZATION

			Wesley; 2nd edition(April 12, I 996)(6) Advanced Semiconductor Fundamentals (2nd Edition) by Robert F. Pierret, PrenticeHall; 2 edition (August 19, 2002)(7) Semiconductor Devices: Physics and Technology, Simon M. Sze, MingK wei Lee,Wiley; 3 edition (May I5 , 20I2)	
MSE629A	3-0-0-0-9		**Course Contents:** Brief review of scientific fundamentals such as thermodynamics, kinetics and trasport phenomena of relevance to steel making: Mathematical modeling techniques: Principles of physical modeling: Successful modeling examples including converter steel making, gas stirred ladles: Alloy addition kinetics, tundish operations and continuous casting. **References/Text Books:**	PHYSICAL & MATHEMATICAL MODELLING OF STEELMAKING PROCESSES
MSE630	3-0-0--4		**Course Contents:** Recent trends in iron and steel making: Gassolid and slagmetal reaction: Spongeiron making: Continuous steel making: Continuous casting: Vacuum degassingand electroslag remelting: Advances in agglomeration, blast furnace and steelmaking, analysis of iron and steel making processes and reactors: Deoxidationand impurity control: Emphasis on application of physical chemistry and transportphenomena. **References/Text Books:**	ADVANCES IN IRON AND STEEL MAKING
MSE631	3-0-0-0-4		**Course Contents:** Introduction, FCC packed structures (MgO, Ce02 etc),HCP packed structures (LiNb03 etc), Other structures such as Perovskite (BaTi03 etc) and Rutile structures, Defects in Elemental Solids and Ionic Compounds, Defect Classes, Point Defects, KrogerVink Notation, Point Defect Formation & Equilibrium, Law of MassAction and electrical neutrality, Thermodynamics of Intrinsic Defects and Defect Reactions. Complexes Containing an Impurity Center and an Ionic. Defect, Intrinsic Ionic Defect Associates and Effect of Impurities on the Concentration of Defect Complexes and Associate.Defect Equilibria in Pure and Stoichiometric Compounds with Schottky Defects, Frenkel Defect Pairs and Intrinsic Ionization of Electrons, **References/Text Books:** 1 L.L. Hench and West, Electroceramics, Wiley2 D. M. Smyth, "The Defect Chemistry of Metal Oxides", Publisher: Oxford University Press, ISBN10:01951101453 Wei Gao and Nigel M. Sammes, "An Introduction to Electronic and Ionic Materials," Publisher: WorldScientific.4 A.J. Moulson & J. M. Herbert, "Eiectroceramics: Materials, Properties, Applications", Publisher: Wiley5 M. W. Barsoum, "Fundamentals of Ceramics", Publisher: Institute of Physics6 "Impedance Spectroscopy: Theory, Experiment and Applications", Edited by J. Ross Macdonald & EvgenijBarsoukov, Publisher: John Wiley and Sons.7 Robert Huggins, "Use of defect equilibrium diagrams to understand minority species transport in solidelectrolytes", Solid State lonics, 143 (2001) 316.	ELECTROCERAMIC MATERIALS AND APPLICATIONS
MSE631A	3-0-0-0-9		**Course Contents:** Introduction, FCC packed structures (MgO, Ce02 etc),HCP packed structures (LiNb03 etc), Other structures such as Perovskite (BaTi03 etc) and Rutile structures, Defects in Elemental Solids and Ionic Compounds, Defect Classes, Point Defects, KrogerVink Notation, Point Defect Formation & Equilibrium, Law of MassAction and electrical neutrality, Thermodynamics of Intrinsic Defects and Defect Reactions. Complexes Containing an Impurity Center and an Ionic. Defect, Intrinsic Ionic Defect Associates and Effect of Impurities on the Concentration of Defect Complexes and Associate.Defect Equilibria in Pure and Stoichiometric Compounds with Schottky Defects, Frenkel Defect Pairs and Intrinsic Ionization of Electrons, **References/Text Books:** 1 L.L. Hench and West, Electroceramics, Wiley2 D. M. Smyth, "The Defect Chemistry of Metal Oxides", Publisher: Oxford University Press, ISBN10:01951101453 Wei Gao and Nigel M. Sammes, "An Introduction to Electronic and Ionic Materials," Publisher: WorldScientific.4 A.J. Moulson & J. M. Herbert, "Eiectroceramics: Materials, Properties, Applications", Publisher: Wiley5 M. W. Barsoum, "Fundamentals of	ELECTROCERAMIC MATERIALS AND APPLICATIONS

			Ceramics", Publisher: Institute of Physics6 "Impedance Spectroscopy: Theory, Experiment and Applications", Edited by J. Ross Macdonald & EvgenijBarsoukov, Publisher: John Wiley and Sons.7 Robert Huggins, "Use of defect equilibrium diagrams to understand minority species transport in solidelectrolytes", Solid State lonics, 143 (2001) 316.	
MSE634	3-0-0-0-4		**Course Contents:** Introduction Different Spray Techniques and their need Combustion Spraying:0 Flame Spraying0 DGunThermal Spraying Techniques: 0 High Velocity oxyfuelPrinciple and Working Arc and Plasma Spraying:0 Wire/Powder Arc Spraying0 Plasma Spraying (Air/ Vacuum) Cold SprayingSpraying Parameters Inflight conditions Plasmal Primary/ Secondary/ Carrier gases Power rating Feed rate Standoff distance Substrate preparationPowder Powder size and distribution Powder Injection Reaction of particlesCoating Formation Evaporation/Condensation Comparison of deposition techniques Single Splat Formation Heat transfer and spreading of splat Splay layering and deposition Microstructure and densification of deposited coatingsDiagnostics and Coating Reliability Thermal and Kinetic Profiles lnflight particle sensor Control of Deposition parametersBulk Nanostructure and Near Net Shape Microstructural distribution Design and control of bulk nanostructure Mandrel choice Mandrel removal Lectures Case Studies: Thermal Barrier/ Ultra high temperatureceramics **References/Text Books:** Reference Books:I. Handbook of thermal spray technology, Joseph R. Davis, ASM International. Thermal Spray SocietyTraining Committee (2004).2. Advanced Structural Ceramics, Bikramjit Basu and Kantesh Balani, Wiley (2011). motedo[, wHI be 'upplemented wUh handout,, ond joumal publicatiom.	FUNDAMENTALS OF SPRAY TECHNIQUES
MSE634A	3-0-0-0-9		**Course Contents:** Introduction Different Spray Techniques and their need Combustion Spraying:0 Flame Spraying0 DGunThermal Spraying Techniques: 0 High Velocity oxyfuelPrinciple and Working Arc and Plasma Spraying:0 Wire/Powder Arc Spraying0 Plasma Spraying (Air/ Vacuum) Cold SprayingSpraying Parameters Inflight conditions Plasmal Primary/ Secondary/ Carrier gases Power rating Feed rate Standoff distance Substrate preparationPowder Powder size and distribution Powder Injection Reaction of particlesCoating Formation Evaporation/Condensation Comparison of deposition techniques Single Splat Formation Heat transfer and spreading of splat Splay layering and deposition Microstructure and densification of deposited coatingsDiagnostics and Coating Reliability Thermal and Kinetic Profiles lnflight particle sensor Control of Deposition parametersBulk Nanostructure and Near Net Shape Microstructural distribution Design and control of bulk nanostructure Mandrel choice Mandrel removal Lectures Case Studies: Thermal Barrier/ Ultra high temperatureceramics **References/Text Books:** Reference Books:I. Handbook of thermal spray technology, Joseph R. Davis, ASM International. Thermal Spray SocietyTraining Committee (2004).2. Advanced Structural Ceramics, Bikramjit Basu and Kantesh Balani, Wiley (2011). motedo[, wHI be 'upplemented wUh handout,, ond joumal publicatiom.	FUNDAMENTALS OF SPRAY TECHNIQUES
MSE637	3-0-0-0-4		**Course Contents:** Definition of micro/nanotribology Origin oftribology Measurement techniques Role oftribology in MEMS/NEMSNanotribology: Measurement techniques and Concepts AFM/FFM Role of Surface roughness Friction, scratching/wear and lubrication Local deformation Nanoindentation Surface elasticity/viscoelastici!YSurface maging, Friction and Adhesion Atomic scale imaging Friction: macro and microscale (Tomlinsonthermal/geometric effects) Surface roughness Nanoscale friction Wear mapping Lubricated adhesion and friction Multi length scaleWear, Scratching Nano and microscale wear Microscale scratching Insitu local deformation characterization NanomachiningIndentation Pico/Nano indentation Localised surface elasticity/viscoelasticity Loaddisplacement curve, indenter geometry,stiffuessBoundary Lubrication Lubricants, monolayers Liquid thin filmsNanomechanics and Testing Instrumentation: AFM, SPM Bulge tests, acoustic/imaging methods Defect NucleationScaling Effects Length scale effect on hardness, yield strength Roughness and contact parameters Model, Adhesion friction, 2body and 3body	Nanotribology and Nanomechanics

			deformation, ratchetmechanism Scale effect on wearCase Studies Ultrathin amorphous carbon films Self assembled mono layers (for controlling adhesion,friction and wear) Nanotribology and nanomechanics of magnetic storagedevices/ NEMS/MEMS Biomaterial/ Biological samples **References/Text Books:** I. Introduction To Micromechanics And Nanomechanics, Shaofan Li and Gang Wang World Scientific Publishing Company (2008)2. Fundamentals oftribology, Ramsey Gohar, Homer Rahnejat Imperial College Press (2008)3. Advanced Structural Ceramics, Bikramjit Basu and Kantesh Balani, Wiley (2011).4. course materials will be supplemented with handouts, and journal publications.	
MSE638	3-0-0-0-4		**Course Contents:** Introduction 1 Symmetries in 1 D, 2D and 3D, Examples of patterns showing various, symmetries, Symmetries and Lattices in 2D space : Operations ofTranslation, Rotation and Reflection, standard symbols, Lattices and Unit Cells, Permissible rotational symmetries, Derivation of lattices: oblique, rectangular, centred rectangular, square, hexagonalPoint Groups in 2D 4 : Set of symmetry operations, Group Theory Essentials, Evolution of 2D crystallographic point groups, 2D Space Groups (Plane Groups) Glide Planes: combination of lattice translation and reflection, Derivation of all the 17 plane groups, Understanding the Plane Group entries in the International Tables, of Crystallography3D Point Groups 4 : Combination of rotation axes in 3D, Development of the 32 point groups, Laue Groups3D Bravais Lattices Addition of a third translation to the plane groups, Derivation of Bravais Lattices3D Space Groups Screw Axes: combination of lattice translation and rotation, Development of the 230 space groups, Understanding the Space Groups entries in the International Tables of Crystallography **References/Text Books:** I. M.J. Buerger, Elementary Crystallography, ????2. International Tables of Crystallography A, International Union of Crystallography3. J. F. Nye, Physical Properties of Crystals (1995), Oxford Science Publications4. D.R. Lovett, Tensor Properties of Crystals (1999), Institute of Physics Pub I ishing5. Robert E. Newnham, " Properties of Materials: Anisotropy, Symmetry, Structure", Oxford Pr.	SYMMETRY AND PROPERTIES OF CRYSTALS
MSE638A	3-0-0-0-9		**Course Contents:** Introduction 1 Symmetries in 1 D, 2D and 3D, Examples of patterns showing various, symmetries, Symmetries and Lattices in 2D space : Operations ofTranslation, Rotation and Reflection, standard symbols, Lattices and Unit Cells, Permissible rotational symmetries, Derivation of lattices: oblique, rectangular, centred rectangular, square, hexagonalPoint Groups in 2D 4 : Set of symmetry operations, Group Theory Essentials, Evolution of 2D crystallographic point groups, 2D Space Groups (Plane Groups) Glide Planes: combination of lattice translation and reflection, Derivation of all the 17 plane groups, Understanding the Plane Group entries in the International Tables, of Crystallography3D Point Groups 4 : Combination of rotation axes in 3D, Development of the 32 point groups, Laue Groups3D Bravais Lattices Addition of a third translation to the plane groups, Derivation of Bravais Lattices3D Space Groups Screw Axes: combination of lattice translation and rotation, Development of the 230 space groups, Understanding the Space Groups entries in the International Tables of Crystallography **References/Text Books:** I. M.J. Buerger, Elementary Crystallography, ????2. International Tables of Crystallography A, International Union of Crystallography3. J. F. Nye, Physical Properties of Crystals (1995), Oxford Science Publications4. D.R. Lovett, Tensor Properties of Crystals (1999), Institute of Physics Pub I ishing5. Robert E. Newnham, " Properties of Materials: Anisotropy, Symmetry, Structure", Oxford Pr.	SYMMETRY AND PROPERTIES OF CRYSTALS
MSE642	3-0-0-0-4		**Course Contents:** Advanced Optical microscopy : Special microscopy techniques and applications: Bright field and dark field imaging; confocal microscopy; interference microscopy; polarized light microscopy; phase contrast microscopy. Scanning near field laser microscopy Image processing and quantification Scanning electron microscope : Basis of image contrast and various operating modes in SEM SE and BSE, Xray, EBIC,	MICROSCOPY AND MICROANALYSIS OF MATERIALS

			cathodoluminescence, voltage contrast mode, Magnetic contrast mode. (2) Environmental SEM, Low voltage SEM, and applications (I) Electron back scattered diffraction /OM: Basic principles, the microtextural data acquisition and analysis, applications (3) Fractography and failure analysis (2)Transmission electron microscope : Wave properties of electrons, lens defects, aberration corrected TEM and subAngstrom resolution (2L) Origin of contrast: massthickness c'ontrast, diffraction contrast and crystal defect analysis. Dynamic diffraction and anomalous absorption effects, image artifacts (3L) BF, OF, Weak beam OF images and applications (I L) Electron Diffraction: SADP, Microdiffraction, CBED. Diffuse scattering and finestructure in Diffraction pattern. (2L) Phase contrast and HRTEM: Contrast transfer function and lattice imaging, Computer simulation of lattice and structural images, Interpretation of images and illustrative examples(2L) STEMHAADF imaging, information limit (lL) Lorentz microscopy and holography (1) Specimen preparation: Mechanical thinning, electrochemical thinning, ion milling, sputter coating and carbon coating, replica methods (2L) **References/Text Books:** I. Fundamental of light microscopy and electronic imaging, 0.8. Murphy, WileyLiss, 20012. Microstructural Characterization of Materials D. Brandon and W.D. Kaplan, John Wiley and Sons,20083. Scanning Electron Microscopy & XRay Microanalysis, J.Goldstein et.al, Springer, 20034. Transmission Electron Microscopy B.D. Will iams & C. B. Carter, Springer, 20095. Science of Microscopy, P.W. Hawkes and J.C.H. Spen(:e, Springer, 20076. Surface Analysis methods in materials science, Editors: D.J.O'Connor, B.A. Sextton, R.St. C. Smart, Springer, 2003.7. Materials Characterisation Techniques, S. Zhang, Lin Li and Ashok Kumar, CRC Press, 20098. Fundamentals of Materials Sciencethe microstructureproperty relationship using metals as model systems, E.J. Mittemeijer, Springer, 2010	
MSE642A	3-0-0-0-9		**Course Contents:** Advanced Optical microscopy : Special microscopy techniques and applications: Bright field and dark field imaging; confocal microscopy; interference microscopy; polarized light microscopy; phase contrast microscopy. Scanning near field laser microscopy Image processing and quantification Scanning electron microscope : Basis of image contrast and various operating modes in SEM SE and BSE, Xray, EBIC, cathodoluminescence, voltage contrast mode, Magnetic contrast mode. (2) Environmental SEM, Low voltage SEM, and applications (I) Electron back scattered diffraction /OM: Basic principles, the microtextural data acquisition and analysis, applications (3) Fractography and failure analysis (2)Transmission electron microscope : Wave properties of electrons, lens defects, aberration corrected TEM and subAngstrom resolution (2L) Origin of contrast: massthickness c'ontrast, diffraction contrast and crystal defect analysis. Dynamic diffraction and anomalous absorption effects, image artifacts (3L) BF, OF, Weak beam OF images and applications (I L) Electron Diffraction: SADP, Microdiffraction, CBED. Diffuse scattering and finestructure in Diffraction pattern. (2L) Phase contrast and HRTEM: Contrast transfer function and lattice imaging, Computer simulation of lattice and structural images, Interpretation of images and illustrative examples(2L) STEMHAADF imaging, information limit (lL) Lorentz microscopy and holography (1) Specimen preparation: Mechanical thinning, electrochemical thinning, ion milling, sputter coating and carbon coating, replica methods (2L) **References/Text Books:** Course Reference : I. Fundamental of light microscopy and electronic imaging, 0.8. Murphy, WileyLiss, 20012. Microstructural Characterization of Materials D. Brandon and W.D. Kaplan, John Wiley and Sons,20083. Scanning Electron Microscopy & XRay Microanalysis, J.Goldstein et.al, Springer, 20034. Transmission Electron Microscopy B.D. Will iams & C. B. Carter, Springer, 20095. Science of Microscopy, P.W. Hawkes and J.C.H. Spen(:e, Springer, 20076. Surface Analysis methods in materials science, Editors: D.J.O'Connor, B.A. Sextton, R.St. C. Smart, Springer, 2003.7. Materials Characterisation Techniques, S. Zhang, Lin Li and Ashok Kumar, CRC Press, 20098. Fundamentals of Materials Sciencethe microstructureproperty relationship using metals as model systems, E.J. Mittemeijer, Springer, 2010	MICROSCOPY AND MICROANALYSIS OF MATERIALS
MSE646	3-0-0--4		**Course Contents:** Elemental compound and alloy crystals, modes of bonding, crystal types, densityof packing, atomic stacking,	X-RAY CRYSTALLOGRAPHY - I

			inter atomic voids, coordination polyhedra,Paulings rules, symmetry elements, space and point groups, group theoreticalformulation, diffraction or radiation. **References/Text Books:**	
MSE648	3-0-0--4		**Course Contents:** Diffusion equations and mathematical solutions: Phenomenological diffusiontheories: Atomic theory of diffusion, theoretical and experimental investigationof diffusion phenomena: Diffusion in ionic solids and semiconductors: Grainboundary and surface diffusion, thermal and electrodiffusion. **References/Text Books:**	DIFFUSION IN SOLIDS
MSE648A	3-0-0-0-9		**Course Contents:** Diffusion equations and mathematical solutions: Phenomenological diffusiontheories: Atomic theory of diffusion, theoretical and experimental investigationof diffusion phenomena: Diffusion in ionic solids and semiconductors: Grainboundary and surface diffusion, thermal and electrodiffusion. **References/Text Books:**	DIFFUSION IN SOLIDS
MSE650	3-0-0--4		**Course Contents:** Concepts and language of stereology; geometrical probability; fundamentaloperations in stereology; averaging with respect to orientation; basic stereologicalparameters on true 2D sections and thick sections; topological parameters ofmicrostructure; error analysis; applications of analysis of optical, scanning andtransmission electron micrographs; numerical density and size distribution ofparticles and grains of various shapes and sizes; stereological analysis ofanisotropic microstructures; fractal description of various microstructures;fractal dimensions and its significance; applications to characterization ofmartensitic, polycrystalline and other structures and fracture surfaces. **References/Text Books:**	FUNDAMENTALS OF STEREOLOGY & APPLICATIONS TO MICROSTRUTURAL ANALYSIS
MSE650A	3-0-0-0-9		**Course Contents:** Concepts and language of stereology; geometrical probability; fundamentaloperations in stereology; averaging with respect to orientation; basic stereologicalparameters on true 2D sections and thick sections; topological parameters ofmicrostructure; error analysis; applications of analysis of optical, scanning andtransmission electron micrographs; numerical density and size distribution ofparticles and grains of various shapes and sizes; stereological analysis ofanisotropic microstructures; fractal description of various microstructures;fractal dimensions and its significance; applications to characterization ofmartensitic, polycrystalline and other structures and fracture surfaces. **References/Text Books:**	FUNDAMENTALS OF STEREOLOGY & APPLICATIONS TO MICROSTRUTURAL ANALYSIS
MSE653	3-0-0-0-4		**Course Contents:** I Introduction :History, Interaction of electrons with matter, Different kinds ofTEMs 22 Electron scattering and diffraction: Terminology of scattering Interaction cross section; concept of mean free path; Scattering in the TEM; Fraunhofer and Fresnel diffraction; electrondiffraction patterns 23 Elastic and inelastic scattering in TEM: Elastic scattering mechanisms; scattering at isolated atoms, atomicscattering factor, the structure factor, simple diffraction concepts. Inelastic processes occur in the tern: 44 Diffraction in TEM and diffraction techniques: diffraction in the tern and dynamical effects; practical aspects of diffractionpattern formation; reciprocal lattice, vector g, Ewald sphere of reflection; excitation error; diffraction from longperiod superlattices, sniall volumes, wedgeshaped specimens, planar defects, particles, dislocations, etc.CBED patterns, comparing sad and CBED. 7 **References/Text Books:**	TRANSMISSION ELECTRON MICROSCOPY & NANO-ANALYSIS OF MATERIALS

			I. Transmission Electron Microscopy B.D. Williams & C.B.Carter, Springer, 20092. Aberrationcorrected analytical transmission electron microscopy, Ric Brydson, Wiley, 20113. Analytical electron microscopy for materials science, D. Shindo and T. Oikawa, Springer, 20024. Introduction to conventional electron microscopy, Marc De Graef, Cambridge University Press, 2005. Science of Microscopy, P.W. Hawkes and J.C.H. Spence, Springer, 20076. Insitu electron microscopy at high resolution, Editor: Flrian Banhart, World Scientific, 20087. Materials Characterisation Techniques, S. Zhang, Lin Li and Ashok Kumar, CRC Press, 20098. Handbook ofMicroscopy:Applications in materials science, solidstate phsysics and chemistry. EditedBy: S. Amelinckx, D. van Dyck, J. van Landuyt, ad G. van Tendeloo, VCH, Weinheim, 19979. Microstructural Characterization of Materials D. Brandon and W.D. Kaplan, John Wiley and Sons,2008	
MSE653A	3-0-0-0-9		**Course Contents:** I Introduction :History, Interaction of electrons with matter, Different kinds ofTEMs 22 Electron scattering and diffraction: Terminology of scattering Interaction cross section; concept of mean free path; Scattering in the TEM; Fraunhofer and Fresnel diffraction; electrondiffraction patterns 23 Elastic and inelastic scattering in TEM: Elastic scattering mechanisms; scattering at isolated atoms, atomicscattering factor, the structure factor, simple diffraction concepts. Inelastic processes occur in the tern: 44 Diffraction in TEM and diffraction techniques: diffraction in the tern and dynamical effects; practical aspects of diffractionpattern formation; reciprocal lattice, vector g, Ewald sphere of reflection; excitation error; diffraction from longperiod superlattices, sniall volumes, wedgeshaped specimens, planar defects, particles, dislocations, etc.CBED patterns, comparing sad and CBED. 7 **References/Text Books:**	TRANSMISSION ELECTRON MICROSCOPY & NANO-ANALYSIS OF MATERIALS
MSE655	3-0-0--4		**Course Contents:** Limitation of conventional metal forming methods: Powder rolling and its variousvariants, spray rolling, direct strip process: Powder, spray, rotary and isothermalforging: Hydrostatic and powder extrusion: Conform process: Applications ofthese processes for making conventional and speciality products. **References/Text Books:**	MODERN TRENDS IN METAL FORMING PROCESESS
MSE657	3-0-0-4-4		**Course Contents:** Slip planes and systems in various crystal systems; Elasticity and Plasticity; Deformation processesincluding Rolling ;Forging, Extrusion; Drawing and deep drawing etc.; Deformation of plastics and polymers; superplastieity; Formability; Failures;Friction wear and lubrication **References/Text Books:** I. Hosford, W. F., and Cadell, R. M., 2007, Metal Forming: Mechanics and Metallurgy, CambrideUniversity Press, Cambridge.2. George Dieter, 1986, Mechanical Metallurgy, McGraw Hill	Deformation Processing
MSE658	3-0-0-0-4		**Course Contents:** Overview of defects in Materials: (point, line, planar and volume defects) and their classification. Overview of plastic deformation mechanisms. Point defects: interaction and distributions, statistical thermodynamics, role in diffusion and deformation. Basic understanding of dislocations using physical and computer models: the Volterra cut, Burgers vector and the Burgers circuit, the line vector, edge, screw and mixed locations, Role of dislocations in weakening the crystal and in plasticity. Elasticity theory of dislocations: Stress, strain and displacement fields and energy of a dislocation, Forces on dislocations (including image force) Interaction between dislocations, Core of a dislocation. Motion of dislocations: The Peierls stress, role of the core structure, interaction of dislocations with other defects (including yield point phenomenon); kinks; jogs; crossslip; climb, Temperature and strainrate dependence of flow stress, Dislocation dynamics and the tensile stressstrain curve. Dislocations in FCC Metals: Partial dislocations (Shockley and Frank partials) stacking faults, Thompson's tetrahedron, LomerCotrell sessile dislocation. Overview of dislocations in other crystal structures: HCP metals, BCC metals, ionic crystals, superlattices, covalent crystals. Origin and multiplication of dislocations: dislocations in freshly grown crystals, nucleation of dislocations, multiplication of	DISLOCATIONS AND PLASTICITY

			dislocations (by FrankRead sources, cross slip and climb), Grain boundary sources, Recovery and recrystallization. Geometrically/structurally necessary dislocations: lowangle & general grain boundaries, indentation, interfacial dislocations, Twinning including incoherent twins. Specific examples of role of dislocations and case studies:Dislocations in nanocrystals, The HallPetch relation and the Inverse HallPetch Effect (IHPE), Dislocations in epitaxial systems, Severe Plastic deformation, Role of dislocations in Creep, Fatigue and Fracture. **References/Text Books:** 1. Introduction to Dislocations, D. Hull and D.J. Bacon, Pergamon Press, Oxford, 1984.2. Theory of Dislocations, J. P. Hirth and J. Lothe, McGrawHill, New York, 1968.3. Crystal Defects and Crystalline Interfaces, W. Bollmann, SpringerVerlag, Berlin, 19704. Elementary Dislocation Theory, J. Weertman and J. Weertman, The MacMillian Company, New York, 1964.5. http://www.tf.unikiel.de/matwis/amat/def_en/	
MSE658A	3-0-0-0-9		**Course Contents:** Overview of defects in Materials: (point, line, planar and volume defects) and their classification. Overview of plastic deformation mechanisms. Point defects: interaction and distributions, statistical thermodynamics, role in diffusion and deformation. Basic understanding of dislocations using physical and computer models: the Volterra cut, Burgers vector and the Burgers circuit, the line vector, edge, screw and mixed locations, Role of dislocations in weakening the crystal and in plasticity. Elasticity theory of dislocations: Stress, strain and displacement fields and energy of a dislocation, Forces on dislocations (including image force) Interaction between dislocations, Core of a dislocation. Motion of dislocations: The Peierls stress, role of the core structure, interaction of dislocations with other defects (including yield point phenomenon); kinks; jogs; crossslip; climb, Temperature and strainrate dependence of flow stress, Dislocation dynamics and the tensile stressstrain curve. Dislocations in FCC Metals: Partial dislocations (Shockley and Frank partials) stacking faults, Thompson's tetrahedron, LomerCotrell sessile dislocation. Overview of dislocations in other crystal structures: HCP metals, BCC metals, ionic crystals, superlattices, covalent crystals. Origin and multiplication of dislocations: dislocations in freshly grown crystals, nucleation of dislocations, multiplication of dislocations (by FrankRead sources, cross slip and climb), Grain boundary sources, Recovery and recrystallization. Geometrically/structurally necessary dislocations: lowangle & general grain boundaries, indentation, interfacial dislocations, Twinning including incoherent twins. Specific examples of role of dislocations and case studies:Dislocations in nanocrystals, The HallPetch relation and the Inverse HallPetch Effect (IHPE), Dislocations in epitaxial systems, Severe Plastic deformation, Role of dislocations in Creep, Fatigue and Fracture. **References/Text Books:** 1. Introduction to Dislocations, D. Hull and D.J. Bacon, Pergamon Press, Oxford, 1984.2. Theory of Dislocations, J. P. Hirth and J. Lothe, McGrawHill, New York, 1968.3. Crystal Defects and Crystalline Interfaces, W. Bollmann, SpringerVerlag, Berlin, 19704. Elementary Dislocation Theory, J. Weertman and J. Weertman, The MacMillian Company, New York, 1964.5. http://www.tf.unikiel.de/matwis/amat/def_en/	DISLOCATIONS AND PLASTICITY
MSE659	3-0-0-0-4		**Course Contents:** Powder Production (Chemical Methods, Electrolytic Methods, Atomization, Mechanical Methods),Powder Characterization (Chemical Composition and Structure, Particle Size and Surface Topography,Pyrophorocity and Toxic/ty), Powder Compaction, Phenomenological Aspects of Sintering, SolidStateSintering, Analytical Approach to Sintering, NonIsothermal Sintering, Microstructural Evolution, LiquidPhase Sintering, Stages of Liquid Phase Sintering, Supersolidus Sintering, Activated Sintering, PressureAssistedSintering, Microwave Sintering, Select Case Studies. **References/Text Books:** I. R.M. German, Powder Metallugy Science, 2"d ed. John Wiley, 1999.2. A. Upadhyaya, G.S. Upadhyaya, Powder Metallurgy: Science, Technology and Materials, 20 II.3. ASM Handbook, Volume 7: Powder Metal Technologies & Applications (1998)	POWDER METALLURGY

MSE659A	3-0-0-0-9		**Course Contents:** Powder Production (Chemical Methods, Electrolytic Methods, Atomization, Mechanical Methods),Powder Characterization (Chemical Composition and Structure, Particle Size and Surface Topography,Pyrophorocity and Toxic/ty), Powder Compaction, Phenomenological Aspects of Sintering, SolidStateSintering, Analytical Approach to Sintering, NonIsothermal Sintering, Microstructural Evolution, LiquidPhase Sintering, Stages of Liquid Phase Sintering, Supersolidus Sintering, Activated Sintering, PressureAssistedSintering, Microwave Sintering, Select Case Studies. **References/Text Books:** I. R.M. German, Powder Metallugy Science, 2"d ed. John Wiley, 1999.2. A. Upadhyaya, G.S. Upadhyaya, Powder Metallurgy: Science, Technology and Materials, 20 II.3. ASM Handbook, Volume 7: Powder Metal Technologies & Applications (1998)	POWDER METALLURGY
MSE663	3-0-0--4		**Course Contents:** Structure of oxides: Ionic diffusion in oxides: Defect structure of nonstoichiometriccompounds: Conductivity dependence on partial pressure of oxygen: Macroscopiccharacterization of dielectric materials: Electronic, atomic dipole, space chargepolarization: Relaxation phenomenoaDebye equations: Ferroelectrics:Diamagnetism, paramagnetism and ferromagnetism, exchange ferromagneticdomain: Structure and properties of ferrites. **References/Text Books:**	ELECTRICAL AND MAGNETIC PROPERTIES OF CERAMIC MATERIALS
MSE664	3-0-0-0-4		**Course Contents:** Perfect Structure, Defects in Elemental Solid and Ionic Compound, Defect Classes,Point Defects, KrogerVink Notation for Point Defects, Point Defect Formation & Equilibrium, Law of Massaction, Thermodynamic Related to Intrinsic Defects and Defect Reactions. Complexes Containing an Impurity Center and an Ionic Defect, Intrinsic Ionic Defect Associates and Effect of Impurities on the Concentration of Defect Complexes and Associate. Basic Concepts of Diffusion, Tracer Diffusion, Self Diffusion, Chemical Diffusion, Ambipolar Diffusion, Ionic Conduction in Crystalline Solid, Intrinsic andExtrinsic Ionic Conduction, Transference Number, NernstEinstein Relationship, and ConductivityDiffusion Relationship. Defect Equilibria in Pure and Stoichiometric Compounds with Schottky Defects,Frenkel Defect Pairs and Intrinsic Ionization of Electrons, Defect Equilibria in Nonstoichiometric Oxides such as Oxygen Deficient Oxide, Oxide with excess Metal, Metal Deficient Oxide, Metal Oxide with Excess Oxygen. Brouwer Diagrams for YSZ, Undoped and Doped Ce02, Ti02 and BaTi03 Electrical Characterization Techniques such as AC Electrochemical Impedance Spectroscopy, Four Point Probe D.C.Method, Van Der Pauw Method, IV Curves, Blocking Electrodes, and HebbWagner Method. OpenCircuit Potential, Efficiency, Nernst Equation Analysis, Activation Losses (Tafel Equation), Ohmic Losses,Concentration Losses. Description of Operation, Configurations, Cell Components, Materials Requirements, Manufacturing Techniques, and Performance of the following electrochemical devices such Solid Oxide Fuel Cells, Gas Sensors and Batteries. **References/Text Books:** 1.D. M. Smyth, "The Defect Chemistry of Metal Oxides", Publisher: Oxford University Press,ISBNIO: 01951101452 A.J. Moulson & J. M. Herbert, "Electroceramics: Materials, Properties, Applications", Publisher:Springer3 M. W. Barsoum, "Fundamentals of Ceramics", Publisher: Institute ofPhysics4 "Impedance Spectroscopy: Theory, Experiment and Applications", Edited by J. Ross Macdonald & Evgenij Barsoukov, Publisher: John Wiley and Sons.5 Robert Huggins, "Use of defect equilibrium diagrams to understand minority species transport in solid electrolytes", Solid State Ionics, 143 (200 I) 316.6 "CRC Handbook of Solid State Electrochemistry", Edited by P. J. Gellings & H. J. M.Bouwmeester, Publisher: CRC Press7 "High Temperature Solid Oxide Fuel Cells, Fundamental, Design and Applications ", Edited by Subhash C. Singhal & Kevin Kendall, Publisher: Elsevier	SOLID STATE IONICS
MSE664A	3-0-0-0-9		**Course Contents:** Perfect Structure, Defects in Elemental Solid and Ionic Compound, Defect Classes,Point Defects,	SOLID STATE IONICS

			KrogerVink Notation for Point Defects, Point Defect Formation & Equilibrium, Law of Massaction, Thermodynamic Related to Intrinsic Defects and Defect Reactions. Complexes Containing an Impurity Center and an Ionic Defect, Intrinsic Ionic Defect Associates and Effect of Impurities on the Concentration of Defect Complexes and Associate. Basic Concepts of Diffusion, Tracer Diffusion, Self Diffusion, Chemical Diffusion, Ambipolar Diffusion, Ionic Conduction in Crystalline Solid, Intrinsic andExtrinsic Ionic Conduction, Transference Number, NernstEinstein Relationship, and ConductivityDiffusion Relationship. Defect Equilibria in Pure and Stoichiometric Compounds with Schottky Defects,Frenkel Defect Pairs and Intrinsic Ionization of Electrons, Defect Equilibria in Nonstoichiometric Oxides such as Oxygen Deficient Oxide, Oxide with excess Metal, Metal Deficient Oxide, Metal Oxide with Excess Oxygen. Brouwer Diagrams for YSZ, Undoped and Doped Ce02, Ti02 and BaTi03 Electrical Characterization Techniques such as AC Electrochemical Impedance Spectroscopy, Four Point Probe D.C.Method, Van Der Pauw Method, IV Curves, Blocking Electrodes, and HebbWagner Method. OpenCircuit Potential, Efficiency, Nernst Equation Analysis, Activation Losses (Tafel Equation), Ohmic Losses,Concentration Losses. Description of Operation, Configurations, Cell Components, Materials Requirements, Manufacturing Techniques, and Performance of the following electrochemical devices such Solid Oxide Fuel Cells, Gas Sensors and Batteries. **References/Text Books:** 1.D. M. Smyth, "The Defect Chemistry of Metal Oxides", Publisher: Oxford University Press,ISBNIO: 01951101452 A.J. Moulson & J. M. Herbert, "Electroceramics: Materials, Properties, Applications", Publisher:Springer3 M. W. Barsoum, "Fundamentals of Ceramics", Publisher: Institute ofPhysics4 "Impedance Spectroscopy: Theory, Experiment and Applications", Edited by J. Ross Macdonald & Evgenij Barsoukov, Publisher: John Wiley and Sons.5 Robert Huggins, "Use of defect equilibrium diagrams to understand minority species transport in solid electrolytes", Solid State Ionics, 143 (200 I) 316.6 "CRC Handbook of Solid State Electrochemistry", Edited by P. J. Gellings & H. J. M.Bouwmeester, Publisher: CRC Press7 "High Temperature Solid Oxide Fuel Cells, Fundamental, Design and Applications ", Edited by Subhash C. Singhal & Kevin Kendall, Publisher: Elsevier	
MSE665	3-0-0-0-4		**Course Contents:** Specimen preparation for TEM analysis : Metallic selfsupporting samplesElectropolishingCeramics and electronic devices: Crosssectional specimen preparation Ion Milling Soft materials, polymers, biological specimens: Ultramicrotomy Powders, Nanoparticles, fibres, fragments Focused Ion Beam techniques Importance and use of Plasma CleanersTEM: Instrumental details and requirements : Physics of Different Electron Sources:Lenses, Ape11ures, and Resolution: Electron Detection Display and Image RecordingPumps and HoldersOperating modes, Illumination System, alignment and aberration correction caliberations : Forming DPs and Images; STEM Imaging System: Alignment and Stigmation Lens Rotation Centers, Correction of Astigmatism in the Imaging Lenses, Calibrating the Imaging System; Magnification Calibration, CameraLength Caltbration;Electron Diffraction and diffraction techniques : Practical aspects of diffraction and diffraction pattern analysis Mathematical Definition ofthe Reciprocal Lattice; Laue Equations and their Relation to Bragg's Law, Ewald Sphere of Reflection; The Excitation Error Experimental SAD Techniques, Indexing SingleCrystal DPs, Ring Patterns from Polycrystalline Materials, HollowCone Diffraction,Amorphous Materials Precession Diffraction, Double Diffraction, Orientation ofthe Specimen, Orientation RelationshipsAmplitude contrast imaging and image interpretations : Image artifacts in TEM Systematic Crystal defect analysis: Dislocation analysis, stacking fault analysis, Grain boundaries and Interphase interface boundaries Volume Defects and Particles **References/Text Books:** 1. Transmission Electron Microscopy B.D. Williams & C.B.Carter, Springer, 20092. Sample preparation handbook for TEM: Methodology, J. Ayache et al., Springer, 20103. Sample preparation handbook for TEM: Techniques, J. Ayache et al., Springer, 20104. Aberrationcorrected analytical transmission electron microscopy, Ric Brydson, Wiley, 20115. Analytical electron microscopy for materials science, D. Shindo and T. Oikawa, Springer, 20026. Handbook of Microscopy:Applications in materials science, solidstate phsysics and chemistry. EditedBy: S. Amelinckx, D. van Dyck, J. van Landuyt, ad G. van Tendeloo, VCH, Weinheim, 19977. Microstructural Characterization of Materials D. Brandon and W.O. Kaplan, John Wiley and	PRACTICAL TRANSMISSION ELECTRON MICROSCOPY & NANOANALYSIS OF MATERIALS

			Sons,2008	
MSE665A	3-0-0-0-9		**Course Contents:** Specimen preparation for TEM analysis : Metallic selfsupporting samplesElectropolishingCeramics and electronic devices: Crosssectional specimen preparation Ion Milling Soft materials, polymers, biological specimens: Ultramicrotomy Powders, Nanoparticles, fibres, fragments Focused Ion Beam techniques Importance and use of Plasma CleanersTEM: Instrumental details and requirements : Physics of Different Electron Sources:Lenses, Ape11ures, and Resolution: Electron Detection Display and Image RecordingPumps and HoldersOperating modes, Illumination System, alignment and aberration correction caliberations : Forming DPs and Images; STEM Imaging System: Alignment and Stigmation Lens Rotation Centers, Correction of Astigmatism in the Imaging Lenses, Calibrating the Imaging System; Magnification Calibration, CameraLength Caltbration;Electron Diffraction and diffraction techniques : Practical aspects of diffraction and diffraction pattern analysis Mathematical Definition ofthe Reciprocal Lattice; Laue Equations and their Relation to Bragg's Law, Ewald Sphere of Reflection; The Excitation Error Experimental SAD Techniques, Indexing SingleCrystal DPs, Ring Patterns from Polycrystalline Materials, HollowCone Diffraction,Amorphous Materials Precession Diffraction, Double Diffraction, Orientation ofthe Specimen, Orientation RelationshipsAmplitude contrast imaging and image interpretations : Image artifacts in TEM Systematic Crystal defect analysis: Dislocation analysis, stacking fault analysis, Grain boundaries and Interphase interface boundaries Volume Defects and Particles **References/Text Books:** 1. Transmission Electron Microscopy B.D. Williams & C.B.Carter, Springer, 20092. Sample preparation handbook for TEM: Methodology, J. Ayache et al., Springer, 20103. Sample preparation handbook for TEM: Techniques, J. Ayache et al., Springer, 20104. Aberrationcorrected analytical transmission electron microscopy, Ric Brydson, Wiley, 20115. Analytical electron microscopy for materials science, D. Shindo and T. Oikawa, Springer, 20026. Handbook of Microscopy:Applications in materials science, solidstate phsysics and chemistry. EditedBy: S. Amelinckx, D. van Dyck, J. van Landuyt, ad G. van Tendeloo, VCH, Weinheim, 19977. Microstructural Characterization of Materials D. Brandon and W.O. Kaplan, John Wiley and Sons,2008	PRACTICAL TRANSMISSION ELECTRON MICROSCOPY & NANOANALYSIS OF MATERIALS
MSE666	3-0-0--4		**Course Contents:** Magnetic units: Magnetic moments: Dia, para and paulipara magnetism:Molecular field: Ferro, antiferro and ferrimagnetism: Alloying effect on transitionmetals and intermetallics: Stability of domain structure: Origin of magneticanisotropy and its application: Effect of inclusions, internal stress, magnetostrictionand preferred orientation on magnetization: Susceptibility and coercivitycalculations: Magnetic thin filmsamorphous and crystalline, soft and permanentmagnets: Technological aspects of magnetic materials. **References/Text Books:**	SCIENCE AND TECHNOLOGY OF MAGNETIC MATERIALS
MSE667	3-0-0--4		**Course Contents:** Overview of the design process: concepts and stages of engineering design anddesign alternatives to develop materials with tailored properties; Performanceindices of materials; function, objective and constraints in design, specificstiffnesslimited and strengthlimited design for maximum performance,Performance indices for thermal, mechanical, thermomechanical applications,damage tolerant designs for structural applications; Basic concepts of materialsscience: processingstructurepropertyperformance correlation; overview ofconventional and advanced materials; Brief overview of the elements of chemicalbonding, crystal structure, defect structure of different material classes, Briefintroduction to the manufacturing processes for metals, polymers, ceramics,glasses and composite materials; design for manufacturability, Ashbys materialproperty charts; Decision matrices and decision matrix techniques in materialsselection, relationship between materials selection and processing; Case studies:designing of Metals and alloys, ceramics and glasses, composite materials (MMC,CMC and PMC/ FRC) for specific applications. **References/Text Books:**	SELECTION AND DESIGNING WITH ENGINEERING MATERIALS

MSE668	3-0-0--4		**Course Contents:** Introduction to basic concepts of Materials Science; Salient properties ofimportant material classes; Property requirement of biomaterials; Concept ofbiocompatibility; cellmaterial interactions and foreign body response; assessmentof biocompatibility of biomaterials, important biometallic alloys; Tibased,stainless steels, CoCrMo alloys; Bioinert, Bioactive and bioresorbable ceramics;Processing and properties of different bioceramic materials with emphasize onhydroxyapatite; synthesis of biocompatible coatings on structural impant materials;Microstructure and properties of glassceramics; biodegradable polymers; Designconcept of developing new materials for bioimplant applications. **References/Text Books:**	MATERIALS FOR BIOMEDICAL APPLICATIONS
MSE670	3-0-0-0-4		**Course Contents:** Thermodynamics of solidification, Nucleation and growth, Pure metal solidification, GibbsThomsoneffect, Alloy Solidification: Mathematical Analysis of redistribution of solute during solidification,Constitutional undercooling, MullinsSekerka instability, Dendritic growth , Multi phase solidification:eutectic and peritectic, Structure of casting and ingots, Types of casting, Heat transfer, Design of riser andgating, Joining, different joining processes, Fusion welding, Solidification, heat transfer, fluid flow duringfusion welding, Modelling of solidification under different conditions **References/Text Books:** I. Solidification Processing; Fleming, M.C., McGrawHill, N.Y., 19742. Solidification ofCasting; Ruddle, R.W., Institute ofMetals, 19573. Solidification and Casting, Davies, G.J., John Wiley and Sons, 19734. Science and Engineering of Casting Solidification; Stefanescu, D.M., Kluwar Publications, 20025. Fundamentals of Solidification by Kurz, W. and Fisher, D.J ., TransTech Publications, Switzerland,19896. Applied Welding Engineering: Process, Codes and Standard; R.Singh,. Elsevier Inc.,2012	SOLIDIFICATION PROCESSING
MSE670A	3-0-0-0-9		**Course Contents:** Thermodynamics of solidification, Nucleation and growth, Pure metal solidification, GibbsThomsoneffect, Alloy Solidification: Mathematical Analysis of redistribution of solute during solidification,Constitutional undercooling, MullinsSekerka instability, Dendritic growth , Multi phase solidification:eutectic and peritectic, Structure of casting and ingots, Types of casting, Heat transfer, Design of riser andgating, Joining, different joining processes, Fusion welding, Solidification, heat transfer, fluid flow duringfusion welding, Modelling of solidification under different conditions **References/Text Books:** I. Solidification Processing; Fleming, M.C., McGrawHill, N.Y., 19742. Solidification ofCasting; Ruddle, R.W., Institute ofMetals, 19573. Solidification and Casting, Davies, G.J., John Wiley and Sons, 19734. Science and Engineering of Casting Solidification; Stefanescu, D.M., Kluwar Publications, 20025. Fundamentals of Solidification by Kurz, W. and Fisher, D.J ., TransTech Publications, Switzerland,19896. Applied Welding Engineering: Process, Codes and Standard; R.Singh,. Elsevier Inc.,2012	SOLIDIFICATION PROCESSING
MSE671	3-0-0-0-4		**Course Contents:** Introduction, Theory of Heat Treatment, Heat Treatment Environment, Different Heat TreatmentTechniques, Fundamentals and Properties; Annealing, Tempering, Hardening, Thermomechanicaltreatment, Fundamentals of Surface Hardening Treatment, Carburizing, Carbonitriding, Nitriding,Modern surface hardening techniques; Economy of Heat Treatment Processes **References/Text Books:** I. Principles of Heat Treatment of Steels by R.C. Sharma2: The Heat Treating Source Book, ASM, 19863. Heat Treatment of Metals by W.S. Owen (1963) (Institute for Metallurgists)4. Engineering Physical Metallurgy and Heat Treatment by Y. Lakhtein (Mir Publisher)5. Phase Transformations in Metals and Alloys by D.A. Porter and K.E. Easterling (Taylor andFrancis)	HEAT TREATMENT AND SURFACE HARDENING

MSE671A	3-0-0-0-9		**Course Contents:** Introduction, Theory of Heat Treatment, Heat Treatment Environment, Different Heat TreatmentTechniques, Fundamentals and Properties; Annealing, Tempering, Hardening, Thermomechanicaltreatment, Fundamentals of Surface Hardening Treatment, Carburizing, Carbonitriding, Nitriding,Modern surface hardening techniques; Economy of Heat Treatment Processes **References/Text Books:** I. Principles of Heat Treatment of Steels by R.C. Sharma2: The Heat Treating Source Book, ASM, 19863. Heat Treatment of Metals by W.S. Owen (1963) (Institute for Metallurgists)4. Engineering Physical Metallurgy and Heat Treatment by Y. Lakhtein (Mir Publisher)5. Phase Transformations in Metals and Alloys by D.A. Porter and K.E. Easterling (Taylor andFrancis)	HEAT TREATMENT AND SURFACE HARDENING
MSE674	3-0-0--4		**Course Contents:** Factors affecting designmaterials and geometry: Specific design of productslike permeable materials, structural parts, bearings and cutting tool materials:conditioning of metal powders to influence processing parameters: Productproperties evaluation and their standardization. **References/Text Books:**	DESIGN OF SINTERED PRODUCTS
MSE676	3-0-0-0-4		**Course Contents:** 1. Introduction to Failure analysis and prevention: Concepts, root causes analysis, primary rootcauses, design deficiencies, material defects, manufacturing/installation defects, categoriesof failure, failure prevention (4 hours)2. Failure Analysis: Processes, objectives, planning and preparation, practices and procedures.(3 hours)l 3. Fracture modes, Ductile fracture of metallic . materials and their interpretations, factorsaffecting ductilebrittle relationships. (3 hours)4. Failure characteristics of Ceramics and Plastics (2 hours)5. Brittle fracture in normally ductile metallic alloy, microstructural aspects of brittle fracture(2 hours)6. Fatigue fracture, macroscopic and microscopic characteristics, statistical aspects of fatigue,Fatigue failure prediction and life assessment. (3 hours)7. Wear Failures and Prevention (2 hours)rt:Y8. Corrosion related failures, Stress corrosion cracking, Hydrogen damage and embrittlement,Biological corrosion failures. (2 hours)9. Elevated temperature failures, creep and stress rupture, metallurgical instabilities(2 hours)I 0. Distortion failures and deformations (2 hours)11. Structural life assessment methods, Nondestructive techniques. (2 hours)12. Tools and techniques in failure analysis: General Practices, Photography, Xrays,Metallographic techniques, Fractography,, (4 hours)13. Illustrative 'Case studies of engineering failure ' due to: improper processing practice,improper treatment procedure, improper design, unanticipated service conditions, impropermaterial selection, improper service condition etc. Examples of component failures in(metals, ceramics and plastics. (8 hours) **References/Text Books:** 1. Source book in failure analysis, American Society of Metals, Metals Park, Ohio, 1974.2. Understanding how components fail , D.J Wulpi, ASM International, The MaterialsInformation Society, 1 999.3. A.J. McEvily, Metal Failures: Mechanisms, Analysis, Prevention, Jolm Wiley and Sons,2002.4. Practical engineering failure analysis, H.M. Tawancy, A. UlHamid and N.M. Abbas,Marcel Dekker, New York, 2004.5. Failure analysis and prevention, Volume II , ASM Handbook, The MaterialsInformation Society, 2002.6. Failure analysis of engineering structures: Methodology and ase Histories, V.Ramachandran, A.C. Raghuram, R.V. Krishnan and S.K. Bhaumik , ASM International,2005.	MATERIALS FAILURE: ANALYSIS AND PREVENTION
MSE676A	3-0-0-0-9		**Course Contents:** 1. Introduction to Failure analysis and prevention: Concepts, root causes analysis, primary rootcauses, design deficiencies, material defects, manufacturing/installation defects, categoriesof failure, failure prevention (4 hours)2. Failure Analysis: Processes, objectives, planning and preparation, practices and procedures.(3 hours)l 3. Fracture modes, Ductile fracture of metallic . materials and their interpretations, factorsaffecting ductilebrittle relationships. (3 hours)4. Failure characteristics of Ceramics and Plastics (2 hours)5. Brittle fracture in normally ductile metallic alloy, microstructural aspects of brittle fracture(2 hours)6. Fatigue	MATERIALS FAILURE: ANALYSIS AND PREVENTION

			fracture, macroscopic and microscopic characteristics, statistical aspects of fatigue,Fatigue failure prediction and life assessment. (3 hours)7. Wear Failures and Prevention (2 hours)rt:Y8. Corrosion related failures, Stress corrosion cracking, Hydrogen damage and embrittlement,Biological corrosion failures. (2 hours)9. Elevated temperature failures, creep and stress rupture, metallurgical instabilities(2 hours)I 0. Distortion failures and deformations (2 hours)11. Structural life assessment methods, Nondestructive techniques. (2 hours)12. Tools and techniques in failure analysis: General Practices, Photography, Xrays,Metallographic techniques, Fractography,, (4 hours)13. Illustrative 'Case studies of engineering failure ' due to: improper processing practice,improper treatment procedure, improper design, unanticipated service conditions, impropermaterial selection, improper service condition etc. **References/Text Books:** 1. Source book in failure analysis, American Society of Metals, Metals Park, Ohio, 1974.2. Understanding how components fail , D.J Wulpi, ASM International, The MaterialsInformation Society, 1 999.3. A.J. McEvily, Metal Failures: Mechanisms, Analysis, Prevention, Jolm Wiley and Sons,2002.4. Practical engineering failure analysis, H.M. Tawancy, A. UlHamid and N.M. Abbas,Marcel Dekker, New York, 2004.5. Failure analysis and prevention, Volume II , ASM Handbook, The MaterialsInformation Society, 2002.6. Failure analysis of engineering structures: Methodology and ase Histories, V.Ramachandran, A.C. Raghuram, R.V. Krishnan and S.K. Bhaumik , ASM International,2005.	
MSE680	3-0-0--4		**Course Contents:** Grain boundary structure : Geometrical aspects, Degress of freedom, Principlesgoverning grain shape and size their orientation. Theoretical formulations :Structurals units model, Plane matching model, O Lattice model, Specialboundaries, CSL and DSC Lattice. Boundary energy and equilibria, Grain Boundarytypes, GB mobility and boundary solute interactions. GB structure and Properties:mechanical strength wear, creep magnetic, electrical etc. Simulation andmodeling . Grain boundary engineering strategy : Deformation, thermomechanicaltreatment trace additions, Magnetic Field etc. GB descriptors : Connectivity,density junction distribution, Character distribution. Boundary CharacterizationTools : Xray, EBSDOIM, CTEM, AEM, HRTEM, etc. Macrotexture analysis : Polefigure measurement, Xray diffraction, neutron diffraction methods. Microtextureanalysis : Automated EBSD Kikuchi pattern, Houghs transform, SEMOIM basedTEM based, Schemes for representation of Data Prospective applications:Superplasticity. Creep resistance, Corrosion Resistance, Superconductivity,Electronic ceramics etc. **References/Text Books:**	GRAIN BOUNDARY ENGINEERING
MSE680A	3-0-0-0-9		**Course Contents:** Grain boundary structure : Geometrical aspects, Degress of freedom, Principlesgoverning grain shape and size their orientation. Theoretical formulations :Structurals units model, Plane matching model, O Lattice model, Specialboundaries, CSL and DSC Lattice. Boundary energy and equilibria, Grain Boundarytypes, GB mobility and boundary solute interactions. GB structure and Properties:mechanical strength wear, creep magnetic, electrical etc. Simulation andmodeling . Grain boundary engineering strategy : Deformation, thermomechanicaltreatment trace additions, Magnetic Field etc. GB descriptors : Connectivity,density junction distribution, Character distribution. Boundary CharacterizationTools : Xray, EBSDOIM, CTEM, AEM, HRTEM, etc. Macrotexture analysis : Polefigure measurement, Xray diffraction, neutron diffraction methods. Microtextureanalysis : Automated EBSD Kikuchi pattern, Houghs transform, SEMOIM basedTEM based, Schemes for representation of Data Prospective applications:Superplasticity. Creep resistance, Corrosion Resistance, Superconductivity,Electronic ceramics etc. **References/Text Books:**	GRAIN BOUNDARY ENGINEERING
MSE681	3-0-0-0-4		**Course Contents:** 1. Introduction to the course. 2. Solar Spectrum. 3. Available solar energy technologies.4. Solar Thermal Energy Conversion. a. Fundamentals. b. Materials and Technologies.c. Applications. d. Present status. 5. Photovoltaic Devices and their fundamentals. 6. Solar Electricity Conversion or Solar Photovoltaics. a.	SOLAR ENERGY TECHNOLOGIES AND MATERIALS

			Technologies _b. Materials, devices and issues, 1. First generation technologies Si based.u. Second generation technologies (low cost) thinfilms (aSi, CdTe, CIGS); solarconcentratorsm. Third generation (high efficiency and low cost) Organic solar cells, multijunction,quantum dotsc. Device Characterizationd. Comparative Performance7. PV Processing with emphasis on migration from solar cells to modules to systems8. Present status and Future outlook **References/Text Books:** 1. Thin Films Solar Cells, K.L. Chopra, McGraw Hill2. Physics and Technology of Solar Energy, H. P. Garg, M. Dayal, G. Furlan (1987)a. Volume 1: Solar Thermal Applicationsb. Volume II: Photovoltaic And Solar Energy Materials)l r._c1'L/3. The Physics of Solar Cells (Properties ofSemiconductor Materials) , Jenny Nelson4. Third Generation Photovoltaics: Advanced Solar Energy Conversion (Springer Series inPhotonics) by M.A. Green5. Flexible Solar Cells by Mario Pagliaro, Giovanni Palmisano, and Rosaria Cirirninna (HardoverDec 10, 2008)6. Physics of Solar Cells: From Basic Principles to Advanced Concepts (Physics Textbook) byPeter W?rfel (Paperback April 13, 2009)	
MSE681A	3-0-0-0-9		**Course Contents:** 1. Introduction to the course. 2. Solar Spectrum. 3. Available solar energy technologies.4. Solar Thermal Energy Conversion. a. Fundamentals. b. Materials and Technologies.c. Applications. d. Present status. 5. Photovoltaic Devices and their fundamentals. 6. Solar Electricity Conversion or Solar Photovoltaics. a. Technologies _b. Materials, devices and issues, 1. First generation technologies Si based.u. Second generation technologies (low cost) thinfilms (aSi, CdTe, CIGS); solarconcentratorsm. Third generation (high efficiency and low cost) Organic solar cells, multijunction,quantum dotsc. Device Characterizationd. Comparative Performance7. PV Processing with emphasis on migration from solar cells to modules to systems8. Present status and Future outlook **References/Text Books:** 1. Thin Films Solar Cells, K.L. Chopra, McGraw Hill2. Physics and Technology of Solar Energy, H. P. Garg, M. Dayal, G. Furlan (1987)a. Volume 1: Solar Thermal Applicationsb. Volume II: Photovoltaic And Solar Energy Materials)l r._c1'L/3. The Physics of Solar Cells (Properties ofSemiconductor Materials) , Jenny Nelson4. Third Generation Photovoltaics: Advanced Solar Energy Conversion (Springer Series inPhotonics) by M.A. Green5. Flexible Solar Cells by Mario Pagliaro, Giovanni Palmisano, and Rosaria Cirirninna (HardoverDec 10, 2008)6. Physics of Solar Cells: From Basic Principles to Advanced Concepts (Physics Textbook) byPeter W?rfel (Paperback April 13, 2009)	SOLAR ENERGY TECHNOLOGIES AND MATERIALS
MSE682	3-0-0-0-4		**Course Contents:** Objective of the course is to introduce students to the field of computational materials science. Thecourse commences with a brief discussion of basic physics and numerical methods, essential for therest of the course. The topics are divided into two major categories, classical and quantum mechanicalsimulation techniques. The first part focuses primarily on two popularly used methods, moleculardynamics and Monte Carlo; discussing basic theory, applications and examples related to materialsscience. The second part focuses on density functional based tight binding (DFTB) method. Basicapplications, such as simple band structure calculation and geometry optimization and advanced topicssuch as electron transport calculations will be discussed. **References/Text Books:** 1. Molecular dynamics simulation: Elementary methods, J. M. Haile (Wiley Professional).2. The art of molecular dynamics simulation, D. C. Rapaport (Cambridge University Press).3. Computer simulation of liquids, Allen and Tildesley (Oxford).4. Computational materials science: an introduction, June Gunn Lee (CRC Press).5. Electronic structure: basic theory and practical mehtods, Richard Martin (Cambridge).	COMPUTER SIMULATIONS IN MATERIALS SCIENCE
MSE682A	3-0-0-0-9		**Course Contents:** Objective of the course is to introduce students to the field of computational materials science. Thecourse commences with a brief discussion of basic physics and numerical methods, essential for therest of the	COMPUTER SIMULATIONS IN MATERIALS SCIENCE

			course. The topics are divided into two major categories, classical and quantum mechanicalsimulation techniques. The first part focuses primarily on two popularly used methods, moleculardynamics and Monte Carlo; discussing basic theory, applications and examples related to materialsscience. The second part focuses on density functional based tight binding (DFTB) method. Basicapplications, such as simple band structure calculation and geometry optimization and advanced topicssuch as electron transport calculations will be discussed. **References/Text Books:** 1. Molecular dynamics simulation: Elementary methods, J. M. Haile (Wiley Professional).2. The art of molecular dynamics simulation, D. C. Rapaport (Cambridge University Press).3. Computer simulation of liquids, Allen and Tildesley (Oxford).4. Computational materials science: an introduction, June Gunn Lee (CRC Press).5. Electronic structure: basic theory and practical mehtods, Richard Martin (Cambridge).	
MSE683	3-0-0-0-4		**Course Contents:** Introduction to crystallographic texture.Refresher on Xray diffraction: basic diffraction concepts, reciprocal space,instrumentation and geometry.Basics of neutron and synchrotron diffraction and comparison.Texture data representation: pole figures, inverse pole figures, orientationdistribution function.Measurement of pole figures: experimental details, data processing, indexingDetermination of Orientation Distribution Function and Misorientation.distribution Function: calculation techniques, different notations, 3D and 2Drepresentation.Introduction to Electron Back Scatter Diffraction and microtexture: instrumentation, sample preparation, data acquisition and analysis.Mechanisms of evolution of texture during processing: solidification, phasetransformation, deformation, annealing.Modelling texture evolution.Texture evolution and measurement in thin films.Grain boundary engineering: Principle, practice and applications.Material formability and texture.Functional properties and texture. **References/Text Books:** 1. An Introduction to Texture in Metals; M. Heatherly, W. B. Hutchinson, Monograph no. 5, The Institution of Metallurgist London 1979.2. Introduction to Texture Analysis: Macrotexture, Microtexture, and Orientation Mapping;0. Engler, V. Randle, CRC Press, 2010.3. Texture and Anisotropy: Preferred Orientations in Polycrystals and their Effect on Materials Properties; U. F. Kocks, C. N. Tome, H.R. Wenk, Cambridge University Press, 2000.4. Research publications on: Texture manipulation and control; Microstructural engineering ; and Grain boundary engineering.	CRYSTALLOGRAPHIC TEXTURE & MECROSTRUCTURAL ENGINEERING
MSE683A	3-0-0-0-9		**Course Contents:** Introduction to crystallographic texture.Refresher on Xray diffraction: basic diffraction concepts, reciprocal space,instrumentation and geometry.Basics of neutron and synchrotron diffraction and comparison.Texture data representation: pole figures, inverse pole figures, orientationdistribution function.Measurement of pole figures: experimental details, data processing, indexingDetermination of Orientation Distribution Function and Misorientation.distribution Function: calculation techniques, different notations, 3D and 2Drepresentation.Introduction to Electron Back Scatter Diffraction and microtexture: instrumentation, sample preparation, data acquisition and analysis.Mechanisms of evolution of texture during processing: solidification, phasetransformation, deformation, annealing.Modelling texture evolution.Texture evolution and measurement in thin films.Grain boundary engineering: Principle, practice and applications.Material formability and texture.Functional properties and texture. **References/Text Books:** 1. An Introduction to Texture in Metals; M. Heatherly, W. B. Hutchinson, Monograph no. 5, The Institution of Metallurgist London 1979.2. Introduction to Texture Analysis: Macrotexture, Microtexture, and Orientation Mapping;0. Engler, V. Randle, CRC Press, 2010.3. Texture and Anisotropy: Preferred Orientations in Polycrystals and their Effect on Materials Properties; U. F. Kocks, C. N. Tome, H.R. Wenk, Cambridge University Press, 2000.4. Research publications on: Texture manipulation and control; Microstructural engineering ; and Grain boundary engineering.	CRYSTALLOGRAPHIC TEXTURE & MECROSTRUCTURAL ENGINEERING

MSE685	3-0-0--4		**Course Contents:** Surface science; experimental techniques to study surfaces; kinetics of surfaceprocesses impingement of atoms, scattering, adsorption, sticking coefficient;Film nucleation and growth mechanisms, critical radius of nuclei, computersimulation of film growth, microstructure evolution; Film growth by evaporation,sputtering, chemical vapour deposition, atomic layer epitaxy, liquid phaseepitaxy, solgel technique etc, Electrical, optical, magnetic and mechanicalproperties of thin films and their applications. **References/Text Books:**	THIN FILM PHYSICS & APPLICATIONS
MSE686	3-0-0-0-4		**Course Contents:** contents: Review of semiconductor physics, carrier statistics, generationrecombination and carrier transport. Devices: PN junctions, Schottky barrier diodes, MOS capacitors, field effect transistors.Planar technology and process flows for PN junctions and Schottky diodes. Oxidation, diffusion (oxidation enhanced diffusion, transient enhanced diffusion), ionimplantation, deposition (chemical and physical vapour techniques), etching; Lithography; Device and process integration, withMOSFET as an example. **References/Text Books:** I . Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects, D.Michael Ashby, Paulo Ferreira. Daniel L. Schodek , ButterworthHeinemann, 2009.2. Handbook ofNanophase and Nanostructured i!Jaterials (in jour volume.). Ed: Z.L. Wang, Y.Liu, Z. Zhang, Kluwer Academic/Plenum Publishers, 2003.3. Encyclopedia ofNanoscience and Nanotechnology, Ed.: Hari Singh Nalwa, AmericanScientific Publishers, 2004.4. Handbook ojNanoceramics and their Based Nanodevices (Vol. 2) Edited by T eungYuenTyeng and Hari Singh NahFa, American Scientific Publishers.	SEMI CONDUCTOR DEVICES AND PROCESSING
MSE688	3-0-0--4		**Course Contents:** Definition and Classification of Nanomaterials, Fundamental Properties of variousprimary material classes (Metals, ceramics and Polymers), Size dependentproperties and various characterization techniques of Nanomaterials, Synthesis/ Consolidation routes to produce Nanomaterials, Mechanochemical synthesisto produce nanosized precursor powders, Various routes to produce Nanometallicalloys (Rapid solidification), Challenges in processing bulk ceramic nanomaterials,Various densification routes for nanoceramics and nanoceramic composites,Processing structureproperties of important bulk nanomaterials, MechanicalProperties, Thermal properties, Tribological Properties, Biological Properties(Biomedical applications), Applications of bulk nanomaterials, Critical issuesrelated to understanding properties of nanomaterials. **References/Text Books:**	NANOMATERIALS: PROCESSING AND PROPERTIES
MSE689	3-0-0--4		**Course Contents:** Fundamentals of oxides : crystal structure, defect chemistry, and properties;focus on various material systems methods of fabrication e.g. solid statechemistry. Oxide thin films. polycrystalline versus epitaxial, main film depositiontechniques: physical vapor and chemical deposition methods, PVD techniques:sputtering (fundamentals of glow discharge processes and film deposition RFand DC magnetron sputtering new approaches), laser ablation (basic science,applications, various approaches), science and technology of evaporation andmolecular beam epitaxy (MBE) Chemical processes basic and technological issuesof solgel chemical vapor deposition atomic layer deposition; PVD visa vischemical processes; issues related to epitaxy and case studies. Characterizationmethods : Structural techniques uses of X ray diffraction, atomic forcemicroscopy scanning and transmission electron microscopy, spetroscopic methods;Electrical Measurements. Devices types of devices, fabrication: fundamentalsand issues; Lithographic methods: conventional and next generation, FIB (fieldion) techniques, Nanofabrication: principles, processes and issues, Use ofScanning force microscopy in nanofabrication case studies. **References/Text Books:**	MULTI FUNCTIONAL OXIDES: THIN FILMS & DEVICE

MSE689A	3-0-0-0-9		**Course Contents:** Fundamentals of oxides : crystal structure, defect chemistry, and properties;focus on various material systems methods of fabrication e.g. solid statechemistry. Oxide thin films. polycrystalline versus epitaxial, main film depositiontechniques: physical vapor and chemical deposition methods, PVD techniques:sputtering (fundamentals of glow discharge processes and film deposition RFand DC magnetron sputtering new approaches), laser ablation (basic science,applications, various approaches), science and technology of evaporation andmolecular beam epitaxy (MBE) Chemical processes basic and technological issuesof solgel chemical vapor deposition atomic layer deposition; PVD visa vischemical processes; issues related to epitaxy and case studies. Characterizationmethods : Structural techniques uses of X ray diffraction, atomic forcemicroscopy scanning and transmission electron microscopy, spetroscopic methods;Electrical Measurements. Devices types of devices, fabrication: fundamentalsand issues; Lithographic methods: conventional and next generation, FIB (fieldion) techniques, Nanofabrication: principles, processes and issues, Use ofScanning force microscopy in nanofabrication case studies. **References/Text Books:**	MULTI FUNCTIONAL OXIDES: THIN FILMS & DEVICE
MSE690	0-0-0-0-0		**Course Contents:** Seminar Participation **References/Text Books:**	SEMINAR PARTICIPATION
MSE690A	0-0-0-0-0		**Course Contents:** Seminar Participation **References/Text Books:**	SEMINAR PARTICIPATION
MSE691	0-0-0-0-0		**Course Contents:** Seminar Participation **References/Text Books:**	SEMINAR PRESENTATION
MSE691A	0-0-0-0-0		**Course Contents:** Seminar Participation **References/Text Books:**	SEMINAR PRESENTATION
MSE693	3-0-0-0-4		**Course Contents:** Introduction to integrating nanotechnology and materials science with life sciences : Introduction to various size regimes in life science and materials science Importance of integration of materials science and engineering with life sciencesProteins and DNA: Structure and properties : Cells organelles and building blocks of important molecules in cell (1) Protein structure, organization, functions with emphasis on antibodies and enzymes, regulation of enzyme activity, protein phosphorylation DNA: structure and function of DNA, DNA replication and repair Microfabrication techniques and soft lithography; Fundamentals of bioMEMS, microfluidic devices and Labonchip devices Materials for MEMS Photolithography: (single crystal silicon, mask, oxide formation, resist application, baking, exposure, positive and negative resist, developing, etching. Etching: Dry Vs wet and isotropic Vs anisotropic, plasma (DC arc and RF), DRIE, wet bulk surface micromachining, 3D structure with sacrificial layer, LIGA Deposition: physical and chemical vapour deposition Soft fabrication: application of polymers in bioMEMS, microcontact printing, microtransfer moling, micromolding in capillaries, injection molding, hot embossingBiocompatibility : Definition of biocompatibility, host response to implanted device, in vivo and in vitro tests for biocompatibility Overview of immune system (inntate and adaptive immunity, cell mediated and humoral immunity), B cells, T cells, MHC	MATERIALS SCIENCE TECHNOLOGIES FOR APPLICATIONS IN LIFE SCIENCES

			References/Text Books: 1. B. Alberts eta/., Essential Cell Biology. (Garland Publishing Inc., New York, ed. Third, 2009).2. S. S. Saliterman, Fundamentals of bioMEMS and medical microdevices. (Wileylnterscience,Bellingham, 2005).3. T.J. Kindt eta/., Kyby immunology. (W.H. Freeman, 61h edition 2007)4. C. S. S. R. Kumar, Biofunctionalization of Nanomaterials. C. S. S. R. Kumar, Ed., Nanotechnologiesfor the life sciences (WileyVCH, Weinheim, 2006), vol. 1, pp. 366.5. C. S. S. R. Kumar, Nanomaterials for biosensors. C. S. S. R. Kumar, Ed., Nanotechnologies for thelife sciences (WileyVCH, Weinheim, 2006), vol. 8.6. C. S. S. R. Kumar, Nanosystem characterization tools in the life sciences. C. S. S. R. kumar, Ed.,Nanotechnologies for the life sciences (WileyVCH, Weinheim, 2005), vol. 3.7. J. M. Anderson, Annu Rev of Matl Res, 31, 81 (2001)	
MSE693A	3-0-0-0-9		**Course Contents:** Introduction to integrating nanotechnology and materials science with life sciences : Introduction to various size regimes in life science and materials science Importance of integration of materials science and engineering with life sciencesProteins and DNA: Structure and properties : Cells organelles and building blocks of important molecules in cell (1) Protein structure, organization, functions with emphasis on antibodies and enzymes, regulation of enzyme activity, protein phosphorylation DNA: structure and function of DNA, DNA replication and repair Microfabrication techniques and soft lithography; Fundamentals of bioMEMS, microfluidic devices and Labonchip devices Materials for MEMS Photolithography: (single crystal silicon, mask, oxide formation, resist application, baking, exposure, positive and negative resist, developing, etching. Etching: Dry Vs wet and isotropic Vs anisotropic, plasma (DC arc and RF), DRIE, wet bulk surface micromachining, 3D structure with sacrificial layer, LIGA Deposition: physical and chemical vapour deposition Soft fabrication: application of polymers in bioMEMS, microcontact printing, microtransfer moling, micromolding in capillaries, injection molding, hot embossingBiocompatibility : Definition of biocompatibility, host response to implanted device, in vivo and in vitro tests for biocompatibility Overview of immune system (innntate and adaptive immunity, cell mediated and humoral immunity), B cells, T cells, MHC **References/Text Books:** 1. B. Alberts eta/., Essential Cell Biology. (Garland Publishing Inc., New York, ed. Third, 2009).2. S. S. Saliterman, Fundamentals of bioMEMS and medical microdevices. (Wileylnterscience,Bellingham, 2005).3. T.J. Kindt eta/., Kyby immunology. (W.H. Freeman, 61h edition 2007)4. C. S. S. R. Kumar, Biofunctionalization of Nanomaterials. C. S. S. R. Kumar, Ed., Nanotechnologiesfor the life sciences (WileyVCH, Weinheim, 2006), vol. 1, pp. 366.5. C. S. S. R. Kumar, Nanomaterials for biosensors. C. S. S. R. Kumar, Ed., Nanotechnologies for thelife sciences (WileyVCH, Weinheim, 2006), vol. 8.6. C. S. S. R. Kumar, Nanosystem characterization tools in the life sciences. C. S. S. R. kumar, Ed.,Nanotechnologies for the life sciences (WileyVCH, Weinheim, 2005), vol. 3.7. J. M. Anderson, Annu Rev of Matl Res, 31, 81 (2001)	MATERIALS SCIENCE TECHNOLOGIES FOR APPLICATIONS IN LIFE SCIENCES
MSE693N	3-0-0-0-4		**Course Contents:** Introduction to integrating nanotechnology and materials science with life sciences Introduction to various size regimes in life science and materials science. Importance of integration of materials science and engineering with life sciences Proteins and DNA: Structure and properties Cells organelles and building blocks of important molecules in cell (1) Protein structure, organization, functions with emphasis on antibodies and enzymes, regulation of enzyme activity, protein phosphorylation DNA: structure and function of DNA, DNA replication and repair Microfabrication techniques and soft lithography; Fundamentals of bioMEMS, microfluidic devices and Labonchip devices Materials for MEMS Photolithography: (single crystal silicon, mask, oxide formation, resist application, baking, exposure, positive and negative resist, developing, etching. Etching: Dry Vs wet and isotropic Vs anisotropic, plasma (DC arc and RF), DRIE, wet bulk surface micromachining, 3D structure with sacrificial layer, LIGA Deposition: physical and chemical vapour deposition Soft fabrication: application of polymers in bioMEMS, microcontact printing, microtransfer moling, micromolding in capillaries, injection molding, hot embossing Biocompatibility Definition of biocompatibility, host response to implanted device, in vivo and in vitro tests for	MATERIALS SCIENCE TECHNOLOGIES FOR APPLICATIONS IN LIFE SCIENCES

			biocompatibility Overview of immune system (innntate and adaptive immunity, cell mediated and humoral immunity), B cells, T cells, MHC Self assembly: Structure, Mechanism and Applications Difference between self assembly and self organization, example (organothiol molecules on gold substrate) Techniques for assembly: microcontact printing,_ dip pen nanolithography Layer by layer self assembly: methods, materials applications Application of multilayer biofilm and ultrathin coatings on medical implants **References/Text Books:** 1. B. Alberts eta/., Essential Cell Biology. (Garland Publishing Inc., New York, ed. Third, 2009).2. S. S. Saliterman, Fundamentals of bioMEMS and medical microdevices. (Wileylnterscience,Bellingham, 2005).3. T.J. Kindt eta/., Kyby immunology. (W.H. Freeman, 61 h edition 2007)4. C. S. S. R. Kumar, Biofunctionalization of Nanomaterials. C. S. S. R. Kumar, Ed., Nanotechnologies for the life sciences (WileyVCH, Weinheim, 2006), vol. 1, pp. 366.5. C. S. S. R. Kumar, Nanomaterials for biosensors. C. S. S. R. Kumar, Ed., Nanotechnologies for the life sciences (WileyVCH, Weinheim, 2006), vol. 8.6. C. S. S. R. Kumar, Nanosystem characterization tools in the life sciences. C. S. S. R. kumar, Ed., Nanotechnologies for the life sciences (WileyVCH, Weinheim, 2005), vol. 3.7. J. M. Anderson, Annu Rev of Matl Res, 31, 81 (2001)	
MSE694	3-0-0-0-4		**Course Contents:** Overview of Nanostructures and Nanomaterials: classification (Dimensionality, Morphology/ shape/structure of nanoentities, New Effect/ Phenomena). Crystallinenanomaterials and defects therein. Hybrid nanomaterials. Effect of size, structure,mechanism, and property on material performanc?. Multiscale hierarchical structures built out of nanosized building blocks (nano to macro). Eucledian, Hyperbolic and Spherical space structures. Nanostructures: Carbon Nanotubes, Fullerenes, Nanowires, Graphene, Quantum Dots. Thermodynamics of Nanomaterials. Configurational entropy and Gibbs free energy of nanocrystals. Wulff reconstruction. Surface reconstruction and reconfiguration. Adsorption and Absorption. **References/Text Books:** 1. Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects, D.Michael Ashby, Paulo Ferreira, Daniel L. Schodek, ButterworthHeinemann, 2009.2. Handbook of Nanophase and Nanostructured Materials (in four volumes), Eds: Z.L. Wang, Y. Liu, Z.Zhang, Kluwer Academic/Plenum Publishers, 2003.3. Encyclopedia of Nanoscience and Nanotechnology, Ed.: Hari Singh Nalwa, American ScientificPublishers, 2004.4. Handbook of Nanoceramics and their Based Nanodevices (Vol. 2} Edited by TseungYuen Tseng andHari Singh Nalwa, American Scientific Publishers.5. Introduction to Nanoscience, G.L. Hornyak, J. Dutta, H. F. Tibbals, A.K. Rao, CRC Press (2008).	NANOSTRUCTURES AND NANOMATERIALS: CHARACTERIZATION AND PROPERTIES
MSE694A	3-0-0-0-9		**Course Contents:** Overview of Nanostructures and Nanomaterials: classification (Dimensionality, Morphology/ shape/structure of nanoentities, New Effect/ Phenomena). Crystallinenanomaterials and defects therein. Hybrid nanomaterials. Effect of size, structure,mechanism, and property on material performanc?. Multiscale hierarchical structures built out of nanosized building blocks (nano to macro). Eucledian, Hyperbolic and Spherical space structures. Nanostructures: Carbon Nanotubes, Fullerenes, Nanowires, Graphene, Quantum Dots. Thermodynamics of Nanomaterials. Configurational entropy and Gibbs free energy of nanocrystals. Wulff reconstruction. Surface reconstruction and reconfiguration. Adsorption and Absorption. **References/Text Books:** 1. Nanomaterials, Nanotechnologies and Design: an Introduction to Engineers and Architects, D.Michael Ashby, Paulo Ferreira, Daniel L. Schodek, ButterworthHeinemann, 2009.2. Handbook of Nanophase and Nanostructured Materials (in four volumes), Eds: Z.L. Wang, Y. Liu, Z.Zhang, Kluwer Academic/Plenum Publishers, 2003.3. Encyclopedia of Nanoscience and Nanotechnology, Ed.: Hari Singh Nalwa, American ScientificPublishers, 2004.4. Handbook of Nanoceramics and their Based Nanodevices (Vol. 2} Edited by TseungYuen Tseng andHari Singh Nalwa, American Scientific Publishers.5. Introduction to Nanoscience, G.L. Hornyak, J. Dutta, H. F. Tibbals, A.K. Rao, CRC Press (2008).	NANOSTRUCTURES AND NANOMATERIALS: CHARACTERIZATION AND PROPERTIES

MSE695	3-0-0-0-4		**Course Contents:** DiiTraction and Spectroscopy Techniques for Surface Course Details: Importance of Smfacc Characterization. Present status sensitivity and resolution achievable.Diffraction Techniques: Revicv.,: of basic diffraction theory; Various Small Angle Xray Scattering techniques, EXAFS. SEXAFS!NEXAFS and its applications; electron cliftl'action,LEED and RHEED. Properties of neutron radiation: neutron sources: Small angle neutron scattering; lllustrative analysis using diffraction techniques Spectroscopy: Basic principles of Spectroscopy. Principles of XPS, Instrumentation, XPSpatterns, Quantitative analysis. Chemical effect, Chemical shilL XPS imaging; Auger electron generation: Principle of AES. Chemical e1Tect, Quantitative analysis, Depth profiling,Applications; Static and Dynamic SlMS, Common modes of analysis, quantitative and Qualitative analysis; Case studies on the spectroscopic analysis of surfaces. **References/Text Books:** l. Encycleopedia ofMateria!s Characterisation, C. R. Brunelle. C. A. Evans and S. Vilson,ButterworthHennmann, 1992. Boston.2. Characterisation ofMaterials Volume 2. Editor:E.N. Kaufmann, Wileylnterscience. 2003.New Jersey.3. Surface Anctvsis kfethods in ;Hateria!s Science. D. J. oconnors, B.A. Sexton. and R. St. Smart, Springer (2003).4. Materials Charocterization. published in 1986 as Volume l 0 of the 9th Edition MetalsHandbook, ASM International. 1986 (Fifth printing 1998).	DIFFRACTION AND SPECTROSCOPY TECHNIQUES FOR SURFACE CHARACTERISATION
MSE698	----		**Course Contents:** SEMINAR PARTICIPATION **References/Text Books:**	SEMINAR PARTICIPATION
MSE699	0-0-0-0-0		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M.TECH THESIS
MSE799	0-0-0-0-		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PH D THESIS
TA201A	1-0-3-0-6		**Course Contents:** Introduction to manufacturing:Evolution of manufacturing, Engineering materials classification, Evolution of manufacturing and its classifications. Engineering Materials: Structure of materials, Types of materials, Properties of materials, Microstructureproperty interrelationship. Casting/ Solidification: Classifications of casting processes, Patterns, Core making, Gating system, Solidificationof pure metals and alloys, shrinkage, gas solubility, Riser design, Investment casting, Casting defects. Joining processes: Fusion welding: Arc (MMAW, SAW, SMAW), Gas welding and resistance welding, Fusion zone, Heat affected zone (HAZ), Brazing and Soldering, Solid state welding processes, Thermit welding. Deformation processes: Engineering stressstrain curve, Effect of temperature on the workability, Extrusion (direct and indirect)Rolling classification, roll camber, defects, Forging (open and closeddie) Wire drawing, Defects, Sheetmetal forming. Powder metallurgy: Introduction, Powder production, Compaction, and Sintering, Engineering stressstrain curve. Plastic injection molding: Flow forming of plastic components. Heat Treatment: Special techniques (Nonconventional techniques). **References/Text Books:**	MANUFACTURING PROCESSES I
TA201N	1-0-6-0-3		**Course Contents:** Introduction to Manufacturing, Historical perspective; Importance ofmanufacturing; Classification of manufacturing processes, Engineering materials,Casting, Fundamentals of casting, Sand casting, Permanent mold castingincluding pressure die casting, Shell, investment & centrifugal casting processes,Continuous	INTRODUCTION TO MANUFACTURING PROCESSES

			casting, Casting defects, Metal Forming, Basic concepts of plasticdeformation, Hot & cold working, Common bulk deformation processes (Rolling,Forging, Extrusion and Drawing), Common sheet metal forming processes,Machining, Chip formation and generation of machined surfaces, Tool geometry,tool material, tool wear and practical machining operations (turning, millingand drilling), Grinding processes, Finishing processes, Introduction tounconventional machining processes (EDM, ECM, UCM, CHM, LBM) etc., Welding& Other Joining Processes, Fundamentals of welding & classification of weldingprocesses, Gas and arc welding, Brazing and soldering, Adhesive bonding,Mechanical fastening, Heat Treatment, Principles of heat treating; annealing,normalizing, hardening and tempering, Manufacturing of Polymer and PowderProducts, Classification of polymers, Introduction to extrusion, injection molding,blow molding, compression and transfer molding , Green compacts from powdersincluding slip casting of ceramics, Sintering, Modern Trends in Manufacturing. **References/Text Books:**	
***** Department of MTH *****				
ESO209	3-1-0-1-4		**Course Contents:** Probability: Axiomatic definition, properties, conditional probability, Bayes' rule andindependence of events. Random variables, distribution function, probability mass and densityfunctions, expectation, moments, moment generating function, Chebyshev's inequality. Specialdistributions; Bernoulli, binomial, geometric, negative binomial, hypergeometric, Poisson,exponential, gamma, Weibull, beta, Cauchy, double exponential, normal. Reliability and hazardrate, reliability of series and parallel systems. Joint distributions, marginal and conditionaldistributions, moments, independence of random variables, covariance and correlation. Functionsof random variables. Weak Law of large numbers and Central limit theorems.Statistics: Descriptive statistics, graphical representation of the data, measures of location andvariability. Population, sample, parameters. Point estimation; method of moments, maximumlikelihood estimator, unbiasedness, consistency. Confidence intervals for mean, difference ofmeans, proportions. Testing of hypothesis; Null and alternate hypothesis, Neyman Pearsonfundamental lemma, Tests for one sample and two sample problems for normal populations, testsfor proportions. **References/Text Books:** 1. Introduction to Mathematical Statistics, by R V Hogg, A Craig and J W McKean.2. An Introduction to Probability and Statistics by V.K. Rohatgi & A.K. Md. E. Saleh.3. "Introduction to Probability and Statistics by 1.S. Milton & J.C. Arnold.4. Introduction to Probability Theory and Statistical Inference by H.J. Larson.5. Introduction to Probability and Statistics for Engineers and Scientists by S.M. Ross	PROBABILITY AND STATISTICS
MSO201A	3-1-0-0-11		**Course Contents:** Probability: Axiomatic definition, properties, conditional probability, Bayes' rule andindependence of events. Random variables, distribution function, probability mass and densityfunctions, expectation, moments, moment generating function, Chebyshev's inequality. Specialdistributions; Bernoulli, binomial, geometric, negative binomial, hypergeometric, Poisson,exponential, gamma, Weibull, beta, Cauchy, double exponential, normal. Reliability and hazardrate, reliability of series and parallel systems. Joint distributions, marginal and conditionaldistributions, moments, independence of random variables, covariance and correlation. Functionsof random variables. Weak Law of large numbers and Central limit theorems.Statistics: Descriptive statistics, graphical representation of the data, measures of location andvariability. Population, sample, parameters. Point estimation; method of moments, maximumlikelihood estimator, unbiasedness, consistency. Confidence intervals for mean, difference ofmeans, proportions. Testing of hypothesis; Null and alternate hypothesis, Neyman Pearsonfundamental lemma, Tests for one sample and two sample problems for normal populations, testsfor proportions. **References/Text Books:** 1. Introduction to Mathematical Statistics, by R V Hogg, A Craig and J W McKean.2. An Introduction to Probability and Statistics by V.K. Rohatgi & A.K. Md. E. Saleh.3. "Introduction to Probability and Statistics	PROBABILITY AND STATISTICS

			by 1.S. Milton & J.C. Arnold.4. Introduction to Probability Theory and Statistical Inference by H.J. Larson.5. Introduction to Probability and Statistics for Engineers and Scientists by S.M. Ross	
MSO203	3-1-0-0-2		**Course Contents:** Sturm Liouville BVP: introduction, examples. Sturm Liouville BVP: orthogonal functions, Sturm Liouville expansions. Fourier series, convergence of Fourier series, Fourier series with arbitrary period. Fourier series: sine and cosine series, half range expansion. Fourier integrals, Fourier:Legendre series. Fourier transform. Introduction to PDE, linear, nonlinear (semi linear, quasi linear) examples, order of PDEs. First order (linear, semi linear) PDEs, interpretation, method of characteristics. First order (linear, semi linear) PDEs, general solutions. First order quasi linear PDEs, interpretation, method of characteristics, general solutions. Classification of 2nd order PDEs, Canonical form: hyperbolic equations. Canonical form: parabolic equations, elliptic equations. Wave equations: DfAlembertfs formula, Duhamelfs principle. Wave equations: solutions for initial boundary value problems. Heat equation: uniqueness and maximum principle, applications. Heat equation: solutions for initial boundary value problems. Laplace and Poisson equations: Uniqueness and maximum principle for Dirichlet problem. Laplace and Poisson equations: BVP in 2D (rectangular, polar). Laplace and Poisson equations: BVP in 3D (spherical, cylindrical) **References/Text Books:** 1. E. Kreyszig. Advanced Engineering Mathematics. (8th Edition) 2. T. Amarnath. An Elementary Course in Partial Differential Equations.	PARTIAL DIFFERENTIAL EQUATIONS
MSO203B	3-1-0-0-6		**Course Contents:** Sturm Liouville BVP: introduction, examples. Sturm Liouville BVP: orthogonal functions, Sturm Liouville expansions. Fourier series, convergence of Fourier series, Fourier series with arbitrary period. Fourier series: sine and cosine series, half range expansion. Fourier integrals, Fourier:Legendre series. Fourier transform. Introduction to PDE, linear, nonlinear (semi linear, quasi linear) examples, order of PDEs. First order (linear, semi linear) PDEs, interpretation, method of characteristics. First order (linear, semi linear) PDEs, general solutions. First order quasi linear PDEs, interpretation, method of characteristics, general solutions. Classification of 2nd order PDEs, Canonical form: hyperbolic equations. Canonical form: parabolic equations, elliptic equations. Wave equations: DfAlembertfs formula, Duhamelfs principle. Wave equations: solutions for initial boundary value problems. Heat equation: uniqueness and maximum principle, applications. Heat equation: solutions for initial boundary value problems. Laplace and Poisson equations: Uniqueness and maximum principle for Dirichlet problem. Laplace and Poisson equations: BVP in 2D (rectangular, polar). Laplace and Poisson equations: BVP in 3D (spherical, cylindrical) **References/Text Books:** 1. E. Kreyszig. Advanced Engineering Mathematics. (8th Edition) 2. T. Amarnath. An Elementary Course in Partial Differential Equations.	PARTIAL DIFFERENTIAL EQUATIONS
MTH100	2-0-0-0-0		**Course Contents:** Mathematical thought process: Proofs by construction, existence, specialization,induction, contradiction, Abstraction, Sets: Russels paradox, Axiom of Choice,Counting, Infinity, Continuum Hypothesis, Numbers:Real numbers, Cantorsdiagonalization arguments, e, p, Complex numbers, Fundamental theorem ofalgebra, Fermats last theorem, Goldbachs conjecture, Analysis: Existence ofnowhere differentiable functions, Zenos paradoxinfinite series, Geometry:Eulers theorem, Mobius strip, Trisection of an angle, Squaring a circle, Euclidsparallel postulate, NonEuclidean geometries, Mathematical structures: Euclideanstructure, Metric spaces, Hilbert spaces, Topology, Groups, Rings, Modules,Vector spaces, Algebraic geometry, Networks, Map coloring, Graphs,Computation:Iteration Approximations, Computability, ChurchTuring thesis **References/Text Books:**	INTRODUCTION TO PROFESSION
MTH101A	3-1-0-0-11		**Course Contents:**	MATHEMATICS I

			Real numbers, Sequences; Series; Power series, Limit, Continuity; Differentiability, Mean value theorems and applications; Linear Approximation, Newton and Picard L-T-P-D-[C] 3-1-0-1-[4] L-T-P-D-[C] 2-0-0-0-[0] L-T-P-D-[C] 3-1-0-1-[4] 313 method, Taylor¿s theorem (one variable), Approximation by polynomials, Critical points, convexity, Curve tracing, Riemann Integral, fundamental theorems of integral calculus, Improper integrals, Trapezoidal and Simpson¿s rule; error bounds, Space coordinates, lines and planes, Polar coordinates, Graphs of polar equations; Cylinders, Quadric surfaces, Volume, Area, length; Continuity, Differentiability of vector functions, arc length; Curvature, torsion, Serret-Frenet formulas, Functions of two or more variables, partial derivatives Statement only, of Taylor¿s theorem and criteria for maxima/Minima/saddle points, Double, triple integrals, Jacobians; Surfaces, integrals, Vector Calculus, Green, Gauss, Stokes Theorems., **References/Text Books:**	
MTH101N	3-1-0-1-4		**Course Contents:** Real numbers, Sequences; Series; Power series, Limit, Continuity; Differentiability, Mean value theorems and applications; Linear Approximation, Newton and Picard method, Taylors theorem (one variable), Approximation by polynomials, Critical points, convexity, Curve tracing, Riemann Integral, fundamental theorems of integral calculus, Improper integrals, Trapezoidal and Simpsons rule; error bounds, Space coordinates, lines and planes, Polar coordinates, Graphs of polar equations; Cylinders, Quadric surfaces, Volume, Area, length; Continuity, Differentiability of vector functions, arc length; Curvature, torsion, SerretFrenet formulas, Functions of two or more variables, partial derivatives Statement only, of Taylors theorem and criteria for maxima/Minima/saddle points, Double, triple integrals, Jacobians; Surfaces, integrals, Vector Calculus, Green, Gauss, Stokes Theorems., **References/Text Books:**	MATHEMATICS I
MTH102A	3-1-0-0-11		**Course Contents:** Matrices: matrix operations (Addition, Scalar Multiplication, Multiplication,Transpose, Adjoint and their properties; Special types of matrices (Null, Identity,Diagonal, Triangular, Symmetric, SkewSymmetric, Hermitian, SkewHermitian,Orthogonal, Unitary, Normal), Solution of the matrix Equation Ax b; RowreducedEchelon form, Determinants and their properties, Vector Space Rn(R);Subspaces; Linear Dependence/Independence; Basis; Standard Basis of Rn;Dimension; Coordinates with respect to a basis; Complementary Subspaces;Standard Inner product; Norm; GramSchmidt Orthogonalization Process;Generalization to the vector space Cn(C), Linear Transformation from Rn toRm (motivation, X* AX); Image of a basis identifies the linear transformation;Range Space and Rank; Null Space and Nullity; Matrix Representation of a lineartransformation; Structure of the solutions of the matrix equation Ax b; LinearOperators on Rn and their representation as square matrices; Similar Matricesand linear operators; Invertible linear operators; Inverse of a nonsingularmatrix; Cramers method to solve the matrix equation Ax b; Eigenvalues andeigenvectors of a linear operator; Characteristic Equation; Bounds on eigenvalues;Diagonalizability of a linear operator; Properties of eigenvalues and eigenvectorsof Hermitian, skewHermitian, Unitary, and Normal matrices (including symmetric,skewsymmetric, and orthogonal matrices), Implication of diagonalaizability ofthe matrix A + AT in the real quadratic form XTAX; **References/Text Books:**	MATHEMATICS - II
MTH102N	3-1-0-1-4		**Course Contents:** Matrices: matrix operations (Addition, Scalar Multiplication, Multiplication,Transpose, Adjoint and their properties; Special types of matrices (Null, Identity,Diagonal, Triangular, Symmetric, SkewSymmetric, Hermitian, SkewHermitian,Orthogonal, Unitary, Normal), Solution of the matrix Equation Ax b; RowreducedEchelon form, Determinants and their properties, Vector Space Rn(R);Subspaces; Linear Dependence/Independence; Basis; Standard Basis of Rn;Dimension; Coordinates with respect to a basis; Complementary Subspaces;Standard Inner product; Norm; GramSchmidt Orthogonalization Process;Generalization to the vector space Cn(C), Linear Transformation from Rn toRm (motivation, X*	MATHEMATICS - II

			AX); Image of a basis identifies the linear transformation;Range Space and Rank; Null Space and Nullity; Matrix Representation of a lineartransformation; Structure of the solutions of the matrix equation Ax b; LinearOperators on Rn and their representation as square matrices; Similar Matricesand linear operators; Invertible linear operators; Inverse of a nonsingularmatrix; Cramers method to solve the matrix equation Ax b; Eigenvalues andeigenvectors of a linear operator; Characteristic Equation; Bounds on eigenvalues;Diagonalizability of a linear operator; Properties of eigenvalues and eigenvectorsof Hermitian, skewHermitian, Unitary, and Normal matrices (including symmetric,skewsymmetric, and orthogonal matrices), Implication of diagonalaizability ofthe matrix A + AT in the real quadratic form XTAX; **References/Text Books:**	
MTH201	3-1-0-0-4		**Course Contents:** Fields and linear equations. Vector spaces. Linear transformations and projections,Determinants. Elementary canonical forms: diagonalization, triangulation,primary decomposition etc. Secondary decomposition theorem, Rational canonicalforms, Jordan canonical forms and some applications. Inner product spaces,Selfadjoint, Unitary and normal operators, Orthogonal projections. Bilinearforms, Symmetric, Skewsymmetric, Positive and semipositive forms etc. **References/Text Books:**	LINEAR ALGEBRA
MTH201A	3-1-0-0-11	MTH102A	**Course Contents:** Fields and linear equations. Vector spaces. Linear transformations and projections,Determinants. Elementary canonical forms: diagonalization, triangulation,primary decomposition etc. Secondary decomposition theorem, Rational canonicalforms, Jordan canonical forms and some applications. Inner product spaces,Selfadjoint, Unitary and normal operators, Orthogonal projections. Bilinearforms, Symmetric, Skewsymmetric, Positive and semipositive forms etc. **References/Text Books:**	A FIRST COURSE IN LINEAR ALGEBRA
MTH201N	3-1-0--4	MTH102N	**Course Contents:** Fields and linear equations. Vector spaces. Linear transformations and projections,Determinants. Elementary canonical forms: diagonalization, triangulation,primary decomposition etc. Secondary decomposition theorem, Rational canonicalforms, Jordan canonical forms and some applications. Inner product spaces,Selfadjoint, Unitary and normal operators, Orthogonal projections. Bilinearforms, Symmetric, Skewsymmetric, Positive and semipositive forms etc. **References/Text Books:**	LINEAR ALGEBRA
MTH202	3-1-0-0-4		**Course Contents:** Permutations and combinations and basic definitions. Generating functions.Polyas enumeration theory. Recurrence relations. Principle of inclusion andexclusion. Balanced incomplete block design. Difference sets. System of distinctrepresentatives. Orthogonal Latin squares. Hadamard matrices. **References/Text Books:**	DISCRETE MATHEMATICS
MTH203N	3-1-0-1-4		**Course Contents:** Introduction and Motivation to Differential Equations, First Order ODE y'f(x,y)geometrical Interpretation of solution, Equations reducible to separable form,Exact Equations, Integrating factor, Linear Equations, Orthogonal trajectories,Picards Theorem for IVP (without proof) and Picards iteration method, EulerMethod, Improved Eulers Method, Elementary types of equations. F(x,y,y') 0; not solved for derivative, Second Order Linear differential equations:fundamental system of solutions and general solution of homogeneous equation.Use of Known solution to find another, Existence and uniqueness of solutionof IVP, Wronskian and general solution of nonhomogeneous equations. EulerCauchy Equation, extensions of the results to higher	MATHEMATICS - III

			order linear equations,Power Series Method application to Legendre Eqn., Legendre Polynomials,Frobenious Method, Bessel equation, Properties of Bessel functions, SturmLiouville BVPs, Orthogonal functions, Sturm comparision Theorem, Laplacetransform, Fourier Series and Integrals, Introduction to PDE, basic concepts,Linear and quasilinear first order PDE, second order PDE and classification ofsecond order semilinear PDE (Canonical form), D Alemberts formula andDuhamels principle for one dimensional wave equation, Laplaces and Poissonsequations, Maximum principle with application, Fourier Method for IBV problemfor wave and heat equation, rectangular region, Fourier method for Laplacesequation in three dimensions, Numerical methods for Laplaces and Poissonsequations. **References/Text Books:**	
MTH204	3-1-0-0-4		**Course Contents:** Some set theoretic notions: Relations, Functions, Partitions, Divisionalgorithm. Various binary operations and examples. Groups and their properties,Subgroups, Cyclic groups and its subgroups, Group of integers and its properties, Fundamentaltheorem of arithmetic. Properties of subgroups, Lagrange theorem. Normal subgroupand Quotient group, Homomorphism, Isomorphism theorems. Symmetric group,Cyclic decomposition of a permutation, Alternating group. Group action, Class equation,Cauchy's theorem, Sylow theorems and their applications. Ring and its properties,Characteristic of a ring, Integral domain, Field, Division ring. Ideals and Quotient ring,Homomorphism, Isomorphism theorems. Polynomial ring, Unique factorization domain,Principal Ideal domain, Euclidean domain, Gaussian ring. **References/Text Books:** 1. Contemporary Abstract Algebra, Joseph A Gallian (Narosa Publishing House, NewDelhi, 1998).2. Algebra, Michael Artin (Prentice Hall of India, New Delhi, 1994).3. Abstract Algebra, John B Fraleigh (Narosa Publishing House, New Delhi, 1988).4. Abstract Algebra, David S Dummit and Richard M Foote (John Wiley & Sons, NewDelhi, 1999).	ALGEBRA I
MTH204A	3-1-0-0-11	MTH102A	**Course Contents:** Some set theoretic notions: Relations, Functions, Partitions, Divisionalgorithm. Various binary operations and examples. Groups and their properties,Subgroups, Cyclic groups and its subgroups, Group of integers and its properties, Fundamentaltheorem of arithmetic. Properties of subgroups, Lagrange theorem. Normal subgroupand Quotient group, Homomorphism, Isomorphism theorems. Symmetric group,Cyclic decomposition of a permutation, Alternating group. Group action, Class equation,Cauchy's theorem, Sylow theorems and their applications. Ring and its properties,Characteristic of a ring, Integral domain, Field, Division ring. Ideals and Quotient ring,Homomorphism, Isomorphism theorems. Polynomial ring, Unique factorization domain,Principal Ideal domain, Euclidean domain, Gaussian ring. **References/Text Books:** 1. Contemporary Abstract Algebra, Joseph A Gallian (Narosa Publishing House, NewDelhi, 1998).2. Algebra, Michael Artin (Prentice Hall of India, New Delhi, 1994).3. Abstract Algebra, John B Fraleigh (Narosa Publishing House, New Delhi, 1988).4. Abstract Algebra, David S Dummit and Richard M Foote (John Wiley & Sons, NewDelhi, 1999).	ABSTRACT ALGEBRA
MTH215	3-1-0--4	#	**Course Contents:** Divisibility, Primes, Congruences, Residue systems, Primitive roots; Quadraticreciprocity, Some arithmetic functions, Farey fractions, Continued fractions,Some Diophantine equations, Bertrands postulate and the partition function. **References/Text Books:**	NUMBER THEORY
MTH215A	3-1-0-0-11		**Course Contents:** Divisibility, Primes, Congruences, Residue systems, Primitive roots; Quadraticreciprocity, Some arithmetic functions, Farey fractions, Continued fractions,Some Diophantine equations, Bertrands postulate and the	NUMBER THEORY

			partition function. **References/Text Books:**	
MTH300	3-1-0--4		**Course Contents:** Finite and Infinite Sets: Finite sets, Countable sets, Uncountable sets. Groupsand Symmetry: Groups, Subgroups, Lagrange theorem, Normal subgroups,Quotient groups, Group actions, Homomorphisms, Group of symmetry rigidmotion group, finite subgroups of the rotation group, symmetric group. MetricSpaces: Open sets, Closed sets, Sequences, Continuity, Complete metric spaces,Contraction principle and applications, Connectedness and compactness. Fractals:Metric space of fractals and its completeness, Iterated function systems,Attractor, Algorithms to generate fractals. Topology of Surfaces: Eulers theorem,Construction of surfaces by identification: Torus, mobius strip, Klein bottle. **References/Text Books:**	BASIC STRUCTURE OF MATHEMATICS
MTH301	3-1-0-0-4		**Course Contents:** Real Number system: Completeness property. Countable and Uncountable.Metric Spaces: Metric spaces, Examples: lp, C[a; b]; Limit, Open sets, Convergenceof a sequence, Closed sets, Continuity. Completeness: Complete metric space,Nested set theorem, Baire category theorem, An application. Compactness: Totallybounded, Characterizations of compactness, Finite intersection property, Continuous functionson compact sets, Uniform continuity. Connectedness: Characterizations of connectedness,Continuous functions on connected sets, Path connected. Riemann integration:Denition and existence of integral, Fundamental theorem of calculus, Set of measurezero, Cantor set, Characterization of integrable functions. Convergence of sequence andseries of functions: Pointwise and uniform convergence of functions, Series of functions,Power series, Dini's theorem, Ascoli's theorem, Continuous function which is no wheredierentiable, Weierstrass approximation theorem. **References/Text Books:** 1. N.L. Carothers, Real Analysis.2. R. R. Goldberg, Methods of Real Analysis.3. W. Rudin, Principles of Mathematical Analysis.	ANALYSIS - I
MTH301A	3-1-0-0-11	MTH101A	**Course Contents:** Real Number system: Completeness property. Countable and Uncountable.Metric Spaces: Metric spaces, Examples: lp, C[a; b]; Limit, Open sets, Convergenceof a sequence, Closed sets, Continuity. Completeness: Complete metric space,Nested set theorem, Baire category theorem, An application. Compactness: Totallybounded, Characterizations of compactness, Finite intersection property, Continuous functionson compact sets, Uniform continuity. Connectedness: Characterizations of connectedness,Continuous functions on connected sets, Path connected. Riemann integration:Denition and existence of integral, Fundamental theorem of calculus, Set of measurezero, Cantor set, Characterization of integrable functions. Convergence of sequence andseries of functions: Pointwise and uniform convergence of functions, Series of functions,Power series, Dini's theorem, Ascoli's theorem, Continuous function which is no wheredierentiable, Weierstrass approximation theorem. **References/Text Books:** 1. N.L. Carothers, Real Analysis.2. R. R. Goldberg, Methods of Real Analysis.3. W. Rudin, Principles of Mathematical Analysis.	ANALYSIS- I
MTH302	3-1-0-0-4		**Course Contents:** Formal theories, Consequence and deduction. Propositional Calculus:Syntax, Semantics, Applications; Axiomatic approach, Soundness, Consistency, Completeness.Other proof techniques: Sequent calculus, Tableaux. Boolean Algebras: Properties,Stone's theorem. Completeness of propositional calculus with respect to the classof Boolean algebras. Classical rst order theories: Syntax, Semantics; Axiomatic approach,Soundness; Sequent calculus, Tableaux. Equality, examples of rst order theorieswith equality.	MATHEMATICAL LOGIC

			Consistency, Completeness (sketch), Elementary model theory, Decidability.Godel's incompleteness theorems: sketch. **References/Text Books:** 1. R. Cori and D. Lascar, Mathematical Logic, Oxford, 2001.2. A. Margaris, First Order Mathematical Logic, Dover, 1990.3. J. GoubaltLarrecq and J. Mackie, Proof Theory and Automated Deduction, Kluwer,1997.	
MTH302A	3-0-0-0-9		**Course Contents:** Formal theories, Consequence and deduction. Propositional Calculus:Syntax, Semantics, Applications; Axiomatic approach, Soundness, Consistency, Completeness.Other proof techniques: Sequent calculus, Tableaux. Boolean Algebras: Properties,Stone's theorem. Completeness of propositional calculus with respect to the classof Boolean algebras. Classical rst order theories: Syntax, Semantics; Axiomatic approach,Soundness; Sequent calculus, Tableaux. Equality, examples of rst order theorieswith equality. Consistency, Completeness (sketch), Elementary model theory, Decidability.Godel's incompleteness theorems: sketch. **References/Text Books:** 1. R. Cori and D. Lascar, Mathematical Logic, Oxford, 2001.2. A. Margaris, First Order Mathematical Logic, Dover, 1990.3. J. GoubaltLarrecq and J. Mackie, Proof Theory and Automated Deduction, Kluwer,1997.	MATHEMATICAL LOGIC
MTH304	3-1-0-0-4		**Course Contents:** Topological spaces, Basis for a topology, The order topology, Subspace topology,Closed sets. Countability axioms, Limit points, Convergence of nets in topologicalspaces, Continuous functions, The product topology, Metric topology, Quotienttopology. Connected spaces, Connected sets in R, Components and pathcomponents, Compact spaces, Compactness in metric spaces, Local compactness,One point compactification. Separation axioms, Uryshons lemma, Uryshonsmetrization theorem, Tietz extension theorem. The Tychonoff theorem, Completelyregular spaces, Stone Czech compactification. **References/Text Books:**	TOPOLOGY
MTH304A	3-1-0-0-11	MTH301A	**Course Contents:** Topological spaces, Basis for a topology, The order topology, Subspace topology,Closed sets. Countability axioms, Limit points, Convergence of nets in topologicalspaces, Continuous functions, The product topology, Metric topology, Quotienttopology. Connected spaces, Connected sets in R, Components and pathcomponents, Compact spaces, Compactness in metric spaces, Local compactness,One point compactification. Separation axioms, Uryshons lemma, Uryshonsmetrization theorem, Tietz extension theorem. The Tychonoff theorem, Completelyregular spaces, Stone Czech compactification. **References/Text Books:**	TOPOLOGY
MTH305	3-1-0-0-4	MTH301	**Course Contents:** Diferentiation: Denition and examples, Mean value inequality, Tangentplanes to level sets of functions; Implicit mapping theorem, Inverse mapping theoremand applications; Taylor's theorem and applications. Curves: Denition and examples,Regular curves, Plane curves, Curvature of plane curves, Isoperimetric inequality forplane curves; Space curves, FrenetSerret formula for space curves; Local existence theoremcurves. Surfaces: Denition and examples; Tangent planes, Maps between surfaces;First fundamental and second fundamental forms; Curvature of surface; Hilbert's theoremfor compact surfaces; Gauss theorema Egregium. **References/Text Books:** 1. Spivak, Calculus on manifolds, Springer2. Kumaresan, Dierential geometry and Lie groups, TRIM Series3. M P do Carmo, Dierential geometry of curves and surfaces, Prentice Hall4. A Pressley, Elementary dierential geometry, Springer India	SEVERAL VARIABLE CALCULUS & DEFFERENTIAL GEOMETRY

MTH305A	3-1-0-0-11	MTH301A	**Course Contents:** Diferentiation: Denition and examples, Mean value inequality, Tangentplanes to level sets of functions; Implicit mapping theorem, Inverse mapping theoremand applications; Taylor's theorem and applications. Curves: Denition and examples,Regular curves, Plane curves, Curvature of plane curves, Isoperimetric inequality forplane curves; Space curves, FrenetSerret formula for space curves; Local existence theoremcurves. Surfaces: Denition and examples; Tangent planes, Maps between surfaces;First fundamental and second fundamental forms; Curvature of surface; Hilbert's theoremfor compact surfaces; Gauss theorema Egregium. **References/Text Books:** 1. Spivak, Calculus on manifolds, Springer2. Kumaresan, Dierential geometry and Lie groups, TRIM Series3. M P do Carmo, Dierential geometry of curves and surfaces, Prentice Hall4. A Pressley, Elementary dierential geometry, Springer India	SEVERAL VARIABLE CALCULUS & DEFFERENTIAL GEOMETRY
MTH306	3-1-0-0-4		**Course Contents:** Linear Models: Formulation and Examples, Basic Polyhedral Theory Convexity,Extreme points, Supporting hyperplanes etc, Simplex Algorithm Algebraic andGeometrical approaches, Artificial variable technique, Duality Theory: Fundamentaltheorem, Dual simplex method, Primaldual method, Sensitivity Analysis, BoundedVariable L.P.P. Transportation Problems: Models and Algorithms, Network Flows:Shortest path Problem, MaxFlow problem and Mincost Flow problem, DynamicProgramming: Principle of optimality, Discrete and continuous models. **References/Text Books:**	LINEAR PROGRAMMING AND EXTENSIONS
MTH306A	3-1-0-0-11	MTH102A	**Course Contents:** Linear Models: Formulation and Examples, Basic Polyhedral Theory Convexity,Extreme points, Supporting hyperplanes etc, Simplex Algorithm Algebraic andGeometrical approaches, Artificial variable technique, Duality Theory: Fundamentaltheorem, Dual simplex method, Primaldual method, Sensitivity Analysis, BoundedVariable L.P.P. Transportation Problems: Models and Algorithms, Network Flows:Shortest path Problem, MaxFlow problem and Mincost Flow problem, DynamicProgramming: Principle of optimality, Discrete and continuous models. **References/Text Books:**	LINEAR PROGRAMMING AND EXTENSIONS
MTH308	3-1-0-0-4		**Course Contents:** Root nding problem: Methods and analysis; Interpolation: Methodsand analysis; Approximation: Least squares and minimax approximation; Numerical differentiation;Numerical integration: Methods and analysis; Numerical solution of linearsystems; Numerical eigenvalue and eigenvector problem; Singular value decomposition. **References/Text Books:** 1. Elementary Numerical Analysis, an algorithmic approach, S.D. Conte and Carl DeBoor2. An Introduction to Numerical Analysis, Kendall E Atkinson3. Numerical Methods for Scientic and Engineering Computations, M.K. Jain, S.R.K.Iyengar, R.K. Jain4. Introduction to Scientic Computing, C.F. Van Loan	PRINCIPLES OF NUMERICAL COMPUTATION
MTH308A	3-1-0-0-11	MTH102A	**Course Contents:** Root nding problem: Methods and analysis; Interpolation: Methodsand analysis; Approximation: Least squares and minimax approximation; Numerical differentiation;Numerical integration: Methods and analysis; Numerical solution of linearsystems; Numerical eigenvalue and eigenvector problem; Singular value decomposition. **References/Text Books:** 1. Elementary Numerical Analysis, an algorithmic approach, S.D. Conte and Carl DeBoor2. An Introduction	PRINCIPLES OF NUMERICAL COMPUTATIONS

			to Numerical Analysis, Kendall E Atkinson3. Numerical Methods for Scientic and Engineering Computations, M.K. Jain, S.R.K.Iyengar, R.K. Jain4. Introduction to Scientic Computing, C.F. Van Loan	
MTH311	3-1-0-0-4		**Course Contents:** Sets and set operations, Sample space, Sigma fields, Measurable spaces, Events.Measure spaces, Caratheodorys extension theorem, Construction of measures,Product spaces, Product measures. Probability measurer and its properties.Independence of events. Measurable functions, Approximations through simplefunctions, Random variables. Induced measures and probability distributionfunctions: discrete, continuous and absolutely continuous, one to onecorrespondence with induced probability measure, decomposition. Independenceof random variables, BorelCantelli lemmas. Integration in measure spaces,Expectation, Fatous lemma, Monotone convergence and dominated convergencetheorems, Uniform integrability, Markov, Chebyshev, CauchySchwarz, Minkowski,Holder, Jensen and Lyapunov inequalities. Absolute continuity of measures,RandonNikodym theorem, Conditional expectation, Conditional probabilitymeasures. Fubinis theorem, Convolution. Functions of random variables,Jacobian theorem. **References/Text Books:**	PROBABILITY THEORY - I
MTH311A	3-1-0-0-11	MSO201A	**Course Contents:** Sets and set operations, Sample space, Sigma fields, Measurable spaces, Events.Measure spaces, Caratheodorys extension theorem, Construction of measures,Product spaces, Product measures. Probability measurer and its properties.Independence of events. Measurable functions, Approximations through simplefunctions, Random variables. Induced measures and probability distributionfunctions: discrete, continuous and absolutely continuous, one to onecorrespondence with induced probability measure, decomposition. Independenceof random variables, BorelCantelli lemmas. Integration in measure spaces,Expectation, Fatous lemma, Monotone convergence and dominated convergencetheorems, Uniform integrability, Markov, Chebyshev, CauchySchwarz, Minkowski,Holder, Jensen and Lyapunov inequalities. Absolute continuity of measures,RandonNikodym theorem, Conditional expectation, Conditional probabilitymeasures. Fubinis theorem, Convolution. Functions of random variables,Jacobian theorem. **References/Text Books:**	PROBABILITY THEORY - I
MTH391A	0-0-0-0-4		**Course Contents:** UG PROJECT (UGPI) **References/Text Books:**	UG PROJECT (UGP-I)
MTH392A	0-0-9-0-9		**Course Contents:** UG PROJECT (UGPII) **References/Text Books:**	UNDER GRADUATE PROJECT II
MTH393A	3-0-0-0-9		**Course Contents:** UG PROJECT (UGPIII) **References/Text Books:**	UG PROJECT (UGP-III)
MTH399A	0-0-0-2-2		**Course Contents:** Technical Communication **References/Text Books:**	TECHNICAL COMMUNICATION SKILLS
MTH401	3-1-0-0-4		**Course Contents:** Regular languages, Deterministic and nondeterministic nite automata,Closure properties, Languages that are and are not regular, State minimizationin deterministic nite automata. Contextfree languages, Closure	THEORY OF COMPUTATION

			properties, Parsetrees, Languages that are and are not contextfree, Pushdown automata. Turing machines,Turing computability, ChurchTuring thesis, Halting problem, Some undecidableproblems. Computational complexity, Classes P and NP, NPcompleteness, Examples ofNPcomplete problems. **References/Text Books:** 1. H.R. Lewis and C.H. Papadimitriou: Elements of the Theory of Computation, PrenticeHall, 1998.2. J.E. Hopcroft, R. Motwani, J.D. Ullman, Introduction to Automata Theory, Languages,and Computation, Pearson Education, 2001.	
MTH401A	3-0-0-0-9	ESO207A	**Course Contents:** Regular languages, Deterministic and nondeterministic nite automata,Closure properties, Languages that are and are not regular, State minimizationin deterministic nite automata. Contextfree languages, Closure properties, Parsetrees, Languages that are and are not contextfree, Pushdown automata. Turing machines,Turing computability, ChurchTuring thesis, Halting problem, Some undecidableproblems. Computational complexity, Classes P and NP, NPcompleteness, Examples ofNPcomplete problems. **References/Text Books:** 1. H.R. Lewis and C.H. Papadimitriou: Elements of the Theory of Computation, PrenticeHall, 1998.2. J.E. Hopcroft, R. Motwani, J.D. Ullman, Introduction to Automata Theory, Languages,and Computation, Pearson Education, 2001.	THEORY OF COMPUTATION
MTH403	3-1-0-0-4		**Course Contents:** Topology on C, Convergence and continuity. CauchyRiemann equation,Elementary Functions. Power series: Convergence, Exponential, Trigonometric functions.Integration along curves, CauchyGoursat Theorem, Cauchy's theorem for disc,Evaluation of some integrals, Cauchy integral formula, Liouville theorem and fundamentaltheorem of Algebra, Identity theorem, Morera's theorem. Zeros and poles, Residuetheorem, Evaluation of some integrals. Riemann theorem on removable singularities,Essential singularities, CasoratiWeierstrass theorem. Riemann sphere, Argument principle,Rouche's theorem, Open mapping theorem, Maximum modulus principle, Cauchy'stheorem for simply connected domain, Analyticity of complex logarithm. Harmonic functions,Poisson integral formula, Characterization of harmonic functions through MVP.Fractional linear transformation, Schwartz lemma, Pick's lemma, Automorphisms of discand upper half plane. Montel theorem, Riemann mapping theorem. **References/Text Books:** 1. Stein and Shakarchi: Complex Analysis, Princeton Lect. in Analysis2. Gamelin : Complex Analysis, Springer	COMPLEX ANALYSIS
MTH403A	3-1-0-0-11	MTH301A	**Course Contents:** Topology on C, Convergence and continuity. CauchyRiemann equation,Elementary Functions. Power series: Convergence, Exponential, Trigonometric functions.Integration along curves, CauchyGoursat Theorem, Cauchy's theorem for disc,Evaluation of some integrals, Cauchy integral formula, Liouville theorem and fundamentaltheorem of Algebra, Identity theorem, Morera's theorem. Zeros and poles, Residuetheorem, Evaluation of some integrals. Riemann theorem on removable singularities,Essential singularities, CasoratiWeierstrass theorem. Riemann sphere, Argument principle,Rouche's theorem, Open mapping theorem, Maximum modulus principle, Cauchy'stheorem for simply connected domain, Analyticity of complex logarithm. Harmonic functions,Poisson integral formula, Characterization of harmonic functions through MVP.Fractional linear transformation, Schwartz lemma, Pick's lemma, Automorphisms of discand upper half plane. Montel theorem, Riemann mapping theorem. **References/Text Books:** 1. Stein and Shakarchi: Complex Analysis, Princeton Lect. in Analysis2. Gamelin : Complex Analysis, Springer	COMPLEX ANALYSIS

MTH404	3-1-0-0-4		**Course Contents:** Lebesgue measure on Rn : Introduction, outer measure, measurable sets,Lebesgue measure, regularity properties, a nonmeasurable set, measurablefunctions, Egoroffs theorem, Lusins theorem. Lebesgue integration: Simplefunctions, Lebesgue integral of a bounded function over a set of finite measure,bounded convergence theorem, integral of nonnegative functions, FatousLemma, monotone convergence theorem, the general Lebesgue integral, Lebesgueconvergence theorem, change of variable formula. Differentiation and integration:Functions of bounded variation, differentiation of an integral, absolutelycontinuity, Lpspaces: The Minkowskis inequality and Hlders inequality,completeness of Lp, denseness results in Lp. Fourier series: Definition of Fourierseries, formulation of convergence problems, The L2 theory of Fourier series,convergence of Fourier series. **References/Text Books:**	ANALYSIS II
MTH404A	3-1-0-0-11	MTH301A	**Course Contents:** Lebesgue measure on Rn : Introduction, outer measure, measurable sets,Lebesgue measure, regularity properties, a nonmeasurable set, measurablefunctions, Egoroffs theorem, Lusins theorem. Lebesgue integration: Simplefunctions, Lebesgue integral of a bounded function over a set of finite measure,bounded convergence theorem, integral of nonnegative functions, FatousLemma, monotone convergence theorem, the general Lebesgue integral, Lebesgueconvergence theorem, change of variable formula. Differentiation and integration:Functions of bounded variation, differentiation of an integral, absolutelycontinuity, Lpspaces: The Minkowskis inequality and Hlders inequality,completeness of Lp, denseness results in Lp. Fourier series: Definition of Fourierseries, formulation of convergence problems, The L2 theory of Fourier series,convergence of Fourier series. **References/Text Books:**	ANALYSIS II
MTH405	3-1-0-0-4		**Course Contents:** Fundamentals of normed linear spaces: Normed linear spaces, Riesz lemma,characterization of finite dimensional spaces, Banach spaces. Bounded linearmaps on a normed linear spaces: Examples, linear map on finite dimensionalspaces, finite dimensional spaces are isomorphic, operator norm. HahnBanachtheorems: Geometric and extension forms and their applications. Three maintheorems on Banach spaces: Uniform boundedness principle, divergence ofFourier series, closed graph theorem, projection, open mapping theorem,comparable norms. Dual spaces and adjoint of an operator: Duals of classicalspaces, weak and weak* convergence, Banach Alaoglu theorem, adjoint of anoperator. Hilbert spaces : Inner product spaces, orthonormal set, GramSchmidtorthonormalization, Bessels inequality, Orthonormal basis, Separable Hilbertspaces. Projection and Riesz representation theorem: Orthonormal complements,orthogonal projections, projection theorem, Riesz representation theorem.Bounded operators on Hilbert spaces: Adjoint, normal, unitary, self adjointoperators, compact operators, eigen values, eigen vectors, Banach algebras.Spectral theorem: Spectral theorem for compact self adjoint operators,statement of spectral theorem for bounded self adjoint operators. **References/Text Books:**	FUNCTIONAL ANALYSIS
MTH405A	3-1-0-0-11	MTH301	**Course Contents:** Fundamentals of normed linear spaces: Normed linear spaces, Riesz lemma,characterization of finite dimensional spaces, Banach spaces. Bounded linearmaps on a normed linear spaces: Examples, linear map on finite dimensionalspaces, finite dimensional spaces are isomorphic, operator norm. HahnBanachtheorems: Geometric and extension forms and their applications. Three maintheorems on Banach spaces: Uniform boundedness principle, divergence ofFourier series, closed graph theorem, projection, open mapping theorem,comparable norms. Dual spaces and adjoint of an operator: Duals of classicalspaces, weak and weak* convergence, Banach Alaoglu theorem, adjoint of anoperator. Hilbert spaces : Inner product spaces, orthonormal set, GramSchmidtorthonormalization, Bessels inequality, Orthonormal basis, Separable Hilbertspaces. Projection and Riesz representation theorem: Orthonormal complements,orthogonal	FUNCTIONAL ANALYSIS

			projections, projection theorem, Riesz representation theorem.Bounded operators on Hilbert spaces: Adjoint, normal, unitary, self adjointoperators, compact operators, eigen values, eigen vectors, Banach algebras.Spectral theorem: Spectral theorem for compact self adjoint operators,statement of spectral theorem for bounded self adjoint operators. **References/Text Books:**	
MTH409	2-1-1-0-4		**Course Contents:** Fortran 77: Integer and real operations, logic and complex operations, Controlstatements, Do statement, arrays subroutines and functions. Introduction todata structures in C Programming Language; Arrays: linear, Multidimensional,Records, Pointers, Stacks, queues, Linked Lists; Singly linked lists, doubleedlinked lists, circular linked lists, Application of Linked Lists; Polynomial addition,sparse matrices, Trees: binary trees, redblack trees, Hash tables. somediscussion about data structures in F90F95 with examples. **References/Text Books:**	COMPUTER PROGRAMMING AND DATA STRUCTURES
MTH409A	2-1-1-0-9		**Course Contents:** Fortran 77: Integer and real operations, logic and complex operations, Controlstatements, Do statement, arrays subroutines and functions. Introduction todata structures in C Programming Language; Arrays: linear, Multidimensional,Records, Pointers, Stacks, queues, Linked Lists; Singly linked lists, doubleedlinked lists, circular linked lists, Application of Linked Lists; Polynomial addition,sparse matrices, Trees: binary trees, redblack trees, Hash tables. somediscussion about data structures in F90F95 with examples. **References/Text Books:**	COMPUTER PROGRAMMING AND DATA STRUCTURES
MTH411	3-1-0-0-4		**Course Contents:** Tight families of probability distributions, Convergence of probability distributionfunctions, Hellys theorem, HellyBray theorem, Skorohods fundamental theorem,Scheffes theorem; Weak convergence, Uniform integrability and convergenceof expectations. Characteristic functions, Inversion formula, Levy continuitytheorem, Expansion of characteristic functions, Polyas theorem, Bochnerstheorem. Moments and uniqueness of the probability distribution, FrechetShohat theorem. Central limit theorems: LindebergLevy, Lyapunov and LindebergFeller. Various modes of convergence and the interrelations. Strong and weaklaws of large numbers. **References/Text Books:**	PROBABILITY THEORY II
MTH412	3-1-0-0-4		**Course Contents:** Definition and classification of general stochastic processes. Markov Chains:definition, transition probability matrices, classification of states, limitingproperties. Markov Chains with Discrete State Space: Poisson process, birthand death processes. Renewal Process: renewal equation, mean renewal time,stopping time. Markov Process with Continuous State Space: Introduction toBrownian motion. **References/Text Books:**	APPLIED STOCHASTIC PROCESS
MTH412A	3-1-0-0-11		**Course Contents:** Definition and classification of general stochastic processes. Markov Chains:definition, transition probability matrices, classification of states, limitingproperties. Markov Chains with Discrete State Space: Poisson process, birthand death processes. Renewal Process: renewal equation, mean renewal time,stopping time. Markov Process with Continuous State Space: Introduction toBrownian motion. **References/Text Books:**	APPLIED STOCHASTIC PROCESS
MTH413	3-1-0--4		**Course Contents:**	REAL AND COMPLEX

			Real and complex numbers; Open, closed and compact sets in Rn ; Limits andcontinuity; Differentiation and Integration; Sequences and series; Sequencesand series of functions; Complex integration. **References/Text Books:**	ANALYSIS
MTH413A	3-1-0-0-11		**Course Contents:** Real and complex numbers; Open, closed and compact sets in Rn ; Limits andcontinuity; Differentiation and Integration; Sequences and series; Sequencesand series of functions; Complex integration. **References/Text Books:**	REAL AND COMPLEX ANALYSIS
MTH415	3-1-0--4	ESO209	**Course Contents:** Review of finite dimensional vector spaces (Null space and nullity), Lineardependence and independence, Matrix algebra, Rank of a Matrix, Inverse ofa nonsingular matrix. Hermite canonical forms, Generalised inverses, MoorePenrose inverse, solution of linear equations, Projection and orthogonal projectionmatrices, Idempotent matrices. Real quadratic forms, reduction of pair of realsymmetric matrices, Singular value decomposition. extrema of a quadraticforms, Vector and matrix differentiation. Least squares theory and GaussMarkoff theorem, Cochran's theorem and distribution of quadratic forms, testof single linear hypothesis and more than one hypothesis, ANOVA table,Confidence interval and regions, Power of Ftest. Multiple comparisons andsimultaneous confidence intervals. **References/Text Books:**	MATRIX THEORY AND LINEAR ESTIMATION
MTH415A	3-1-0-0-11	MSO201A	**Course Contents:** Review of finite dimensional vector spaces (Null space and nullity), Lineardependence and independence, Matrix algebra, Rank of a Matrix, Inverse ofa nonsingular matrix. Hermite canonical forms, Generalised inverses, MoorePenrose inverse, solution of linear equations, Projection and orthogonal projectionmatrices, Idempotent matrices. Real quadratic forms, reduction of pair of realsymmetric matrices, Singular value decomposition. extrema of a quadraticforms, Vector and matrix differentiation. Least squares theory and GaussMarkoff theorem, Cochran's theorem and distribution of quadratic forms, testof single linear hypothesis and more than one hypothesis, ANOVA table,Confidence interval and regions, Power of Ftest. Multiple comparisons andsimultaneous confidence intervals. **References/Text Books:**	MATRIX THEORY AND LINEAR ESTIMATION
MTH416	3-1-0-0-4		**Course Contents:** Simple and multiple linear regression, Polynomial regression and orthogonalpolynomials, Test of significance and confidence intervals for parameters.Residuals and their analysis for test of departure from the assumptions suchas fitness of model, normality, homogeneity of variances, detection of outliers,Influential observations, Power transformation of dependent and independentvariables. Problem of multicollinearity, ridge regression and principal componentregression, subset selection of explanatory variables, Mallow's Cp statistic.Nonlinear regression, different methods for estimation (Least squares andMaximum likelihood), Asymptotic properties of estimators. Generalised LinearModels (GLIM), Analysis of binary and grouped data using logistic and loglinearmodels. **References/Text Books:**	REGRESSION ANALYSIS
MTH416A	3-1-0-0-11	MSO201A/MTH415A	**Course Contents:** Simple and multiple linear regression, Polynomial regression and orthogonalpolynomials, Test of significance and confidence intervals for parameters.Residuals and their analysis for test of departure from the assumptions suchas fitness of model, normality, homogeneity of variances, detection of outliers,Influential observations, Power transformation of dependent and independentvariables. Problem of multicollinearity, ridge regression and principal componentregression, subset selection of explanatory	REGRESSION ANALYSIS

			variables, Mallow's Cp statistic.Nonlinear regression, different methods for estimation (Least squares andMaximum likelihood), Asymptotic properties of estimators. Generalised LinearModels (GLIM), Analysis of binary and grouped data using logistic and loglinearmodels. **References/Text Books:**	
MTH417	3-1-0-0-4		**Course Contents:** Principles of sample surveys; Simple, Stratified and unequal probability samplingwith and without replacement; ratio, product and regression method of estimation;systematic sampling; cluster and subsampling with equal unequal sizes; doublesampling; sources of errors in surveys. **References/Text Books:**	SAMPLING THEORY
MTH417A	3-1-0-0-11		**Course Contents:** Principles of sample surveys; Simple, Stratified and unequal probability samplingwith and without replacement; ratio, product and regression method of estimation;systematic sampling; cluster and subsampling with equal unequal sizes; doublesampling; sources of errors in surveys. **References/Text Books:**	SAMPLING THEORY
MTH418	3-1-0--4	ESO209/MTH311	**Course Contents:** Parametric models, parametrs, random sample and its likelihood, statistic andits sampling distributions, problems of inference. Examples from standarddiscrete and continuous models such as Bernoulli, Binomial, Poisson, NegativeBinomial, Normal, Exponential, Gamma, Weibull, Pareto etc. Concept of sufficiency,minimal sufficiency, Neyman factorization criterion, Fisher information,exponential families. Maximum likelihood estimators, method of momentestimators, percentile estimators, least squares estimators, minimum meansquares estimators, uniformly minimum variance unbiased estimators, RaoBlackwell theorem, CramerRao lower bond, different examples. StatisticalHypthesessimple and composite, statistical tests, critical regions, TypeI andTypeII errors, size and power of a test, Neyman Pearson lemma and its differentapplications. Most powerful test, uniformly most powerful test, unbiased testand uniformly most unbiased test. Likelihood ratio test. Interval estimation,confidence intervals, construction of confidence intervals, shortest expectedlength confidence interval, most accurate one sided confidence interval and itsrelation to UMP test. **References/Text Books:**	INFERENCE I
MTH418A	3-1-0-0-11	MSO201A/MTH311	**Course Contents:** Parametric models, parametrs, random sample and its likelihood, statistic andits sampling distributions, problems of inference. Examples from standarddiscrete and continuous models such as Bernoulli, Binomial, Poisson, NegativeBinomial, Normal, Exponential, Gamma, Weibull, Pareto etc. Concept of sufficiency,minimal sufficiency, Neyman factorization criterion, Fisher information,exponential families. Maximum likelihood estimators, method of momentestimators, percentile estimators, least squares estimators, minimum meansquares estimators, uniformly minimum variance unbiased estimators, RaoBlackwell theorem, CramerRao lower bond, different examples. StatisticalHypthesessimple and composite, statistical tests, critical regions, TypeI andTypeII errors, size and power of a test, Neyman Pearson lemma and its differentapplications. Most powerful test, uniformly most powerful test, unbiased testand uniformly most unbiased test. Likelihood ratio test. Interval estimation,confidence intervals, construction of confidence intervals, shortest expectedlength confidence interval, most accurate one sided confidence interval and itsrelation to UMP test. **References/Text Books:**	INFERENCE -I
MTH421	3-1-0-0-4		**Course Contents:**	ORDINARY DIFFERENTIAL

			Introduction to ODE; Existence and uniqueness of solution; Continuityand dierentiability of solution w.r.t. initial condition and parameters; Generaltheory of linear dierential equations; Methods of solving nonhomogeneous linear equations;CauchyEuler equation; Linear equations with periodic coecients; System of lineardierential equations; Stability theory for system of linear dierential equations; StrumLiouville boundary value problems, Oscillation theory; Green's function. **References/Text Books:** 1. Martin Brown, Dierential Equations and Their Applications, Springer, 1992.2. S. L. Ross, Introduction to Ordinary Dierential Equations, Wiley, 1980.3. Deo, Lakshmikantham, Raghavendra, Textbook of Ordinary Dierential Equations,Tata McGraw Hill, 1997.4. C. Y. Lin, Theory and Examples of Ordinary Dierential Equations, World Scientic,2011.	EQUATIONS
MTH421A	3-1-0-0-11	MTH102A	**Course Contents:** Introduction to ODE; Existence and uniqueness of solution; Continuityand dierentiability of solution w.r.t. initial condition and parameters; Generaltheory of linear dierential equations; Methods of solving nonhomogeneous linear equations;CauchyEuler equation; Linear equations with periodic coecients; System of lineardierential equations; Stability theory for system of linear dierential equations; StrumLiouville boundary value problems, Oscillation theory; Green's function. **References/Text Books:** 1. Martin Brown, Dierential Equations and Their Applications, Springer, 1992.2. S. L. Ross, Introduction to Ordinary Dierential Equations, Wiley, 1980.3. Deo, Lakshmikantham, Raghavendra, Textbook of Ordinary Dierential Equations,Tata McGraw Hill, 1997.4. C. Y. Lin, Theory and Examples of Ordinary Dierential Equations, World Scientic,2011.	ORDINARY DIFFERENTIAL EQUATIONS
MTH423	3-1-0-0-4		**Course Contents:** Fundamental concepts; Introduction to Cartesian tensors; Stress tensorsand equilibrium equations; Theory of strain and rate of deformation tensor; Conservationlaws and basic equations; Linear Elasticity{Hooke's law, plane elasticity, Airy'sstress principle, Torsion and bending; Fluid mechanics{Incompressible inviscid ow, Incompressibleviscous ow, Introduction to boundary layer theory **References/Text Books:** 1. Introduction to Continuum Mechanics{M. Lai, D. Rubin, E. Krempl2. Continuum Mechanics for Engineers{G. T. Mase and G. E. Mase3. Elementary uid mechanics{D. J. Acheson4. Fluid Mechanics{P K Kundu and I M Cohen5. Mathematical Theory of Elasticity{Sokolniko	INTRODUCTION TO CONTINUUM MACHANICS
MTH423A	3-1-0-0-11	MTH102A	**Course Contents:** Fundamental concepts; Introduction to Cartesian tensors; Stress tensorsand equilibrium equations; Theory of strain and rate of deformation tensor; Conservationlaws and basic equations; Linear Elasticity{Hooke's law, plane elasticity, Airy'sstress principle, Torsion and bending; Fluid mechanics{Incompressible inviscid ow, Incompressibleviscous ow, Introduction to boundary layer theory **References/Text Books:** 1. Introduction to Continuum Mechanics{M. Lai, D. Rubin, E. Krempl2. Continuum Mechanics for Engineers{G. T. Mase and G. E. Mase3. Elementary uid mechanics{D. J. Acheson4. Fluid Mechanics{P K Kundu and I M Cohen5. Mathematical Theory of Elasticity{Sokolniko	INTRODUCTION TO CONTINUUM MACHANICS
MTH424	3-1-0-0-4		**Course Contents:** Introduction to PDEs, First order quasilinear and nonlinear equations;Higher order equations and classications; Solution of wave equations, Duhamel's principleand applications; Existence and uniqueness of solutions; BVPs for Laplace's andPoisson's equations, Green's function, Maximum principle for the Laplace equation; Heatequation, Maximum principle for the heat equation, Uniqueness of solutions of IVPs forheat	PARTIAL DIFFERENTIAL EQUATIONS

			conduction equation. **References/Text Books:** 1. Robert C. McOwen: Partial Dierential Equations, Pearson Education Inc.2. Alen Jerey: Applied Partial Dierential Equations, Academic Press3. Ervin Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons4. T. Amarnath, An Elementary Course in Partial Dierential Equations, Narosa Publications	
MTH424A	3-1-0-0-11		**Course Contents:** Introduction to PDEs, First order quasilinear and nonlinear equations;Higher order equations and classications; Solution of wave equations, Duhamel's principleand applications; Existence and uniqueness of solutions; BVPs for Laplace's andPoisson's equations, Green's function, Maximum principle for the Laplace equation; Heatequation, Maximum principle for the heat equation, Uniqueness of solutions of IVPs forheat conduction equation. **References/Text Books:** 1. Robert C. McOwen: Partial Dierential Equations, Pearson Education Inc.2. Alen Jerey: Applied Partial Dierential Equations, Academic Press3. Ervin Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons4. T. Amarnath, An Elementary Course in Partial Dierential Equations, Narosa Publications	PARTIAL DIFFERENTIAL EQUATIONS
MTH428	3-1-0-0-4		**Course Contents:** Multiple Integral Theorems and their Applications: Greens theorem, Stokestheorem and Gauss divergence theorem. Integral Transforms: Fourier, Fouriersine/cosine and Hankel Transforms with their inverse transforms (properties,convolution theorem and application to solve differential equation). PerturbationMethods: Perturbation theory, Regular perturbation theory, Singular perturbationtheory, Asymptotic matching. Calculus of Variation: Introduction, Variationalproblem with functionals containing first order derivatives and Euler equations.Functionals containing higher order derivatives and several independent variables.Variational problem with moving boundaries. Boundaries with constraints.Higher order necessary conditions, Weiretrass function, Legendres and Jacobiscondition. Existence of solutions of variational problems. RayleighRitz method,statement of Ekelands variational principle; Self adjoint, normal and unitaryoperators; Banach algebras. **References/Text Books:**	MATHEMATICAL METHODS
MTH428A	3-1-0-0-11		**Course Contents:** Multiple Integral Theorems and their Applications: Greens theorem, Stokestheorem and Gauss divergence theorem. Integral Transforms: Fourier, Fouriersine/cosine and Hankel Transforms with their inverse transforms (properties,convolution theorem and application to solve differential equation). PerturbationMethods: Perturbation theory, Regular perturbation theory, Singular perturbationtheory, Asymptotic matching. Calculus of Variation: Introduction, Variationalproblem with functionals containing first order derivatives and Euler equations.Functionals containing higher order derivatives and several independent variables.Variational problem with moving boundaries. Boundaries with constraints.Higher order necessary conditions, Weiretrass function, Legendres and Jacobiscondition. Existence of solutions of variational problems. RayleighRitz method,statement of Ekelands variational principle; Self adjoint, normal and unitaryoperators; Banach algebras. **References/Text Books:**	MATHEMATICAL METHODS
MTH506	3-1-0-0-4		**Course Contents:** Optimization Problem: various examples, Characterization of optimality andconstrained optimal problems, Convex sets and convex functions and theirproperties, Nonlinear programming theory KuhnTucker conditions, Lagrangestheory, Duality theory, Search techniques one variable and several variables,Pontryagins maximum principle and its applications, Dynamic programming andits applications.	OPTIMIZATION

			References/Text Books:	
MTH511	3-1-0-0-4		**Course Contents:** Simulation of random variables from discrete, continuous, multivariate distributionsand stochastic processes, MonteCarlo methods. Regression analysis, scatterplot, residual analysis. Computer Intensive Inference Methods JackKnife,Bootstrap, cross validation, Monte Carlo methods and permutation tests.Graphical representation of multivariate data, Cluster analysis, Principal componentanalysis for dimension reduction. **References/Text Books:**	STATISTICAL SIMULATION AND DATA ANALYSIS
MTH511A	3-1-0-0-11	MSO201A	**Course Contents:** Simulation of random variables from discrete, continuous, multivariate distributionsand stochastic processes, MonteCarlo methods. Regression analysis, scatterplot, residual analysis. Computer Intensive Inference Methods JackKnife,Bootstrap, cross validation, Monte Carlo methods and permutation tests.Graphical representation of multivariate data, Cluster analysis, Principal componentanalysis for dimension reduction. **References/Text Books:**	STATISTICAL SIMULATION AND DATA ANALYSIS
MTH512	3-1-0-0-4		**Course Contents:** Fundamentals of the financial markets, meaning of notions like asset portfolioderivatives (example : Futures, options forwwards etc.)Binomial asset pricing model under no arbitrage condition singleperiod model,multiperiod model. riskneutral probabilities, martingales in the discreateframework, riskneutral valuation of European and American ooptions under noarbitrage condition in the binomial framework.Introduction to continuous time models. Basic notions of probability theory onan infinite sample space. Change of measure and the RadonNikodym derivative.Random walk and Brownian motion, Ito intergral and Ito formula BlackScholesformula for pricing an European call option.Markowitz meanvariance portfolio optimization problem. Singleperiod andmulti period model, Capital asset pricing model, outlines of the measures ofrisk, Value at Risk (VaR) and Conditional Value at Risk (CVaR) **References/Text Books:**	FOUNDATIONS OF MATHEMATICAL FINANCE
MTH512A	3-1-0-0-11	MSO201A	**Course Contents:** Fundamentals of the financial markets, meaning of notions like asset portfolioderivatives (example : Futures, options forwwards etc.)Binomial asset pricing model under no arbitrage condition singleperiod model,multiperiod model. riskneutral probabilities, martingales in the discreateframework, riskneutral valuation of European and American ooptions under noarbitrage condition in the binomial framework.Introduction to continuous time models. Basic notions of probability theory onan infinite sample space. Change of measure and the RadonNikodym derivative.Random walk and Brownian motion, Ito intergral and Ito formula BlackScholesformula for pricing an European call option.Markowitz meanvariance portfolio optimization problem. Singleperiod andmulti period model, Capital asset pricing model, outlines of the measures ofrisk, Value at Risk (VaR) and Conditional Value at Risk (CVaR) **References/Text Books:**	FOUNDATIONS OF MATHEMATICAL FINANCE
MTH513	3-1-0--4	MTH416	**Course Contents:** Analysis of completely randomized design, randomized block design, Latinsquares design; Splitplot, 2" and 3" factorials with total and partial confounding,twoway nonorthogonal experiment, BIBD, PBIBD; Analysis of covariance, missingplot techniques; First and second order response surface designs. **References/Text Books:**	ANALYSIS OF VARIANCE
MTH513A	3-1-0-0-11	MTH416A	**Course Contents:** Analysis of completely randomized design, randomized block design, Latinsquares design; Splitplot, 2" and 3" factorials with total and partial confounding,twoway nonorthogonal experiment, BIBD, PBIBD; Analysis	ANALYSIS OF VARIANCE

			of covariance, missingplot techniques; First and second order response surface designs. **References/Text Books:**	
MTH514	3-1-0--4	MTH418	**Course Contents:** Multivariate normal distribution, assessing normality, Wishart and HotellingsT2; Comparisons of several multivariate means, MANOVA; multivariate linearregression models; principal components, factor analysis; canonical correlations;discrimination & classification. **References/Text Books:**	MULTIVARIATE ANALYSIS
MTH514A	3-1-0-0-11	MTH418A	**Course Contents:** Multivariate normal distribution, assessing normality, Wishart and HotellingsT2; Comparisons of several multivariate means, MANOVA; multivariate linearregression models; principal components, factor analysis; canonical correlations;discrimination & classification. **References/Text Books:**	MULTIVARIATE ANALYSIS
MTH515	3-1-0--4	MTH418	**Course Contents:** Group families, the principle of equivariance, location family, scale family,location scale family. Minimum risk equivariance estimators, risk functions,admissibility, prior distribution, posterior distribution, geometric interpretationfor finite parameter space, Bayes estimators, limit of Bayes estimators, minimaxestimators and their relations. Review of convergence in probability andconvergence in distributions. Consistency results of the mle's, and the mme's.Asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) estimators,Invariance of CAN estimators under different transformations. CAN estimatorsobtained by moments and MLE methods in one parameter xponential familyand multiparameter exponential family. Sequential Probability Ratio Tests andits applications in different practical problems. Invariant test and unbiased tests,Likelihood ratio test and its asymptotic distributions, Wald test, Rao's scoretest, Pearson c2 test for goodness of fit. Large sample tests and confidenceintervals based on CAN estimators. Consistency of large sample tests andasymptotic powers of large sample tests. **References/Text Books:**	INFERENCE - II
MTH515A	3-1-0-0-11	MTH418A	**Course Contents:** Group families, the principle of equivariance, location family, scale family,location scale family. Minimum risk equivariance estimators, risk functions,admissibility, prior distribution, posterior distribution, geometric interpretationfor finite parameter space, Bayes estimators, limit of Bayes estimators, minimaxestimators and their relations. Review of convergence in probability andconvergence in distributions. Consistency results of the mle's, and the mme's.Asymptotic relative efficiency. Consistent and Asymptotic Normal (CAN) estimators,Invariance of CAN estimators under different transformations. CAN estimatorsobtained by moments and MLE methods in one parameter xponential familyand multiparameter exponential family. Sequential Probability Ratio Tests andits applications in different practical problems. Invariant test and unbiased tests,Likelihood ratio test and its asymptotic distributions, Wald test, Rao's scoretest, Pearson c2 test for goodness of fit. Large sample tests and confidenceintervals based on CAN estimators. Consistency of large sample tests andasymptotic powers of large sample tests. **References/Text Books:**	INFERENCE - II
MTH516	3-1-0--4	ESO209/MTH411	**Course Contents:** Order statistics, Run tests, Goodness of fit tests, rank order statistics, signtest and signed rank test. general twosample problems, MannWhitney test,Linear rank tests for location and scale problem, ksample problem, Measuresof association, Power and asymptotic relative efficiency, Concepts of jackknifing,Bootstrap	NON-PARAMETRIC INFERENCE

			methods. **References/Text Books:**	
MTH516A	3-1-0-0-11	MSO201A/MTH411A	**Course Contents:** Order statistics, Run tests, Goodness of fit tests, rank order statistics, signtest and signed rank test. general twosample problems, MannWhitney test,Linear rank tests for location and scale problem, ksample problem, Measuresof association, Power and asymptotic relative efficiency, Concepts of jackknifing,Bootstrap methods. **References/Text Books:**	NON-PARAMETRIC INFERENCE
MTH517	3-1-0-0-4		**Course Contents:** Linear stationary processes, AR, MA, ARMA and ARIMA; identification, estimationof the models; forecasting time series regression; Fourier analysis, spectralrepresentation of a stochastic process, properties of ARMA processes in thefrequency domain; estimation of the spectrum, Kalman filter. **References/Text Books:**	TIME SERIES ANALYSIS
MTH517A	3-1-0-0-11		**Course Contents:** Linear stationary processes, AR, MA, ARMA and ARIMA; identification, estimationof the models; forecasting time series regression; Fourier analysis, spectralrepresentation of a stochastic process, properties of ARMA processes in thefrequency domain; estimation of the spectrum, Kalman filter. **References/Text Books:**	TIME SERIES ANALYSIS
MTH520	3-1-0--4	MTH102N	**Course Contents:** Computer arithmetic. Vector and matrix norms. Condition number of a matrixand its applications. Singular value decomposition of a matrix and its applications.Linear leastsquares problem. Householder matrices and their applications.Numerical methods for matrix eigenvalue problem. Numerical methods forsystems and control. **References/Text Books:**	NUMERICAL LINEAR ALGEBRA
MTH522	3-1-0-0-4		**Course Contents:** Introduction and motivation, Weak formulation of BVP and Galerkin approximation,Piecewise polynomial spaces and finite element method, Computer implementationof FEM, Results from Sobolev spaces, Variational formulation of elliptic BVP,LaxMilgram theorem, Estimation for general FE approximation, Constructionof FE spaces, Polynomial approximation theory in Sobolev spaces, Variationalproblem for second order elliptic operators and approximations, Mixed methods,Iterative techniques. **References/Text Books:**	FINITE ELEMENT METHOD
MTH522A	3-1-0-0-11		**Course Contents:** Introduction and motivation, Weak formulation of BVP and Galerkin approximation,Piecewise polynomial spaces and finite element method, Computer implementationof FEM, Results from Sobolev spaces, Variational formulation of elliptic BVP,LaxMilgram theorem, Estimation for general FE approximation, Constructionof FE spaces, Polynomial approximation theory in Sobolev spaces, Variationalproblem for second order elliptic operators and approximations, Mixed methods,Iterative techniques. **References/Text Books:**	FINITE ELEMENT METHOD
MTH523	3-1-0-0-4		**Course Contents:**	FLUID MECHANICS

			Review and General Properties of Navier Stokes Equations; Some Exact solutionsof NS equations; Introduction to boundary layer theory; Introduction to turbulentflow; Introduction to compressible flow; Applications. **References/Text Books:**	
MTH523A	3-1-0-0-11		**Course Contents:** Review and General Properties of Navier Stokes Equations; Some Exact solutionsof NS equations; Introduction to boundary layer theory; Introduction to turbulentflow; Introduction to compressible flow; Applications. **References/Text Books:**	FLUID MECHANICS
MTH524	3-1-0-0-4		**Course Contents:** Preliminaries: Introduction to algorithms; Analyzing algorithms: space and timecomplexity; growth of functions; summations; recurrences; sets, etc. GreedyAlgorithms: General characteristics; Graphs: minimum spanning tree; Theknapsack problem; scheduling. Divide and Conquer: Binary search; Sorting:sorting by merging, qucksort. Dynamic Programming: Elements of dynamicprogramming; The principle of optimality; The knapsack problem; Shortestpaths; Chained matrix multiplication. Graph Algorithms: Depthfirst search;Breadthfirst search; Backtracking; Branchandbound. Polynomials and FFT:Representation of polynomials; The DFT and FFT; Efficient FFT implementation.Number Theoretic Algorithms: Greatest common divisor; Modular arithmetic;Solving modular linear equations. Introduction to cryptography. ComputationalGeometry: Line segment properties; Intersection of any pair of segments;Finding the convex hull; Finding the closest pair of points. Heuristic andApproximate Algorithms: Heuristic algorithms; Approximate algorithms; NPhardapproximation problems. **References/Text Books:**	ALGORITHMS
MTH524A	3-0-0-0-9		**Course Contents:** Preliminaries: Introduction to algorithms; Analyzing algorithms: space and timecomplexity; growth of functions; summations; recurrences; sets, etc. GreedyAlgorithms: General characteristics; Graphs: minimum spanning tree; Theknapsack problem; scheduling. Divide and Conquer: Binary search; Sorting:sorting by merging, qucksort. Dynamic Programming: Elements of dynamicprogramming; The principle of optimality; The knapsack problem; Shortestpaths; Chained matrix multiplication. Graph Algorithms: Depthfirst search;Breadthfirst search; Backtracking; Branchandbound. Polynomials and FFT:Representation of polynomials; The DFT and FFT; Efficient FFT implementation.Number Theoretic Algorithms: Greatest common divisor; Modular arithmetic;Solving modular linear equations. Introduction to cryptography. ComputationalGeometry: Line segment properties; Intersection of any pair of segments;Finding the convex hull; Finding the closest pair of points. Heuristic andApproximate Algorithms: Heuristic algorithms; Approximate algorithms; NPhardapproximation problems. **References/Text Books:**	ALGORITHMS
MTH598	0-0-7-0-4		**Course Contents:** PROJECT I **References/Text Books:**	PROJECT-I
MTH599	0-0-7-0-4		**Course Contents:** PROJECT II **References/Text Books:**	PROJECT- II

MTH599.	0-0-0--0		**Course Contents:** PROJECT I , II **References/Text Books:**	PROJECT I , II
MTH603	3-0-0--4	#	**Course Contents:** Elementary mathematical models; Role of mathematics in problem solving;Concepts of mathematical modelling; System approach; formulation, Analyses ofmodels; Sensitivity analysis, Simulation approach; Pitfalls in modelling, Illustrations. **References/Text Books:**	MATHEMATICAL MODELLING
MTH606	3-0-0--4	#	**Course Contents:** Biofluid dynamics; Blood flow & arterial diseases; Transport in intestines& lungs; Diffusion processes in human systems; Mathematical study of nonlinearVolterra equations, Stochastic & deterministic models in population dynamicsand epidemics. **References/Text Books:**	BIOMATHEMATICS
MTH610	3-0-0--4	#	**Course Contents:** Review of basic lin.alg. canonical factorization. QForms. Courant Fischerminmax & related theorems. PerronFrobenius theory. Matrixstability. Inequalities,ginverse (A, Am, A+). Direct, iterative, projection and rotations methods forsolving linear systems & eigenvalues problems. Applications. **References/Text Books:**	APPLIED MATRIX THEORY
MTH610A	3-0-0-0-9		**Course Contents:** Review of basic lin.alg. canonical factorization. QForms. Courant Fischerminmax & related theorems. PerronFrobenius theory. Matrixstability. Inequalities,ginverse (A, Am, A+). Direct, iterative, projection and rotations methods forsolving linear systems & eigenvalues problems. Applications. **References/Text Books:**	APPLIED MATRIX THEORY
MTH611	3-1-0-0-4		**Course Contents:** Fields: definition and examples. Ring of polynomials over a field. Fieldextensions. Algebraic and transcendental elements, Algebraic extensions. Splittingfield of a polynomial. Algebraic closure of a field, Uniqueness. Normal, separable,purely inseparable extensions. Primitive elements of a field extension simpleextensions. Fundamental theorem of Galois. Solvability by radicals Solutionsof cubic and quartic polynomials, Insolvabity of quintic and higher degreepolynomials. Geometric constructions. Cyclotomic extensions. Finite fields.Cyclotomic polynomials and its properties. Traces and norms. Modules definition, examples and basic properties. Free modules, submodules andquotient modules, isomorphism theorems. Localization. Direct sum and directproducts. Noetherian and Artinian rings and modules, structure of Artinian rings,Hilbert basis theorem. Jordan Holder theorem. Radicals of modules, Nakayamalemma. **References/Text Books:**	ALGEBRA II
MTH611A	3-0-0-0-9		**Course Contents:** Fields: definition and examples. Ring of polynomials over a field. Fieldextensions. Algebraic and transcendental elements, Algebraic extensions. Splittingfield of a polynomial. Algebraic closure of a field, Uniqueness. Normal, separable,purely inseparable extensions. Primitive elements of a field extension simpleextensions. Fundamental theorem of Galois. Solvability by radicals Solutionsof cubic and quartic polynomials, Insolvabity of quintic and higher degreepolynomials. Geometric constructions. Cyclotomic extensions. Finite fields.Cyclotomic polynomials and its properties. Traces and norms. Modules definition,	ALGEBRA II

			examples and basic properties. Free modules, submodules andquotient modules, isomorphism theorems. Localization. Direct sum and directproducts. Noetherian and Artinian rings and modules, structure of Artinian rings,Hilbert basis theorem. Jordan Holder theorem. Radicals of modules, Nakayamalemma. **References/Text Books:**	
MTH612	3-0-0--4	#	**Course Contents:** Commutative rings, ideals, prime and maximal ideals, Noetherian Artinian rings,Primary decomposition and Noetherian rings, Modules over commutative rings,Exact sequences, the Hom and tensorufunctors, rings and modules of fractions,integral dependence, valuations and dedekind domains. **References/Text Books:**	INTRODUCTION TO COMMUTATIVE ALGEBRA
MTH612A	3-0-0-0-9		**Course Contents:** Commutative rings, ideals, prime and maximal ideals, Noetherian Artinian rings,Primary decomposition and Noetherian rings, Modules over commutative rings,Exact sequences, the Hom and tensorufunctors, rings and modules of fractions,integral dependence, valuations and dedekind domains. **References/Text Books:**	INTRODUCTION TO COMMUTATIVE ALGEBRA
MTH620	3-1-0-0-4		**Course Contents:** Algebras and salgebras, Measures, Outer measures, Lebesgue measure in Rn,Completeness and regularity. Measurable functions and their properties,Convergence in measure, Integral, Convergence theorems. Signed and complexmeasures, Radon Nikodym theorem, Lebesgue decompostion theorem, Lpspacesand their dual. Product measures, Construction, Fubini theorem and itsapplications, Differentiation of measures. **References/Text Books:**	MEASURE THEORY
MTH620A	3-0-0-0-9		**Course Contents:** Algebras and salgebras, Measures, Outer measures, Lebesgue measure in Rn,Completeness and regularity. Measurable functions and their properties,Convergence in measure, Integral, Convergence theorems. Signed and complexmeasures, Radon Nikodym theorem, Lebesgue decompostion theorem, Lpspacesand their dual. Product measures, Construction, Fubini theorem and itsapplications, Differentiation of measures. **References/Text Books:**	MEASURE THEORY
MTH621	3-0-0--4	#	**Course Contents:** Fourier series; Norm and pointwise convergence, Approximate identities,Plancherel theorem, Conjugation, Maximal functions, Classical Hardy spaces,F. and M. Riesz theorem, Interpolation of linear operators. Fourier & FourierStieltjes transforms, Tempered distributions, PaleyWiener theorems. WienerTauberian theorems & applications. **References/Text Books:**	FOURIER ANALYSIS
MTH621A	3-0-0-0-9		**Course Contents:** Fourier series; Norm and pointwise convergence, Approximate identities,Plancherel theorem, Conjugation, Maximal functions, Classical Hardy spaces,F. and M. Riesz theorem, Interpolation of linear operators. Fourier & FourierStieltjes transforms, Tempered distributions, PaleyWiener theorems. WienerTauberian theorems & applications. **References/Text Books:**	FOURIER ANALYSIS
MTH624	3-0-0--4	#	**Course Contents:**	DIFFERENTIABLE

			Differentiable manifolds; Tangent space. Vector fields; Frobenius theorem;Relation between Lie subalgebras & Lie subgroups; Cartans theorem on closedsubgroups; One parameter subgroups; Exponential maps; Adjoint representation;Homogeneous spaces; Compact Lie groups; Symmetric spaces. **References/Text Books:**	MANIFOLDS AND LIE GROUPS
MTH624A	3-0-0-0-9		**Course Contents:** Differentiable manifolds; Tangent space. Vector fields; Frobenius theorem;Relation between Lie subalgebras & Lie subgroups; Cartans theorem on closedsubgroups; One parameter subgroups; Exponential maps; Adjoint representation;Homogeneous spaces; Compact Lie groups; Symmetric spaces. **References/Text Books:**	DIFFERENTIABLE MANIFOLDS AND LIE GROUPS
MTH627	3-0-0-0-4		**Course Contents:** Basic Fourier Analysisa review Convolutions, Multipliers and Filters, PoissonSummation Formula, Shannon Sampling Discrete Fourier Transform, Fast FourierTransform, Discrete Wavelets, Continuous Wavelets, Uncertainty Principles,Radar Ambiguity, Phase Retrieval, Random Transform, Basic Properties, Convolutionand Inversion, Computerized Tomography **References/Text Books:**	APPLIED HARMONIC ANALYSIS
MTH628	3-0-0--4	#	**Course Contents:** Classification of 2dimensional surfaces; Fundamental group; Knots and coveringspaces; Braids and links; Simplicial homology groups and applications; Degreeand Lefschetz Number; BorsukUlam Theorem; Lefschetz FixedPoint Theorem. **References/Text Books:**	TOPICS IN TOPOLOGY
MTH628A	3-0-0-0-9		**Course Contents:** Classification of 2dimensional surfaces; Fundamental group; Knots and coveringspaces; Braids and links; Simplicial homology groups and applications; Degreeand Lefschetz Number; BorsukUlam Theorem; Lefschetz FixedPoint Theorem. **References/Text Books:**	TOPICS IN TOPOLOGY
MTH631	3-0-0--4	#	**Course Contents:** Best approximation in normed spaces. Tchebycheff systems. TchebycheffWeierstrass Jackson Bernstein ZygmundNikolaev etc. theorems. Fourierseries, Splines, Convolutions, Linear positive, Variation diminishing, Simultaneousetc. approximations. Directinversesaturation theorems. Applications. **References/Text Books:**	APPROXIMATION THEORY
MTH631A	3-0-0-0-9		**Course Contents:** Best approximation in normed spaces. Tchebycheff systems. TchebycheffWeierstrass Jackson Bernstein ZygmundNikolaev etc. theorems. Fourierseries, Splines, Convolutions, Linear positive, Variation diminishing, Simultaneousetc. approximations. Directinversesaturation theorems. Applications. **References/Text Books:**	APPROXIMATION THEORY
MTH632	3-0-0-0-4		**Course Contents:** Unbounded Operators, Matrix representation, Selfadjointness Criterion, Quadratic Forms, Differential Operators, Selfadjoint Extensions, Functional Calculus, Spectra of Selfadjoint Operators, Semianalytic vectors, Theorems of Nelson and Nussbaum, States and Observables, Superselection Rules, Position and	SPECTRAL THEORY FOR SELF-ADJOINT OPERATORS

			Momentum, An Uncertainty Principle of Bargmann, Canonical Commutation Relations, Schrodinger representations, Schrodinger Operators, Selfadjointness, A Theorem of Kato, Spectral Theory for Schrodinger Operators, Discrete Spectrum, Essential Spectrum **References/Text Books:** N. Akhiezer, I. Glazman, Theory of Linear Operators in Hilbert Space II, Dover, 1961.* J. Blank, P. Exner, M. Havlivcek, Hilbert Space Operators in Quantum Physics, Springer, 2008.* T. Kato, Perturbation Theory, Springer, 1976.* M. Miklavcic, Applied Functional Analysis and Partial Differential Equations, World Scientific, 1998.* M. Reed and B. Simon, Methods of Modern Mathematical Physics II, Academic Press, 1975.	
MTH632A	3-0-0-0-9		**Course Contents:** Unbounded Operators, Matrix representation, Selfadjointness Criterion, Quadratic Forms, Differential Operators, Selfadjoint Extensions, Functional Calculus, Spectra of Selfadjoint Operators, Semianalytic vectors, Theorems of Nelson and Nussbaum, States and Observables, Superselection Rules, Position and Momentum, An Uncertainty Principle of Bargmann, Canonical Commutation Relations, Schrodinger representations, Schrodinger Operators, Selfadjointness, A Theorem of Kato, Spectral Theory for Schrodinger Operators, Discrete Spectrum, Essential Spectrum **References/Text Books:** N. Akhiezer, I. Glazman, Theory of Linear Operators in Hilbert Space II, Dover, 1961.* J. Blank, P. Exner, M. Havlivcek, Hilbert Space Operators in Quantum Physics, Springer, 2008.* T. Kato, Perturbation Theory, Springer, 1976.* M. Miklavcic, Applied Functional Analysis and Partial Differential Equations, World Scientific, 1998.* M. Reed and B. Simon, Methods of Modern Mathematical Physics II, Academic Press, 1975.	SPECTRAL THEORY FOR SELF-ADJOINT OPERATORS
MTH633	3-0-0-0-4		**Course Contents:** Models of Hyperbolic Space: Upper Half Space Model & Disc Model; Isometries of HyperbolicSpace; Geodesics; Slimness of Triangles and Exponential Divergence of Geodesics in HyperbolicSpace; Isoperimetric Inequalities in Euclidean & Hyperbolic Space; Boundary of Hyperbolic Space;Review of Covering Spaces, Local Isometries and Fundamental groups; Properly DiscontinuousGroup actions; Fundamental Domains; Hyperbolic Surfaces. **References/Text Books:** * Lectures on Hyperbolic Geometry; Riccardo Benedetti and Carlo Petronio;SpringerVerlag.* Kleinian Groups; Bernard Maskit; SpringerVerlag.* Metric Spaces of NonPositive Curvature; Martin R. Bridson, Andre Haefliger;Springer.* Fuchsian Groups; Svetlana Katok; The University of Chicago Press.* A course on geometric group theory;Brian H. Bowditch, preprint.	INTRODUCTION TO HYPERBOLIC GEOMETRY
MTH633A	3-0-0-0-9		**Course Contents:** Models of Hyperbolic Space: Upper Half Space Model & Disc Model; Isometries of HyperbolicSpace; Geodesics; Slimness of Triangles and Exponential Divergence of Geodesics in HyperbolicSpace; Isoperimetric Inequalities in Euclidean & Hyperbolic Space; Boundary of Hyperbolic Space;Review of Covering Spaces, Local Isometries and Fundamental groups; Properly DiscontinuousGroup actions; Fundamental Domains; Hyperbolic Surfaces. **References/Text Books:** * Lectures on Hyperbolic Geometry; Riccardo Benedetti and Carlo Petronio;SpringerVerlag.* Kleinian Groups; Bernard Maskit; SpringerVerlag.* Metric Spaces of NonPositive Curvature; Martin R. Bridson, Andre Haefliger;Springer.* Fuchsian Groups; Svetlana Katok; The University of Chicago Press.* A course on geometric group theory;Brian H. Bowditch, preprint.	INTRODUCTION TO HYPERBOLIC GEOMETRY
MTH634	3-0-0--4	#	**Course Contents:**	BASES IN LOCALLY

			Preliminaries, Elements of basis theory, Types of bases, Summability (summationof infinite series), Koethe sequence spaces, Bases in OTVS, Isomorphismtheorems. **References/Text Books:**	CONVEX SPACES AND KOETHE SEQUENCE SPACES
MTH637	3-0-0--4	#	**Course Contents:** Operators on Hilbert spaces: Compact operators, Schatten class and HilbertSchmidt operators, Spectral theorem. Fourier series, Smooth functions anddistributions. Hardy spaces, Carleson measures, H1BMO duality. Hankel andToeplitz operators on H2. Representation theory of compact groups, Representationof SU(2) and SO(3). **References/Text Books:**	TOPICS IN OPERATOR THEORY AND HARMONIC ANALYSIS
MTH637A	3-0-0-0-9		**Course Contents:** Operators on Hilbert spaces: Compact operators, Schatten class and Hilbert Schmidt operators, Spectral theore. Fourier series, Smooth functions and distributions. Hardy spaces, Carleson measures, H1BMO duality. Hankel and Toeplitz operators on H2. Representation theory of compact groups, Representation of SU(2) and SO (3). **References/Text Books:**	TOPICS IN OPERATOR THEORY AND HARMONIC ANALYSIS
MTH638	3-0-0-0-4		**Course Contents:** Banach Algebras and Spectral theory, Locally compact groups, Basic representation theory, Analysis on Locally compact abelian group, Analysis on compact groups, Group C* algebra and structure of dual space **References/Text Books:** Recommended books: 1. G.B. Folland: Course in Abstract harmonic analysis, Studies inAdvanced Maths., CRC Press, Boca Raton, etc., 1995.	ABSTRACT HARMONIC ANALYSIS
MTH638A	3-0-0-0-9	Instructor¿s permission	**Course Contents:** Banach Algebras and Spectral theory, Locally compact groups, Basic representation theory, Analysis on Locally compact abelian group, Analysis on compact groups, Group C* algebra and structure of dual space **References/Text Books:** Recommended books: 1. G.B. Folland: Course in Abstract harmonic analysis, Studies inAdvanced Maths., CRC Press, Boca Raton, etc., 1995.	ABSTRACT HARMONIC ANALYSIS
MTH639	3-0-0--4	#	**Course Contents:** Topological linear spaces, Equicontinuity, Function spaces, Convexity & convextopological spaces, HahnBanach theorem, Barrelled spaces, Principle of uniformboundedness, Bornological spaces, Duality theory (Arens Th., Mackey topology,Stopology, Polarity). **References/Text Books:**	LOCALLY CONVEX SPACES
MTH639A	3-0-0-0-9		**Course Contents:** Topological linear spaces, Equicontinuity, Function spaces, Convexity & convextopological spaces, HahnBanach theorem, Barrelled spaces, Principle of uniformboundedness, Bornological spaces, Duality theory (Arens Th., Mackey topology,Stopology, Polarity). **References/Text Books:**	LOCALLY CONVEX SPACES
MTH640	3-0-0--4	#	**Course Contents:** Cauchy integral formula, Taylor series, Associated radii of convergence, Analyticfunctions, Reinhardt	SEVERAL COMPLEX VARIABLES

			domain, Logarithmic convexity, Laurents expansion, Envelopeof holomorphy, Goldbergs growth parameter, Factorization, Weirestrass preparationtheorem, Types of singularity, Domain of holomorphy, Complex analytic structure. **References/Text Books:**	
MTH641	3-0-0-0-4		**Course Contents:** Definitions and first examples. Classical Lie algebras. Ideals and homomorphisms. Niporent Lie algegras. Engel's theorem. Solvable Lie algebras. Lie's theorem. JordanChevalley Decomposition. Radical and semisimplicity. The Killing form and Cartan's criterion. THe structure of semisimple Lie algebras. Complete reducibility and Weyls theorem. Representation theory of the Lie algebra sl(2). Total subalgebras and root systems. Integrality properties. Simple Lie algebras and irreducible root systems. **References/Text Books:** 1. Humphreys, James E. (1972), Introduction to Lie Algebras and Representation Theory, Berlin, New York.2. J.P. Serre, Complex semisimple Lie algebras (trnslated from French: Algebras de Lie complex semisimple).	INTRODUCTION TO LIE ALGEBRAS AND REPRESENTATION THEORY
MTH641A	3-0-0-0-9		**Course Contents:** Definitions and first examples. Classical Lie algebras. Ideals and homomorphisms. Niporent Lie algegras. Engel's theorem. Solvable Lie algebras. Lie's theorem. JordanChevalley Decomposition. Radical and semisimplicity. The Killing form and Cartan's criterion. THe structure of semisimple Lie algebras. Complete reducibility and Weyls theorem. Representation theory of the Lie algebra sl(2). Total subalgebras and root systems. Integrality properties. Simple Lie algebras and irreducible root systems. **References/Text Books:** Course Reference : 1. Humphreys, James E. (1972), Introduction to Lie Algebras and Representation Theory, Berlin, New York.2. J.P. Serre, Complex semisimple Lie algebras (trnslated from French: Algebras de Lie complex semisimple).	INTRODUCTION TO LIE ALGEBRAS AND REPRESENTATION THEORY
MTH644	3-0-0--4	#	**Course Contents:** Fundamental theorems, Winding number & applications,Normal families, Riemannmapping theorem, Fundamentals of univalent functions & entire functions,PhragmenLindelf theorems, Gamma, Riemannzeta functions; Harmonicfunctions,Dirichlet problem for disc, Analytical continuation, Runges theorem. **References/Text Books:**	COMPLEX FUNCTION THEORY
MTH647	3-0-0--4	#	**Course Contents:** Chordal & spherical metrics, Normal families. Iteration of polynomials andrational functions, Periodic points & orbits, Julia & Fatous sets and theircharacterizations, Dynamics of Julia and Fatous sets for quadratic, Rational& entire functions; The Mandelbrot set. Julia sets & fractals, Selfsimilarityand fractal dimension. **References/Text Books:**	COMPLEX ANALYTIC DYNAMICS AND FRACTALS
MTH647A	3-0-0-0-9		**Course Contents:** Chordal & spherical metrics, Normal families. Iteration of polynomials andrational functions, Periodic points & orbits, Julia & Fatous sets and theircharacterizations, Dynamics of Julia and Fatous sets for quadratic, Rational& entire functions; The Mandelbrot set. Julia sets & fractals, Selfsimilarityand fractal dimension. **References/Text Books:**	COMPLEX ANALYTIC DYNAMICS AND FRACTALS
MTH648	3-1-0-0-4		**Course Contents:** Theory of Space CurvesThe SerretFrenet formulas. Gauss Theory of SurfacesFirst and second fundamental	DIFFERENTIAL GEOMETRY

			form, Examples, Weingarten map, Principalcurvatures, Gaussian curvature, Examples. Computation of the curvature instandard spaces: Sphere, Torus, Surfaces of revolution etc. LeviCivita connectionUniqueness, Gauss theorem Egregium, Hilberts theorem on the positivity ofcurvature at a point on a compact surface in R3. Geodesics, Equations ofgeodesics, Examples. Jacobi fields, Conjugate points etc. Riemannian areaelement on a surface, Gauss Bonnet theorem. Differentiable manifold,Differentiable structure. Submanifolds, Immersions, Embeddings. Metric tensor,Riemannian connection and curvature. **References/Text Books:**	
MTH648A	3-0-0-0-9		**Course Contents:** Theory of Space CurvesThe SerretFrenet formulas. Gauss Theory of SurfacesFirst and second fundamental form, Examples, Weingarten map, Principalcurvatures, Gaussian curvature, Examples. Computation of the curvature instandard spaces: Sphere, Torus, Surfaces of revolution etc. LeviCivita connectionUniqueness, Gauss theorem Egregium, Hilberts theorem on the positivity ofcurvature at a point on a compact surface in R3. Geodesics, Equations ofgeodesics, Examples. Jacobi fields, Conjugate points etc. Riemannian areaelement on a surface, Gauss Bonnet theorem. Differentiable manifold,Differentiable structure. Submanifolds, Immersions, Embeddings. Metric tensor,Riemannian connection and curvature. **References/Text Books:**	DIFFERENTIAL GEOMETRY
MTH649	3-1-0-0-4		**Course Contents:** Homotopy, Path homotopy. The fundamental group. Covering spaces. Thefundamental group of the circle, S1, sphere, S2, Surfaces 2dimensional,Punctured plane etc. Techniques of calculation. The special Van Kampentheorem. Essential and Inessential maps Applications. The fundamentaltheorem of algebra, Browers fixed point theorem for the disc etc. Triangulations.Simplical complexes. Barycentric subdivision. Simplical mappings, The simplicalapproximation theorem. Simplical homology groups; Calculations for conecomplex, Sn etc. The EulerPoincare formula. The Lefschetz fixed point theorem.Singular homology groups, Topological invariance. The exact homology sequence.The Eilenberg Steenrod axioms. **References/Text Books:**	ALGEBRAIC TOPOLOGY
MTH649A	3-0-0-0-9		**Course Contents:** Homotopy, Path homotopy. The fundamental group. Covering spaces. Thefundamental group of the circle, S1, sphere, S2, Surfaces 2dimensional,Punctured plane etc. Techniques of calculation. The special Van Kampentheorem. Essential and Inessential maps Applications. The fundamentaltheorem of algebra, Browers fixed point theorem for the disc etc. Triangulations.Simplical complexes. Barycentric subdivision. Simplical mappings, The simplicalapproximation theorem. Simplical homology groups; Calculations for conecomplex, Sn etc. The EulerPoincare formula. The Lefschetz fixed point theorem.Singular homology groups, Topological invariance. The exact homology sequence.The Eilenberg Steenrod axioms. **References/Text Books:**	ALGEBRAIC TOPOLOGY
MTH652A	3-0-0-0-9		**Course Contents:** Least upper bound principle; limits; monotone sequence; subsequences, BolzanoWeierstrass, Cauchy sequence, copleteness; countable and uncountable sets; convergence of series, conditional convergence; equivalence of completeness of R; limsup, liminf, convergent series; absolute and conditional convergent, Riemann Rearragngement Theorem; convergence in R, open sets and closed sets on R; Cantor intersection Theorem, Cantor set; limits and continuity; discontinuous functions; properties of continuous functions; uniform continuity; monotone functions; differentiation, Mean Value Theorem; Riemann integration; Fundamental Theorem of Calculus; sequence and series of functions; point wise convergence; uniform convergence, Weierstrass Mtest, Dedekind test; uniform convergence and continuity; term by term integration and differenciation; power series; Taylor series, Weierstrass Approximation Theorem; analytic functions; Fourier series; differenciation of f:R>R; partial derivatives; chain rule; higher derivatives, local	ADVANCED CALCULUS

			extrema; Taylor expansion; multiple integrals, determinant and volume, Jacobians. **References/Text Books:** [1]. K R Davidson and A P Donsig: Real Analysis and Applications, Springer, 2010. [2]. R S Strichartz: The Way of Analysis, Jones and Bartlet Mathematices, 2010.	
MTH653	3-0-0--4	#	**Course Contents:** Volterra and Fredholm integral equations, Resolvent Kernels. Operator equations,Fredholm theory, HilbertSchmidt theory. Nonlinear integral equations, Singularintegral equations. **References/Text Books:**	INTEGRAL EQUATIONS
MTH653A	3-0-0-0-9		**Course Contents:** Volterra and Fredholm integral equations, Resolvent Kernels. Operator equations,Fredholm theory, HilbertSchmidt theory. Nonlinear integral equations, Singularintegral equations. **References/Text Books:**	INTEGRAL EQUATIONS
MTH656	3-0-0--4	#	**Course Contents:** Elements of operator theory and Hilbert spaces; Introduction to the theoryof distributions. Sobolev Spaces : Imbedding and compactness theorems,Fractional spaces and elements of trace theory. Applications to ellipticequations or parabolic equations. **References/Text Books:**	SOBOLEV SPACES AND APPLICATIONS
MTH656A	3-0-0-0-9		**Course Contents:** Elements of operator theory and Hilbert spaces; Introduction to the theoryof distributions. Sobolev Spaces : Imbedding and compactness theorems,Fractional spaces and elements of trace theory. Applications to ellipticequations or parabolic equations. **References/Text Books:**	SOBOLEV SPACES AND APPLICATIONS
MTH657	3-1-0-0-4		**Course Contents:** Basic definitions. Blocks. Ramsey Numbers. Degree sequences. Connectivity.Eulerian and Hamiltonian Graphs. Planar graphs and 5colour theorem. Chromaticnumbers. Enumeration. MaxFlow MinCut Theorem. Groups and graphs. Matricesand graphs. Matchings and Halls Marriage Theorem. Eigen values of graphs. **References/Text Books:**	GRAPH THEORY
MTH657A	3-0-0-0-9		**Course Contents:** Basic definitions. Blocks. Ramsey Numbers. Degree sequences. Connectivity.Eulerian and Hamiltonian Graphs. Planar graphs and 5colour theorem. Chromaticnumbers. Enumeration. MaxFlow MinCut Theorem. Groups and graphs. Matricesand graphs. Matchings and Halls Marriage Theorem. Eigen values of graphs. **References/Text Books:**	GRAPH THEORY
MTH658	3-0-0--4	MTH421	**Course Contents:** Picard's theorem, Boundedness of solutions, Omega limit points of boundedtrajectories.LaSalle's invariance principle; Stability via Lyapanov's indirect method,Converse Lyapanov functions, Sublevel sets of Lyapanov functions, Stability viaLyapanov's direct method, Converse Lyapanov's theorems, Brokett's theorem,Applications to control system; Stable and unstable manifolds of equilibria, Stablemanifold theorem, HartmanGrobman theorem, Examples and applications,Center manifold theorem, Center manifold theorem, Normal form theory,Examples and applications to nonlinear systems and control; Poincare map, andstability	NONLINEAR DYNAMICAL SYSTEMS

			theorems for periodic orbits; Elementary Bifurcation theory. **References/Text Books:**	
MTH658A	3-0-0-0-9		**Course Contents:** Picard's theorem, Boundedness of solutions, Omega limit points of boundedtrajectories.LaSalle's invariance principle; Stability via Lyapanov's indirect method,Converse Lyapanov functions, Sublevel sets of Lyapanov functions, Stability viaLyapanov's direct method, Converse Lyapanov's theorems, Brokett's theorem,Applications to control system; Stable and unstable manifolds of equilibria, Stablemanifold theorem, HartmanGrobman theorem, Examples and applications,Center manifold theorem, Center manifold theorem, Normal form theory,Examples and applications to nonlinear systems and control; Poincare map, andstability theorems for periodic orbits; Elementary Bifurcation theory. **References/Text Books:**	NONLINEAR DYNAMICAL SYSTEMS
MTH659A	3-0-0-0-9	MTH405A,MTH406A	**Course Contents:** REVIEW OF TOPIC IN FUNCTIONAL ANALYSIS AND SOBOLEV SPACE. MAPPING BETWEEN BANACH SPACES.DEGREE THEORY. BIFURCATION THEORY. VARIATION METHOD: CONSTRAINED CRITICAL POINTS, DEFORMATION AND PALAIS CONDITION,LINKING THEOREMS,MOUNTAIN PASS THEOREM AND EKELAND VARIATION PRINCIPAL. **References/Text Books:**	NONLINEAR ANALYSIS AND ITS APPLLICATIONS TO PDE
MTH664	3-0-0--4	#	**Course Contents:** The fundamentals of lubrication, friction & wear. Boundary lubrication,Hydrodynamic lubrication, Elastohydrodynamic lubrication. Compressibility &thermal effects, Non Newtonian lubrication, Roughness effects, Magnetohydrodynamiceffects, Application to engineering & human systems. **References/Text Books:**	TRIBOLOGY
MTH664A	3-0-0-0-9		**Course Contents:** The fundamentals of lubrication, friction & wear. Boundary lubrication,Hydrodynamic lubrication, Elastohydrodynamic lubrication. Compressibility &thermal effects, Non Newtonian lubrication, Roughness effects, Magnetohydrodynamiceffects, Application to engineering & human systems. **References/Text Books:**	TRIBOLOGY
MTH681	3-0-0--4	#	**Course Contents:** Decision function, Risk function, Optimal decision rules, Admissibility &completeness, The minimax theorem, The complete class theorem, Sufficientstatistics. Invariant decision problems, Admissible & minimax invariant rules,The Pitman estimates, Estimation of a distribution function. **References/Text Books:**	STATISTICAL DECISION THEORY
MTH682	3-0-0--4	#	**Course Contents:** Basic distribution theory, Moments of order statistics including recurrencerelations, Bounds and approximations, Estimation of parameters, Life testing,Short cut procedures, Treatment of outliers, Asymptotic theory of extremes. **References/Text Books:**	ORDER STATISTICS
MTH682A	3-0-0-0-9		**Course Contents:** Basic distribution theory, Moments of order statistics including recurrence relations, Bounds and	ORDER STATISTICS

			approximations, Estimation of parameters, Life testing, Short cut procedures, Treatment of outliers, Asymptotic theory of exremes. **References/Text Books:**	
MTH683	3-0-0--4	#	**Course Contents:** Order statistics, Tests of goodness of fit, Sign & signed rank tests, WaldWolfowitz, KolmogorovSmirnov, Median & MannWhitney tests, Linear ranktests for the location problem & scale problem, Measures of association,Asymptotic relative efficiency. **References/Text Books:**	NON-PARAMETRIC INFERENCE
MTH684	3-0-0--4	#	**Course Contents:** Introduction to simulation & MonteCarlo studies; Generation of random variables.Interactive computational & graphical techniques in model building; Data basedinference methods such as JackKnife, Bootstrap and crossvalidation techniques;Use of statistical packages in data analysis. **References/Text Books:**	STATISTICAL SIMULATION,DATA ANALYSIS AND MODEL BUILDING
MTH685	3-0-0--4	#	**Course Contents:** Linear stationary processes, Autocovariance & spectral density functions &moving average processes, Linear nonstationary processes, Model estimation& identification, Forecasting, Transfer function models, Design for discretecontrol. **References/Text Books:**	TIME SERIES ANALYSIS:FORECASTING AND CONTROL
MTH686	3-0-0--4	#	**Course Contents:** Estimation methods, Commonly encountered problems in estimation, Statisticalinference, Multiresponse nonlinear model, Asymptotic theory, Computationalmethods. **References/Text Books:**	NON-LINEAR REGRESSION
MTH686A	3-0-0-0-9		**Course Contents:** Estimation methods, Commonly encountered problems in estimation, Statisticalinference, Multiresponse nonlinear model, Asymptotic theory, Computationalmethods. **References/Text Books:**	NON-LINEAR REGRESSION
MTH690A	3-0-0-0-9		**Course Contents:** Results of convergence in almost sure sense and in probability, DCT, Basic inequalities, Conditional expectation, Methods of resampling. Introduction to discriminant analysis, Basyes' risk, and its properties. Distance measures for deensity functions, and its relation with Bayes' risk. Empirical Bayes' risk and its convergence. Parametric methods: Maximum likelihood principle Fisher's linear discriminant function (LDA), quadratic discriminat analysis (QDA). Consistency results. Logistic regression, Linear support vector machines (SVM), Maximum linear separation and Projection pursuit. Non parametric methods : Kernel discriminant analysis (KDA), nearest neighbor classification (kNN), Universal consistencyh results. Idea of curse of dimensionality, and the use of dimension reduction techniques like random projections pricipal component analysis, etc. Semiparametric methods : Mixture Discriminant Analysis (MDA), Nonlinear SVM, Hybrid classifiesrs, Classification using data depth, Related consistency results. **References/Text Books:** 1. Pattern Calssification by Richard Duda, Peter Hart and David Sstork, Wiley. 2. A Probabilistic Theory of Pattern Recognition by Luc Devroye, Laszlo Gyorfi and Gabor Lugosi. Springer. 3. The Elements of	PROBABILISTIC THEORY OF PATTERN RECOGNITION

			Statistical Learning : Data Mining, Inference, and Prediction by Trevor Hastie, Robert Tibshirani, Jerome Friedman. Springer.	
MTH691	3-0-0--4	#	**Course Contents:** Triangular form, Matrix norms, Conditioning of linear systems, Direct methods(Gauss, Cholesky, Householder), Iterative methods (Jacobi, GaussSeidel,Relaxation) for solving linear systems, Computing of eigenvalues & eigenvectors(Jacobi, GivensHouseholder, QR, Inverse methods), Conjugate gradientmethod & its preconditioning. **References/Text Books:**	NUMERICAL LINEAR ALGEBRA
MTH691A	3-0-0-0-9		**Course Contents:** Triangular form, Matrix norms, Conditioning of linear systems, Direct methods(Gauss, Cholesky, Householder), Iterative methods (Jacobi, GaussSeidel,Relaxation) for solving linear systems, Computing of eigenvalues & eigenvectors(Jacobi, GivensHouseholder, QR, Inverse methods), Conjugate gradientmethod & its preconditioning. **References/Text Books:**	NUMERICAL LINEAR ALGEBRA
MTH692	3-1-0-0-4		**Course Contents:** Introduction. RungeKutta methods derivation, error bounds and error estimates.Weak stability theory for RungeKutta methods. Order and convergence of thegeneral explicit onestep methods. Linear multistep methods derivation, orderconsistency, zerostability and convergence. Weak stability theory for generallinear multistep methods. PredictorCorrector methods. Stiff systems. **References/Text Books:**	NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS
MTH692A	3-1-0-0-9		**Course Contents:** Introduction. RungeKutta methods derivation, error bounds and error estimates.Weak stability theory for RungeKutta methods. Order and convergence of thegeneral explicit onestep methods. Linear multistep methods derivation, orderconsistency, zerostability and convergence. Weak stability theory for generallinear multistep methods. PredictorCorrector methods. Stiff systems. **References/Text Books:**	NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS
MTH693	3-1-0-0-4		**Course Contents:** Basic linear algebra vector and matrix norms and related theorems. Parabolicequations in one and two space dimensions explicit and implicit formulae.Consistency, stability and convergence. Iterative methods for linear systems.Split operator methods. Multilevel difference schemes. Nonlinear equations.Elliptic Equations Dirichlet, Neumann and mixed problems. Direct factorizationmethods and successive overrelaxation (S.O.R.). ADI and conjugate gradientmethods. Hyperbolic equations. First order hyperbolic systems in one and twospace dimensionsstability and convergence. Second order equations in one andtwo space dimensions. The Galerkin method and applications. **References/Text Books:**	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS
MTH693A	3-0-0-0-9		**Course Contents:** Basic linear algebra vector and matrix norms and related theorems. Parabolicequations in one and two space dimensions explicit and implicit formulae.Consistency, stability and convergence. Iterative methods for linear systems.Split operator methods. Multilevel difference schemes. Nonlinear equations.Elliptic Equations Dirichlet, Neumann and mixed problems. Direct factorizationmethods and successive overrelaxation (S.O.R.). ADI and conjugate gradientmethods. Hyperbolic equations. First order hyperbolic systems in one and twospace dimensionsstability and convergence. Second order equations in one andtwo space dimensions.	NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS

			The Galerkin method and applications. **References/Text Books:**	
MTH694	3-0-0--4	#	**Course Contents:** Conservation laws, Weak solutions & shocks, Monotone difference schemes, Totalvariation diminishing schemes, Godunovtype schemes, Essentially nonoscillatorymethods, Flux limiters. **References/Text Books:**	COMPUTATIONAL FLUID DYNAMICS
MTH696	3-0-0--4	#	**Course Contents:** Galerkin, Collocation & Tau methods, Spectral approximation, The Fourier system,Continuous & discrete Fourier expansion, Orthogonal polynomials in (1,1),Fundamentals of spectral methods for PDEs, Temporal discretization, TheGalerkin Collocation method, Implicit spectral equations, Case of nonsmoothsolutions. **References/Text Books:**	SPECTRAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS
MTH698	3-0-0--4	#	**Course Contents:** Fundamentals of parallel computing; Parallel techniques and algorithms; Parallelalgorithms for linear algebriac equations; Design of parallel algorithms for eigenvalue problem; Parallel issues of factorization : singular value decompositionand related problems; Parallel implementation of classical iterative methods;Conjugate gradient method; Parallel methods for ordinary and partial differentialequations. **References/Text Books:**	PARALLEL NUMERICAL ALGORITHM
MTH698A	3-0-0-0-9		**Course Contents:** Fundamentals of parallel computing; Parallel techniques and algorithms; Parallelalgorithms for linear algebriac equations; Design of parallel algorithms for eigenvalue problem; Parallel issues of factorization : singular value decompositionand related problems; Parallel implementation of classical iterative methods;Conjugate gradient method; Parallel methods for ordinary and partial differentialequations. **References/Text Books:**	PARALLEL NUMERICAL ALGORITHM
MTH701	3-0-0--4		**Course Contents:** Modal Propositional LogicSystems K, T, D, S4, S5, B; Automated Proof Methods,Decidability; Consistency, Frames, Canonical Models, Completeness; FiniteModels, Incompleteness.Algebraic semanticsLindenbaumTarski Algebras, JonssonTarski Theorem,GoldblattThomason Theorem.Modal Predicate LogicCompletedness; Automated Proof Methods; Identity. someModal Systems and applicationsTemporal, dynamic and epistemic Logics,Topology via Modal Logic **References/Text Books:**	MODAL LOGIC
MTH701A	3-0-0-0-9		**Course Contents:** Modal Propositional LogicSystems K, T, D, S4, S5, B; Automated Proof Methods,Decidability; Consistency, Frames, Canonical Models, Completeness; FiniteModels, Incompleteness.Algebraic semanticsLindenbaumTarski Algebras, JonssonTarski Theorem,GoldblattThomason Theorem.Modal Predicate LogicCompletedness; Automated Proof Methods; Identity. someModal Systems and applicationsTemporal, dynamic and epistemic Logics,Topology via Modal Logic **References/Text Books:**	MODAL LOGIC
MTH712A	3-0-0-0-9		**Course Contents:** A brief review of commutative algebra Localization, Noetherian rings and modules, integral extensions,	A FIRST COURSE IN ALGEBRAIC NUMBER

			Dedekind domains and discrete valuation ring, Spec of ring. Number field, ring of integer, primes and ramifications. Class group, initeness of class number, Dirichlet's unit theorem. Global fields, local fields, valuations. Cyclotomic fields. Zeta functions and Lfunctions, class number formula. Adeles and ideles. **References/Text Books:** 1. Number Fields, D. Marcus, Universitext, SpringerVerlag.2. Problems in Algebraic Number Theory, E. Jody and M.Ram Murty, GTM 190, SpringerVerlog. 3. Algebraic Number Theory, J.S. Milne, Course notes, available at http://www.jmilne.org. 4. Algebraic Number Theory, J. Neukirch, Grundlehren der Mathematischen Wissenschaften 322, SpringerVerlog. 5. Algebraic Number Theory, S. Lang, GTM 110, SpringerVerlog. 6. A course in Arithmetic, J P Serre, GTM 7, SpringerVerlog. 7. Algebraic Number Theory, R. Narasimhan et.al, TIFR Pamphlet, available at www.math.tifr.res.in/ publ/pamphlets/index.html. 8. Introduction to commutative algebra, M.F. Atiyah, and I.G. Macdonald, AddisonWesley Publishing Co.	THEORY
MTH732A	3-0-0-0-9		**Course Contents:** Basic representation theory, Irreducible representation, Equivalence and unitary equivalence, Construction of new representation, Character of a representation, Schur's lemma and its applications, Schur's orthogonality relations, Schur's theory of characters, induced representations, Frobenius reciprocity, group algebra of S and A for small values of n. **References/Text Books:**	REPRESENTATION THEORY OF FINITE GROUPS
MTH733	3-0-0--4		**Course Contents:** Representation theory of Compact groups; Peter Weyl Theorem. Linear LieGroups; The Exponential map, Lie Algebra, Invarient Differential Operaters.Representations of the group and its Lie Algebra. Fourier Analysis on SU(2) andSU(3). Representation theory of the heisenberg Group and some HarmonicAnalysis. Representation of the Euclidean Motion Group. **References/Text Books:**	REPRESENTATION THEORY OF LINEAR LIE GROUPS
MTH733A	3-0-0-0-9		**Course Contents:** Representation theory of Compact groups; Peter Weyl Theorem, Linear Lie Group/ The Exponential map, Lie Algebra, Invarient Differential Operaters. Representations of the group and its Lie Algebra, Fourier Analysis on SU(2) and SU(3). Representation theory of the heisenberg Group and some Harmonic Analysis. Representation of the Euclidean Motion Group. **References/Text Books:**	REPRESENTATION THEORY OF LINEAR LIE GROUPS
MTH734	3-0-0--4		**Course Contents:** Elementary properties of Banach Algebras and examples; Ideals and quotients,the Spectrum, the Riesz Functional Calculas.Abelian Banach Algebras, C* Algebras;Representations of C* Algebras and the Gelfand Naimark Segal Construction.Normal Operators on Hilbert Space, Spectral measure and representation ofabelian C* algebras; The Spectral theorem; Some applications. **References/Text Books:**	BANACH ALGEBRAS, C* ALGEBRAS AND SPECTRAL THEORY
MTH734A	3-0-0-0-9		**Course Contents:** Elementary properties of Banach Algebras and examples; Ideals and quotients, the Spectrum, the Riesz Functional Calculas. Abelian Banach Algebras, C* Algebras; Representations of C* Algebras and the Gelfand Naimark Segal Construction. Normal Operators on Hilbert Space, Spectral measure and representation of abelian C* algebras; The Spectral theorem; Some applications. **References/Text Books:**	BRANCH ALGEBRAS, C* ALGEBRAS AND SPECTRAL THEORY

MTH736	3-0-0-0-4		**Course Contents:** Introduction, Test function spaces, Calculus with distributions, supports ofdistributions, Structure theorems, convolutions, Fourier transforms, L1, L2 theoryof Fourier Transform, Tempered distributions, PaleyWiener theorem, wienerTauberian theorem, Applications of distributions theory and Fourier transformto differential equations. **References/Text Books:**	FOURIER ANALYSIS-I & DISTRIBUTION THEORY
MTH736A	3-0-0-0-9		**Course Contents:** Introduction, Test function spaces, Calculus with distributions, supports ofdistributions, Structure theorems, convolutions, Fourier transforms, L1, L2 theoryof Fourier Transform, Tempered distributions, PaleyWiener theorem, wienerTauberian theorem, Applications of distributions theory and Fourier transformto differential equations. **References/Text Books:**	FOURIER ANALYSIS-I & DISTRIBUTION THEORY
MTH751	3-0-0--4		**Course Contents:** Groups, Basic properties, Isomorphism theorems, Permutation groups, SylowTheorems, Structure theorem for finite abelian groups, Rings, Integral domains,Fields, division rings, Ideals, Maximal ideals, Euclidean rings, Polynomial ringover a ring, Maximal & Prime ideals over a commutative ring with unity, Primeavoidance theorem and Chinese Remainder theorem, Field Extension, Cramer'srule, Algebraic elements and extensions, Finite fields.Determinants and their properties, Systems of linear equations, Eigenvaluesand Eigenvectors, CaleyHamilton theorem, Characteristic and minimal polynomial,diagonalization, Vector spaces, Linear transformations, Inner product spaces. **References/Text Books:**	ALGEBRA
MTH751A	3-0-0-0-9		**Course Contents:** Groups, Basic properties, Isomorphism theorems, Permutation groups, SylowTheorems, Structure theorem for finite abelian groups, Rings, Integral domains,Fields, division rings, Ideals, Maximal ideals, Euclidean rings, Polynomial ringover a ring, Maximal & Prime ideals over a commutative ring with unity, Primeavoidance theorem and Chinese Remainder theorem, Field Extension, Cramer'srule, Algebraic elements and extensions, Finite fields.Determinants and their properties, Systems of linear equations, Eigenvaluesand Eigenvectors, CaleyHamilton theorem, Characteristic and minimal polynomial,diagonalization, Vector spaces, Linear transformations, Inner product spaces. **References/Text Books:**	ALGEBRA
MTH752	3-0-0--4		**Course Contents:** Calculus of Variations; Sturm Liouville Problem and Green's Function; PerturbationMethods and Similarity Analysis; Stability Theory. **References/Text Books:**	MATHEMATICAL METHODS
MTH752A	3-0-0-0-9		**Course Contents:** Calculus of Variations; Sturm Liouville Problem and Green's Function; PerturbationMethods and Similarity Analysis; Stability Theory. **References/Text Books:**	MATHEMATICAL METHODS
MTH753	3-0-0--4		**Course Contents:** Metric spaces, Open and closed sets, Compactness and connectedness,Completeness, Continuous functions (several variables and on metric spaces),uniform continuity C(X), X, compact metric space, Uniform	ANALYSIS

			convergence,compactness criterion, Differentiation, Inverse and Implicit fuction theorems.Riemann Integration, Lebesgue Integration, Lpspaces.Complex Analysis: Analytic functions, Harmonic conjugates, Cauchy theoremsand consequences, Power series, Zeros of analytic functions, Maximum modulustheorem, Singularities, Laurent series, Residues. Mobius transformations.Hilbert spaces: Inner product, Orthogonality, Orthonormal bases, Riesz Lemma,The space L2 as a Hilbert space. **References/Text Books:**	
MTH753A	3-0-0-0-9		**Course Contents:** Metric spaces, Open and closed sets, Compactness and connectedness,Completeness, Continuous functions (several variables and on metric spaces),uniform continuity C(X), X, compact metric space, Uniform convergence,compactness criterion, Differentiation, Inverse and Implicit fuction theorems.Riemann Integration, Lebesgue Integration, Lpspaces.Complex Analysis: Analytic functions, Harmonic conjugates, Cauchy theoremsand consequences, Power series, Zeros of analytic functions, Maximum modulustheorem, Singularities, Laurent series, Residues. Mobius transformations.Hilbert spaces: Inner product, Orthogonality, Orthonormal bases, Riesz Lemma,The space L2 as a Hilbert space. **References/Text Books:**	ANALYSIS
MTH754	3-0-0-0-4		**Course Contents:** Algebras and sigma algebras; Measurable spaces; Methods of introducingprobability measures on measurable space; Random variables; Lebesgue integral;Expectation; Conditional probabilities and conditional expectations with respectto sigmaalgebras; Radon Nikodym theorem; Inequalities of random variables;Fubini's theorem; Various kinds of convergence of sequence of random variables;Convergence of probability measures; Central limit theorem; delta method;Infinitely divisible and stable distributions; ZeroorOne laws; Convergence ofseries; Strong law of large numbers; Law of iteratedlogarithm; Matringales andtheir basic properties. **References/Text Books:**	PROBABILITY THEORY
MTH754A	3-0-0-0-9		**Course Contents:** Algebras and sigma algebras; Measurable spaces; Methods of introducingprobability measures on measurable space; Random variables; Lebesgue integral;Expectation; Conditional probabilities and conditional expectations with respectto sigmaalgebras; Radon Nikodym theorem; Inequalities of random variables;Fubini's theorem; Various kinds of convergence of sequence of random variables;Convergence of probability measures; Central limit theorem; delta method;Infinitely divisible and stable distributions; ZeroorOne laws; Convergence ofseries; Strong law of large numbers; Law of iteratedlogarithm; Matringales andtheir basic properties. **References/Text Books:**	PROBABILITY THEORY
MTH755	3-0-0--4		**Course Contents:** Population and samples; Parametric and nonparametricmodels; Exponential andlocationscale families; Sufficiency and minimal sufficiancy; Complete statistics;Unbiased and UMVU estimation; Asymptotically unbiased estimators; Method ofmoments; Bayes estimators; Invariance; Minimaxity and admissibility; Themethod of maximum likelihood; Asymptotically efficient estimation; Varianceestimation; The jacknife; The bootstrap; The NP lemma; MLR; UMP tests forone and two sided hypotheses; Unbiased and similarity; UMPU tests in exponentialfamilies; Invariance and UMPI tests; LR tests; Asymptotic tests based onlikelihoods; Chisquare tests; Bayes tests; Pivotal quantities; Inverting acceptanceregions of tests; The Bayesian confidence interval; Prediction sets; Length ofconfidence intervals; UMA and UMAU confidence sets; Invariant confidence sets. **References/Text Books:**	STATISTICAL INFERENCE

MTH755A	3-0-0-0-9		**Course Contents:** Population and samples; Parametric and nonparametricmodels; Exponential andlocationscale families; Sufficiency and minimal sufficiancy; Complete statistics;Unbiased and UMVU estimation; Asymptotically unbiased estimators; Method ofmoments; Bayes estimators; Invariance; Minimaxity and admissibility; Themethod of maximum likelihood; Asymptotically efficient estimation; Varianceestimation; The jacknife; The bootstrap; The NP lemma; MLR; UMP tests forone and two sided hypotheses; Unbiased and similarity; UMPU tests in exponentialfamilies; Invariance and UMPI tests; LR tests; Asymptotic tests based onlikelihoods; Chisquare tests; Bayes tests; Pivotal quantities; Inverting acceptanceregions of tests; The Bayesian confidence interval; Prediction sets; Length ofconfidence intervals; UMA and UMAU confidence sets; Invariant confidence sets. **References/Text Books:**	STATISTICAL INFERENCE
MTH761	3-0-0-0-4		**Course Contents:** Smooth Manifolds, Vector bundles, Constructing New vector bundles Out of Old. Grassmann Manifolds and Universal bundles, The classification of vector bundles.Characteristic classes for vector bundles, StiefelWhitney classes of manifolds, Characteristic numbers of manifolds, Thom spaces and the Thom isomorphism theorem, The construction of Stiefel Whitney classes, Chern, Pontryagin, and Euler classes. **References/Text Books:** J. P. May. A concise course in Algebraic Topology. Chicago Lectures in Mathematics. University of Chicago Press, Chicago, IL, 1999. x+243 pp.John W. Milnor and James D. Stasheff. Characteristic classes. Annals of Mathematics Studies, No. 76. Princeton University Press, Princeton, N. J.; University of Tokyo Press, Tokyo, 1974. vii+331 pp.	VECTOR BUNDLES AND CHARACTERISTIC CLASSES
MTH781	3-0-0-0-4		**Course Contents:** Introduction to pattern recongnition supervised and unsupervised classification. Dimension reduction techniques: principal component analysis, multidimensional scaling features for maximum linear separation projection pursuit. Parametric methods for discriminant analysis: Fisher's linear discriminant function. Linear and quadratic discriminant analysis regularized discriminant analysisi. Linear and nonlinear support vector machines. Cluster analysis: hierarchical and nonhirerarchical techniques classification using Gaussian mixtures. Data depth: different notions of depth, concept of multivariate median, application of depth in supervised and unsupervised classification. **References/Text Books:**	STATISTICAL PATTERN RECONGNITION
MTH781A	3-0-0-0-9		**Course Contents:** Introduction to pattern recongnition supervised and unsupervised classification. Dimension reduction techniques: principal component analysis, multidimensional scaling features for maximum linear separation projection pursuit. Parametric methods for discriminant analysis: Fisher's linear discriminant function. Linear and quadratic discriminant analysis regularized discriminant analysisi. Linear and nonlinear support vector machines. Cluster analysis: hierarchical and nonhirerarchical techniques classification using Gaussian mixtures. Data depth: different notions of depth, concept of multivariate median, application of depth in supervised and unsupervised classification. **References/Text Books:**	STATISTICAL PATTERN RECONGNITION
MTH785	3-0-0--4		**Course Contents:** Multiple linear model , estimation of parameters under spherical and nonsphericaldisturbances by least squares and maximum likelihood methods, testsof hypothesis, R2 and adjusted R2. Prediction, within and outside samplepredictions. Problem of structural change, tests for structural change. Use ofdummy variable. Specification error analysis related to explanatory variables,inlusion and deletion of explanatory variables. Idea of Steinrule estimation.Exactand stochastic linear restrictions, restricted and mixed regression	ECONOMETRIC THEORY

			analysis.Multicollinearity, problem, implications and tools for handling the problem, ridgeregression. Heteroskedasticity, problem and test, estimation under Heteroskedasticity.Autocorrelation, DurbinWatson test. Errorsinvariables, inconsistencyof least squares method, methods of consistent estimation, instrumental variableestimation. Seemingly unrelated regression equation model, least squares,generalized least squares and feasible generalized least squares estimators.Simultaneous equations model, structural and reduced forms, rank and orderconditions for identifiability, indirect least squares, two stage least squares andlimited information maximum likelihood methods of estimation. Additional topicslike as Panel data models and unit roots & cointegration. **References/Text Books:**	
MTH799	----		**Course Contents:** Ph. D. Research **References/Text Books:**	RESEARCH
MTH800	----		**Course Contents:** RESEARCH **References/Text Books:**	RESEARCH
SE351	3-1-0-0-4		**Course Contents:** Fields and linear equations. Vector spaces. Linear transformations and projections,relations, etc. Determinants. Elementary canonical forms: diagonalization,triangulation, primary decomposition etc. Secondary decomposition theorem,Rational canonical forms, Jordan canonical forms and some applications. Innerproduct spaces, Selfadjoint, Unitary and normal operators, Orthogonal projections.Bilinear forms, Symmetric, Skewsymmetric, Positive and semipositive formsetc. **References/Text Books:**	LINEAR ALGEBRA
SE352	3-1-0-0-4		**Course Contents:** Permutations and combinations and basic definitions. Generating functions.Polyas enumeration theory. Recurrence relations. Principle of inclusion andexclusion. Balanced incomplete block design. Difference sets. System of distinctrepresentatives. Orthogonal Latin squares. Hadamard matrices. **References/Text Books:**	DISCRETE MATHEMATICS
SE353	3-1-0--4		**Course Contents:** Finite and Infinite Sets: Finite sets, Countable sets, Uncountable sets. Groupsand Symmetry: Groups, Subgroups, Lagrange theorem, Normal subgroups,Quotient groups, Group actions, Homomorphisms, Group of symmetry rigidmotion group, finite subgroups of the rotation group, symmetric group. MetricSpaces: Open sets, Closed sets, Sequences, Continuity, Complete metric spaces,Contraction principle and applications, Connectedness and compactness. Fractals:Metric space of fractals and its completeness, Iterated function systems,Attractor, Algorithms to generate fractals. Topology of Surfaces: Eulers theorem,Construction of surfaces by identification: Torus, mobius strip, Klein bottle. **References/Text Books:**	BASIC STRUCTURES OF MATHEMATICS
SE354	3-1-0-0-4		**Course Contents:** Formal theories, consequence and deduction. Classical Propositional Calculus:Syntax, truth, validity, Adequacy of connectives, normal forms, applications tocircuit design, Axiomatic treatment, deduction theorem, derived rules ofinference, Soundness, Independence of axioms, Consistency, completeness,Completeness w.r.t. Boolean algebras, Computerassisted formal proofs: tableaux,resolution.	MATHEMATICAL LOGIC

			Classical first order theories: Syntax, satisfaction, truth validity,Axiomatic treatment, Equality, Examples of firstorder theories : Peano arithmetic,Groups, Orderings, Basis of axiomatic set theory, Deduction theorem, derivedrules of inference, soundness, Consistency, completeness, LowenheimSkolemtheorems, compactness, Firstorder theories with equality, Decidability, Computerassistedformal proofs: tableaux, resolution. Godels incompleteness theorems.Examples of other/nonclassical logics. Other proof techniques natural deduction,sequent calculus. **References/Text Books:**	
SE356	3-1-0-0-4		**Course Contents:** Linear Models: Formulation and Examples, Basic Polyhedral Theory Convexity,Extreme points, Supporting hyperplanes etc, Simplex Algorithm Algebraic andGeometrical approaches, Artificial variable technique, Duality Theory: Fundamentaltheorem, Dual simplex method, Primaldual method, Sensitivity Analysis, BoundedVariable L.P.P. Transportation Problems: Models and Algorithms, Network Flows:Shortest path Problem, MaxFlow problem and Mincost Flow problem, DynamicProgramming: Principle of optimality, Discrete and continuous models. **References/Text Books:**	OPERATIONS RESEARCH - I
SE358	3-1-0-0-4		**Course Contents:** Generalized Inverses, Cochrans theorem, Gauss Markov Setup, Least squaresestimators with restriction on parameters, Test of Hypothesis of linear parametericfunction, ANOVA, power of tests, Confidence Intervals and Regions, Multiplecomparison, Linear, Polynomial and Multiple Regression, Residual Analysis, Multico llinearity, Ridge Regression and Principal Component Analysis, SubsetSelection, Nonlinear Regression. **References/Text Books:**	REGRESSION ANALYSIS
SE359	3-1-0-0-4		**Course Contents:** Definition and classification of general stochastic processes. Markov Chains:definition, transition probability matrices, classification of states, limitingproperties. Markov Chains with Discrete State Space: Poisson process, birthand death processes. Renewal Process: renewal equation, mean renewal time,stopping time. Markov Process with Continuous State Space: Introduction toBrownian motion. **References/Text Books:**	APPLIED STOCHASTIC PROCESSES
SE360	3-1-0-0-4		**Course Contents:** Multiple Integral Theorems and their Applications: Greens theorem, Stokestheorem and Gauss divergence theorem. Integral Transforms: Fourier, Fouriersine/cosine and Hankel Transforms with their inverse transforms (properties,convolution theorem and application to solve differential equation). PerturbationMethods: Perturbation theory, Regular perturbation theory, Singular perturbationtheory, Asymptotic matching. Calculus of Variation: Introduction, Variationalproblem with functionals containing first order derivatives and Euler equations.Functionals containing higher order derivatives and several independent variables.Variational problem with moving boundaries. Boundaries with constraints. Higherorder necessary conditions, Weirstrass function, Legendres and Jacobis condition.Existence of solutions of variational problems. RayleighRitz method, statementof Ekelands variational principle and applications. **References/Text Books:**	MATHEMATICAL METHODS
SE361	3-1-0-0-4		**Course Contents:** Simulation of random variables from discrete, continuous, multivariate distributionsand stochastic processes, MonteCarlo methods. Regression analysis, scatterplot, residual analysis. Computer Intensive Inference Methods JackKnife,Bootstrap, cross validation, Monte Carlo methods and permutation tests.Graphical	STATISTICAL SIMULATION & DATA ANALYSIS

			representation of multivariate data, Cluster analysis, Principal componentanalysis for dimension reduction. **References/Text Books:**	
SE363	3-1-0--4		**Course Contents:** Introduction and motivation, Weak formulation of BVP and Galerkin approximation,Piecewise polynomial spaces and finite element method, Computer implementationof FEM, Results from Sobolev spaces, Variational formulation of elliptic BVP,LaxMilgram theorem, Estimation for general FE approximation, Constructionof FE spaces, Polynomial approximation theory in Sobolev spaces, Variationalproblem for second order elliptic operators and approximations, Mixed methods,Iterative techniques. **References/Text Books:**	FINITE ELEMENT METHOD
SE364	3-1-0--4		**Course Contents:** Elementary mathematical models. Role of mathematics in problem solving.Concepts of mathematical modeling. System approach. Formulation. Analysisof models. Sensitivity analysis & parameter estimation. Design of experiment,Validation. Simulation approach. Pitfalls in modeling. Illustrations. **References/Text Books:**	MATHEMATICAL MODELING
***** Department of NET *****				
NE620A	3-0-0-0-9	NONE	**Course Contents:** Applications of Radiation. Half Life Determination. Radiation Dose Levels and Calculation :Inverse Square Law Verification, ALARA Principle, Linearnothreshold model. Basic Principles of Radiation Detection. Gamma Ray Interactions: photoelectric, Compton scattering, pairproduction Empirical calculation of crosssections, Linear Attention Coefficient Measurement. Evaluation of GM Detector Characteristics: Plateau determination, Dead time calculations, paralyzable and nonparalyzable detectors. Measurements and Counting Statistics for Error Evalution Limits. Ionizing radiation and detection, Neutron and special nuclear material (SNM) detection for security applications. Mechanisms of neutron interaction: capture, scientillation etc. Scintillation detectors, Capture detectors, Fission chambers. Semiconductor Detectors. Pulse shaping and signal processing. Radiation detection and shielding methods for safety at various nuclear facilities. Measuring gamma dose and shielding calculations. Measuring neutron spectrum and dose and shielding calculations. Measuring other forms of radiation, dose and shielding calculations. Principles of particle accelerator and measurements on the 1.7 MeV TANDETRON* OR Instrumentation and controls used in existing and advanced nuclear power plants* **References/Text Books:**	RADIATION INTERACTION, DETECTION, AND SHIELDING-THEORY ON NUCLEAR MEASUREME
NT602	3-0-0--4		**Course Contents:** Introduction to quantum mechanics, Schrodinger equation and its solution byseparation of variables. Potential well, quantum states. Nuclear charge, radiusand mass. Binding energy. Nuclear forces and the deuteron problem. Semiempiricalmass formula. Energetics of nuclear stability. Reaction channels, Compoundnucleus. Energy dependence of neutron cross sections and Brecitwigner formula.The fission process.Neutron diffusion theory showing down length. Critical mass and size. Numericalcriticality search. Fourfactor formula. Energy dependent diffusion. Multigroupdiffusion, group constants and matrix formulation. Twogroup analysis. Agetheory. Slowing down theory. **References/Text Books:**	NUCLEAR AND REACTOR PHYSICS
NT602A	3-0-0-0-9		**Course Contents:** Introduction to quantum mechanics, Schrodinger equation and its solution byseparation of variables. Potential well, quantum states. Nuclear charge, radiusand mass. Binding energy. Nuclear forces and the deuteron	NUCLEAR AND REACTOR PHYSICS

			problem. Semiempiricalmass formula. Energetics of nuclear stability. Reaction channels, Compoundnucleus. Energy dependence of neutron cross sections and Brecitwigner formula.The fission process.Neutron diffusion theory showing down length. Critical mass and size. Numericalcriticality search. Fourfactor formula. Energy dependent diffusion. Multigroupdiffusion, group constants and matrix formulation. Twogroup analysis. Agetheory. Slowing down theory. **References/Text Books:**	
NT611A	3-0-0-0-9		**Course Contents:** Types of nuclear reactors. Heat generation in fuel elements and temperaturedistributions. Heat removal, Reactor coolants. Single phase and two phase heattransfer. Boiling and flow regimes. Heat transfer and fluid flow correlations.Pressure drops due to friction and pumping power. Reactor core **References/Text Books:**	NUCLEAR POWER ENGINEERING I
NT614	3-0-0--4		**Course Contents:** Introduction to control theory. Point reactor kinetics with introduction to feedbackeffects. Nonlinear effects. Shielding. Introduction to reactor reliability andsafety analysis. Radioactive waste disposal. Economics of nuclear power. Introductionto nuclear fuel cycles. **References/Text Books:**	NUCLEAR POWER ENGINEERING II
NT614A	3-0-0-0-9		**Course Contents:** Introduction to control theory. Point reactor kinetics with introduction to feedbackeffects. Nonlinear effects. Shielding. Introduction to reactor reliability andsafety analysis. Radioactive waste disposal. Economics of nuclear power. Introductionto nuclear fuel cycles. **References/Text Books:**	NUCLEAR POWER ENGINEERING II
NT615	3-0-0--4	NT602 NT611	**Course Contents:** Health Physics: introduction, radiation protection, regulatory aspects, radiationbiology, operational radiation protection, radiation protection monitoring.Process Instrumentation and Control: basic concepts, sensing and transmission/receiving of temperature, flow, liquid level, pressure, force, viscousity, humidity.Nuclear Materials: fabrication and properties of zircaloy, metallic fuels, ceramicfuels, applications.Nuclear Chemistry: role of chemistry in nuclear engineering, chemical processesin the nuclear fuel cycle, production of uranium, plutonium, thorium, heavy water,water treatment, corrosion, decontamination. **References/Text Books:**	NUCLEAR POWER ENGINEERING III
NT620A	1-0-0-0-3		**Course Contents:** Applications of Radiation. Half Life Determination. Radiation Dose Levels and Calculation :Inverse Square Law Verification, ALARA Principle, Linearnothreshold model. Basic Principles of Radiation Detection. Gamma Ray Interactions: photoelectric, Compton scattering, pairproduction Empirical calculation of crosssections, Linear Attention Coefficient Measurement. Evaluation of GM Detector Characteristics: Plateau determination, Dead time calculations, paralyzable and nonparalyzable detectors. Measurements and Counting Statistics for Error Evalution Limits. Ionizing radiation and detection, Neutron and special nuclear material (SNM) detection for security applications. Mechanisms of neutron interaction: capture, scientillation etc. Scintillation detectors, Capture detectors, Fission chambers. Semiconductor Detectors. Pulse shaping and signal processing. Radiation detection and shielding methods for safety at various nuclear facilities. Measuring gamma dose and shielding calculations. Measuring neutron spectrum and dose and shielding calculations. Measuring other forms of radiation, dose and shielding calculations. Principles of particle accelerator and measurements on the 1.7 MeV TANDETRON* OR Instrumentation and controls used in	RADIATION INTERACTION, DETECTION, AND SHIELDING-THEORY ON NUCLEAR MEASUREME

			existing and advanced nuclear power plants* **References/Text Books:** 1. G.F. Knoll, Radiation Detection and Measurements, John Wiley & Sons, Hoboken, New Jersey (2010).2. S.S. Kapoor and V.S. Ramamurthy, Nuclear Radiation Detectors, Wiley Eastern Limited (1986).3. K.S. Ram, Nuclear Measurement and Techniques, Affiliated EastWest Press, New Delhi (1986).	
NT621	1-0-6-0-4		**Course Contents:** Biological effects of radiation; Radiation monitoring; GM Counter characteristics,counting statistics. Scintillation detectors and gamma spectrometry. Multichannelanalysis. Semiconductor detectors for alpha and gamma spectrometry.Coincidence measurements. BF 3 counters. Foil Activation. Cadmium ratiomeasurements. Neutron diffusion length and age measurements. Experimentsusing Van de Graaff. Radioisotope applications, Computer simulation studies. **References/Text Books:**	NUCLEAR MEASUREMENTS LABORATORY
NT621A	1-0-6-0-9		**Course Contents:** Biological effects of radiation; Radiation monitoring; GM Counter characteristics,counting statistics. Scintillation detectors and gamma spectrometry. Multichannelanalysis. Semiconductor detectors for alpha and gamma spectrometry.Coincidence measurements. BF 3 counters. Foil Activation. Cadmium ratiomeasurements. Neutron diffusion length and age measurements. Experimentsusing Van de Graaff. Radioisotope applications, Computer simulation studies. **References/Text Books:**	NUCLEAR MEASUREMENTS LABORATORY
NT633	3-0-0--4	#	**Course Contents:** Basic physics of fusion reactions, thermonuclear crosssections. Radiation losses:bremsstrahlung and cyclotron radiation. Energy balance: Lawson criterion,neutronnics in a fusion reactor. Plasma confinement: Pinch effect, stellaratorand magnetic mirrors. Plasma heating ohmic and adiabatic compression:Tokamaks. Inertial confinement of plasma microexplosion and laser fusion. **References/Text Books:**	NUCLEAR FUSION
NT641	3-0-0--4		**Course Contents:** Overview, medical imaging, nondestructive testing, radiographic techniques,various applications, data collection, design of CT scanners for materials testing,flow measurement, related instrumentation, Radons inversion formula, centralslicetheorem, fanbeam inversion, filter functions, convolving functions transformmethods, seriesexpansion methods, convolution algorithms, error estimates,direct theorems, inverse theorems. **References/Text Books:**	INTRODUCTION TO COMPUTERIZED TOMOGRAPHY
NT641A	3-0-0-0-9		**Course Contents:** Overview, medical imaging, nondestructive testing, radiographic techniques,various applications, data collection, design of CT scanners for materials testing,flow measurement, related instrumentation, Radons inversion formula, centralslicetheorem, fanbeam inversion, filter functions, convolving functions transformmethods, seriesexpansion methods, convolution algorithms, error estimates,direct theorems, inverse theorems. **References/Text Books:**	INTRODUCTION TO COMPUTERIZED TOMOGRAPHY
NT642A	3-0-0-0-9		**Course Contents:** Introduction, various NDE techniques ultrasonics, eddy current, magnetic fluxleakage, radiography, optical,	NON-DESTRUCTIVE EVALUATION

			tomographic extensions of classical NDE/NDT methodsRadon inversion, data collection mechanisms, applications in industrial situations. **References/Text Books:**	
NT651	3-0-0--4		**Course Contents:** Introduction, Core design, Fuelelement design, Fuel management, Heat transportsystems, Steamgenerators, IHX design, Sodium pumps & piping, Instrumentation& controls, safety, extractive and physical metallurgy of nuclear materials,Metallic fuels, cladding, post irradiation examination, fabrication of fuel, Steelsfor nuclear environment, advanced NDT techniques, corrosion. **References/Text Books:**	FAST REACTOR TECHNOLOGY
NT651A	3-0-0-0-9		**Course Contents:** Introduction, Core design, Fuelelement design, Fuel management, Heat transportsystems, Steamgenerators, IHX design, Sodium pumps & piping, Instrumentation& controls, safety, extractive and physical metallurgy of nuclear materials,Metallic fuels, cladding, post irradiation examination, fabrication of fuel, Steelsfor nuclear environment, advanced NDT techniques, corrosion. **References/Text Books:**	FAST REACTOR TECHNOLOGY
NT652	3-0-0--4	NT602/NT611	**Course Contents:** Introduction, nuclear fuels, uranium technology, xirconium process, babricationof fuel assemblies, PWR fuel, mixedoxide fuel, irradiated fuel, reprocessing,radioactivity, contamination, waste management, enrichment of uranium, thoriumcycle, fast reactor fuel cycle and fuel fabrication, environmental impact andsafety. **References/Text Books:**	NUCLEAR FUEL CYCLE
NT699	----		**Course Contents:** M. Tech. Thesis **References/Text Books:**	M TECH THESIS
NT799	----		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PHD THESIS
***** Department of PHY *****				
PHY100	1-0-2-0-0		**Course Contents:** Frontiers of physics at various scales, unifying themes and tools ofphysics, significant discoveries, which shaped our current understanding ofthe physical World. physicsinduced technologies.The course will include physics demonstrations along with some handsonexperience in the Nuclear, Laser, Low Temperature, and CondensedMatter laboratories of the Physics Department. **References/Text Books:**	INTRODUCTION TO PROFESSION
PHY101A	0-0-3-0-3		**Course Contents:** Introduction to error analysis and graphdrawing; spring oscillation apparatus;trajectory of a projectile on an inclined plane; moment of inertia of a bicyclewheel; bar pendulum; torsional pendulum; coupled pendulum; study of collisionson an air track; gyroscope; current balance; measurement of capacitance usinggalvanometer; charging of a plate capacitor; electromagnetic induction; prismspectrometer; Fraunhofer	PHYSICS LABORATORY

			diffraction using HeNe laser; magnetic fieldin Helmholtz coil; resonance in electrical circuits. **References/Text Books:**	
PHY101N	0-0-4-0-2		**Course Contents:** Introduction to error analysis and graphdrawing; spring oscillation apparatus;trajectory of a projectile on an inclined plane; moment of inertia of a bicyclewheel; bar pendulum; torsional pendulum; coupled pendulum; study of collisionson an air track; gyroscope; current balance; measurement of capacitance usinggalvanometer; charging of a plate capacitor; electromagnetic induction; prismspectrometer; Fraunhofer diffraction using HeNe laser; magnetic fieldin Helmholtz coil; resonance in electrical circuits. **References/Text Books:**	PHYSICS LAB
PHY102A	3-1-0-0-11		**Course Contents:** Transformation of Scalars and Vectors under Rotation, Form Invariance of Newtons Second Law, Forces in Nature; Solving Newtons Equations of Motion in Polar Coordinates for problems including Constraint and Friction, extension to Cylindrical and Spherical Coordinates; Potential Energy Function, Conservative and NonConservative Forces; Central Forces, Energy Equation and Diagrams, Elliptical, Parabolic, and Hyperbolic Orbits, Harmonic Oscillator with Damping, Forced Oscillations and Resonance, inclusion of Nonlinear Force and Chaotic Motion, PhaseSpace Description; NonInertial Frames of Reference, Centrifugal and Coriolis Forces, Weather Systems, Foucault Pendulum; Angular Momentum and Torque, Rigid Body Dynamics, Moment of Inertia Tensor, Principal Axes, TorqueFree Precession, Gyroscopes, Eulers Equations; Special Relativity, Lorentz Transformation, Length Contraction, Time Dilation, Velocity Addition, Relativistic Dynamics, EnergyMass Relation **References/Text Books:**	PHYSICS-I
PHY102N	3-1-0-1-4		**Course Contents:** Coordinate systems, elements of vector algebra in plane polar, cylindrical,spherical polar coordinate systems, dimensional analysis; solutions forone dimensional equation of motion in various forms, frames of reference,relative velocity and accelerations; Newtons laws and applications (to includefriction, constraint equations, rough pulleys), line integrals, gradient, curl,conservative forces, potential, workenergy theorems, energy diagrams;conservation of linear momentum and collisions, variable mass problems;central forces, gravitation, Keplers law, hyperbolic, elliptic and parabolicorbits, forced oscillations, damping, resonance; waves: motion in noninertialframes, centrifugal and Coriolis forces; conservation of angular momentum andelementary rigid body dynamics; special theory of relativity. **References/Text Books:**	PHYSICS-I
PHY103A	3-1-0-0-11		**Course Contents:** Vector calculus; Electrostatic with full use of vector calculus calculation of electric fields, electrostatic potential and Laplaces equation and uniqueness of its solution; Method of images; Energy in electrostatics; Introduction to multipole expansion, Dipole moment of a charge distribution, potential and field of a dipole, force and torque on a dipole in an electric field; Electrostatics in a medium, Displacement vector and boundary conditions, linear dielectrics, force on a dielctric; Magnetostatics with full use of vector calculus, introduction to vector potential; current densities, Lorentz force law, force and torque on a magnetic dipole in a magnetic field Magnetostatics in a medium, magnetization, bound currents, magnetic field H, boundary condition on B and H, magnetic susceptibility, ferro, para and diamagnetism.; Faradays law, energy in magnetic field; displacement current; fields produced by timedependent electric and magnetic fields within quasistatic approximation; Maxwells equations in vacuum and conducting and nonconducting medium, Energy in electromagnetic field, Poynting vector, plane electromagnetic waves; Reflection and refraction of electromagnetic wave from a boundary, Brewsters angle.	PHYSICS-II

			References/Text Books:	
PHY103N	3-1-0-1-4		**Course Contents:** Vector calculus; electrostatics; Gauss law and applications, electrostatic potentialand curl of E; work and energy in electrostatics, Laplaces equation and (first)LTPD[C]1020[0]CoreLTPD[C]0003[2]CoreLTPD[C]3110[4]CoreLTPD[C]3110[4]Core384uniqueness theorem, method of images, multipoles (introduction), force andtorque on dipoles; polarization, bound charges, electric displacementand boundary conditions, linear dielectrics, force on dielectrics; motion ofcharges in electric & magnetic fields; magnetostatics: current density,curl and divergence of B, Ampres law and applications, magnetization, boundcurrents and bound pole densities, magnetic field H, magnetic susceptibility,ferro, para and diamagnetism, boundary conditions on B and H, Faradayslaw, energy in magnetic field, displacement current, Maxwells equations inmedia, Poyntings theorem, e.m. waves: wave equation, plane waves, polarizationand types of polarization, energy and momentum of plane e.m. waves.propagation through linear media and conductors. reflection and transmissionat normal incidence from dielectric and metal interfaces. magnetism as arelativistic phenolmenon, relativistic transformations of E and B fields (simpleillustrations only), diffraction, quantum mechanics, photons, uncertaintyprinciple, electron diffraction experiments, de Broglie hypothesis, Borninterpretation, Schrdinger equation and application to 1d box problem. **References/Text Books:**	PHYSICS - II
PHY204	3-1-0-1-4		**Course Contents:** Foundations of quantum mechanics Black body radiation, photoelectric effect,Compton effect, de Broglie hypothesis and its experimental verification 5 lecturesTimeindependent and timedependent Schrodinger equation, Born interpretation,Expectation values, freeparticle wavefunctions and wavepackets, uncertainty principle 5 lecturesSolution of stationarystate Schrodinger equation for particle in a box, particle in a finitewell, reflection and transmission across a step potential, application to phenomena likealphadecay , onedimensional harmonic oscillator 5 lecturesSolution of stationarystate Schrodinger equation for the groundstate of hydrogen,Discussion of excited state, Explanation of the periodic table by introduction of electronspin and Pauli's exclusion principle, StemGerlach experiment, two level systems 5lecturesFree particle wavefunctions and metals, KronigPenny model and formation of bands inone dimension 4 lecturesVariational principle for approximate solutions and simple applications, groundstateenergy of helium atom 3 lecturesInteraction of light with matter Einstein's phenomenological theory, lifetime of a state,LASERS 3 lectures **References/Text Books:** F eynman lectures volume IIIMax Jammer Conceptual development of quantum mechanicsB.L. van der Waerden Sources of quantum mechanicsE. Shroedinger Papers on wave mechanicsR. Shankar Principles of quantum mechanics	QUANTUM PHYSICS
PHY210	3-1-0-0-4		**Course Contents:** Principles of thermodynamics (with applications to simple fluids), applicationsof thermodynamics: concept of thermodynamic state, extensive and intensivevariables; heat and work, internal energy function and the first lawof thermodynamics; fundamental relation and equations of state; conceptsof entropy and temperature as conjugate pair of variables; secondlaw of thermodynamics, entropy maximum and energy minimum principles;thermodynamic potentials: enthalpy, Helmholtz potential, Gibbs potential;conditions of equilibrium, concepts of stable, metastable and unstable equilibrium;components and phases, GibbsDuhem relations; firstorder phase transitionsand ClausiusClapeyron equation; concepts associated with critical and multicriticalphenomena, some chosen applications from surfaces and interfaces,chemical reactions (magnetic, dielectric and superconducting); heat enginesand black body radiation; elementary kinetic theory of gases: equilibriumproperties pressure and equation of state; transport processes momentumtransport and viscosity, energy transport and thermal conductivity, chargetransport & electrical conductivity (without using Boltzmann transport equation);entropy, multiplicity and disorder: entropy measures multiplicity rather	THERMAL PHYSICS

			thandisorder, illustration with simple examples; Maxwells demon; qualitativejustifications of laws of thermodynamics (without introducing ensembles),thermodynamics of irreversible processes: entropy production. **References/Text Books:**	
PHY210A	3-1-0-0-6		**Course Contents:** Principles of thermodynamics (with applications to simple fluids), applicationsof thermodynamics: concept of thermodynamic state, extensive and intensivevariables; heat and work, internal energy function and the first lawof thermodynamics; fundamental relation and equations of state; conceptsof entropy and temperature as conjugate pair of variables; secondlaw of thermodynamics, entropy maximum and energy minimum principles;thermodynamic potentials: enthalpy, Helmholtz potential, Gibbs potential;conditions of equilibrium, concepts of stable, metastable and unstable equilibrium;components and phases, GibbsDuhem relations; firstorder phase transitionsand ClausiusClapeyron equation; concepts associated with critical and multicriticalphenomena, some chosen applications from surfaces and interfaces,chemical reactions (magnetic, dielectric and superconducting); heat enginesand black body radiation; elementary kinetic theory of gases: equilibriumproperties pressure and equation of state; transport processes momentumtransport and viscosity, energy transport and thermal conductivity, chargetransport & electrical conductivity (without using Boltzmann transport equation);entropy, multiplicity and disorder: entropy measures multiplicity rather thandisorder, illustration with simple examples; Maxwells demon; qualitativejustifications of laws of thermodynamics (without introducing ensembles),thermodynamics of irreversible processes: entropy production. **References/Text Books:**	THERMAL PHYSICS
PHY218	0-0-4-0-4		**Course Contents:** Experiments based on Fresnels equations, study of optical surfaces, Fraunhoferand Fresnel diffraction, interferometers, modulation transfer function,fibre optics, spatial filtering, characteristics of HeNe and diode lasers,etc. **References/Text Books:**	OPTICS LAB
PHY224	3-1-0-0-4		**Course Contents:** Review of Maxwell's equations, wave equation and solutions for plane andspherical wavesLinear dispersion theoryDerivation and discussion of Fresnel's equationsPolarization states of polarization, Jones vectors, Jones matrices, indexellipsoidInterference basics, 2beam, Nbeam discussion, interferometers Michelsonand FabryPerot, multilayers for high and antireflectionDiffraction Kirchhoff integral, Fraunhofer diffraction, diffraction gratingCoherence spatial, temporal coherence, measurement techniques, mutualcoherence function, coherency matrix **References/Text Books:** 1.M.Born and E.Wolf, Principles of Optics (Cambridge Univ Press)2.J. B. Peatross and M. Ware: Physics of Light and OpticsThis book is freely available at http://optics.byu.edu/BYUOpticsBook.pdf3.F.L. Pedrotti, L.M. Pedrotti and L.S.Pedrotti: Introduction to Optics (Pearson InternationalEdition)4.A.Ghatak, Optics (Tata McGrawHill)5.E.Hecht, Optics (AddisonWesley)6. K.K.Sharma, Optics: Principles and Applications (Academic Press)	OPTICAL PHYSICS
PHY224A	2-0-6-0-12		**Course Contents:** Review of Maxwell's equations, wave equation and solutions for plane andspherical wavesLinear dispersion theoryDerivation and discussion of Fresnel's equationsPolarization states of polarization, Jones vectors, Jones matrices, indexellipsoidInterference basics, 2beam, Nbeam discussion, interferometers Michelsonand FabryPerot, multilayers for high and antireflectionDiffraction Kirchhoff integral, Fraunhofer diffraction, diffraction gratingCoherence spatial, temporal coherence, measurement techniques, mutualcoherence	OPTICS

			function, coherency matrix **References/Text Books:** 1.M.Born and E.Wolf, Principles of Optics (Cambridge Univ Press)2.J. B. Peatross and M. Ware: Physics of Light and OpticsThis book is freely available at http://optics.byu.edu/BYUOpticsBook.pdf3.F.L. Pedrotti, L.M. Pedrotti and L.S.Pedrotti: Introduction to Optics (Pearson InternationalEdition)4.A.Ghatak, Optics (Tata McGrawHill)5.E.Hecht, Optics (AddisonWesley)6. K.K.Sharma, Optics: Principles and Applications (Academic Press)	
PHY226B	3-1-0-0-6		**Course Contents:** Special Relativity: empirical evidence for the constancy of c, frames ofreference; 6Lorentz transformations; relativity of simultaneity; twin and otherparadoxes; Spacetime diagrams; 4Transformation laws for velocity, momentum, energy; massenergyequivalence; 4vectors; 4Force equations, kinematics of decays and collisions; Maxwell's equationsin covariant form. **References/Text Books:**	RELATIVITY
PHY301	3-0-0--4		**Course Contents:** Indian and global energy resources, current energy exploitation, energy demand,energy planning, renewable energy sources, wind energy, energy from water,solar energy, energy from mineral oils, nuclear energy, energy for sustainabledevelopment, environmental concerns. **References/Text Books:**	ENERGY
PHY301A	3-0-0-0-9		**Course Contents:** Indian and global energy resources, current energy exploitation, energy demand,energy planning, renewable energy sources, wind energy, energy from water,solar energy, energy from mineral oils, nuclear energy, energy for sustainabledevelopment, environmental concerns. **References/Text Books:**	ENERGY
PHY303	3-0-0--4		**Course Contents:** Gaussian optics, optical resonators and their mode structure, atomiclevels, absorption, spontaneous and stimulated emission, Einstein coefficients,rate equations, population inversion, gain media, 3 and 4 level lasers CW &pulsed Lasers, Qswitching, modelocking, short pulses Ar+, CO2, Nd:YAg, diodelasers, etc.; metrology, optical communication, materials processing, holography,medical applications. **References/Text Books:**	PRINCIPLES OF LASERS & THEIR APPLICATIONS
PHY303A	3-0-0-0-9		**Course Contents:** Gaussian optics, optical resonators and their mode structure, atomiclevels, absorption, spontaneous and stimulated emission, Einstein coefficients,rate equations, population inversion, gain media, 3 and 4 level lasers CW &pulsed Lasers, Qswitching, modelocking, short pulses Ar+, CO2, Nd:YAg, diodelasers, etc.; metrology, optical communication, materials processing, holography,medical applications. **References/Text Books:**	PRINCIPLES OF LASERS & THEIR APPLICATIONS
PHY305	3-0-0--4		**Course Contents:** Astronomical observations and instruments, photometry, stellar spectraand structure; stellar evolution, nucleosynthesis and formation of elements,variable stars, compact stars, star clusters and binary stars, galaxies, theirevolution and origin, active galaxies and quasars, Big Bang model,early Universe and CMBR. **References/Text Books:**	PHYSICS OF UNIVERSE

PHY305A	3-0-0-0-9		**Course Contents:** Astronomical observations and instruments, photometry, stellar spectraand structure; stellar evolution, nucleosynthesis and formation of elements,variable stars, compact stars, star clusters and binary stars, galaxies, theirevolution and origin, active galaxies and quasars, Big Bang model,early Universe and CMBR. **References/Text Books:**	PHYSICS OF UNIVERSE
PHY306	3-0-0-0-4		**Course Contents:** Dynamical systems, importance of nonlinearity, nonlinear dynamics of flows (in1, 2 and 3 dimensions) and maps (in 1, 2 dimensions) in phase space(equilibrium, periodicity, bifurcation, catastrophe, deterministic chaos, strangeattractor), routes to chaos (period doubling, quasiperiodicity/intermittency,universality, renormalization), measurement of chaos (Poincar section, Lyapunovindex, entropy), fractal geometry and fractal dimension, examples fromphysicalsciences, engineering and biology. **References/Text Books:**	ORDER AND CHAOS IN NATURE
PHY306A	3-0-0-0-9		**Course Contents:** Dynamical systems, importance of nonlinearity, nonlinear dynamics of flows (in1, 2 and 3 dimensions) and maps (in 1, 2 dimensions) in phase space(equilibrium, periodicity, bifurcation, catastrophe, deterministic chaos, strangeattractor), routes to chaos (period doubling, quasiperiodicity/intermittency,universality, renormalization), measurement of chaos (Poincar section, Lyapunovindex, entropy), fractal geometry and fractal dimension, examples fromphysicalsciences, engineering and biology. **References/Text Books:**	ORDER AND CHAOS IN NATURE
PHY307	3-0-0--4		**Course Contents:** Review of Maxwells and electromagnetic wave equations, wave propagation inanisotropic media, polarized light, diffraction from circular aperture and conceptof resolution, Fourier transforms and Fourier optics, spatial filtering, and imageprocessing, coherence, holography, optical waveguides and integrated optics,optical fibres, optical communication sources (LED, lasers etc.) and detectors,and optical, electro and magnetooptic effects, lasermatter interaction. **References/Text Books:**	MODERN OPTICS (ITS PHYSICS & ENGINEERING)
PHY307A	3-0-0-0-9		**Course Contents:** Review of Max wells and electromagnetic wave equations, wave propagation in anisotropic media, polarized light, diffraction from circular aperture and concept of resolution, Fourier transforms and Fourier optics, spatial filtering, and image processing, coherence, holography, optical waveguides and integrated optics, optical fibers, optical communication sources (LED, lasers etc.) and detectors, and optical, electro and magneto optic effects, laser matter interaction. **References/Text Books:**	MODERN OPTICS
PHY311	3-0-0-0-4		**Course Contents:** Introduction: examples of nonequilibrium phenomena(i) glass transition;(ii) nucleation; (iii) phase separation; experimental probes: dynamicscattering; inelastic neutron scattering, theoretical tools: two alternativetheoretical approaches (a) Langevin equation dissipation, nonlinearity andnoise; illustration with translational Brownian motion; (b) FokkerPlanck equationdiffusionand drift; illustration with (i) translational Brownian motion, (ii)rotational Brownian motion; master equation loss and gain of probabilities;concept of detailed balance . metastability and bistability: Kramers theoryof thermally activated barrier crossing applications in (i) chemical reactions(ii) rock magnetism. enhancing signals with the help of noise applicationsof stochastic resonance in (a) nonlinear optics, (b) solid state devices, (c)neuroscience, (d) molecular motors and biological locomotion; BeckerDoringtheory of homogeneous nucleation and its	PHYSICS OF NON-EQUILIBRIUM PHENOMENA

			modern extensions applicationsin (a) condensation and (b) crystallization. unstable states: AllenCahn scenarioof interfacial dynamics and domain growth applications to domain growth inquenched magnets; LifshitzSlyozov arguments for phase separation controlledby topological defects: application to liquid crystals; theory of coarsening ofcellular patterns applications to soap froths (e.g., shaving foams); nonequilibriumsteadystates in driven system: drivensystems of interacting particles applications to vehicular traffic; drivensurfaces applications in molecular beam epitaxy (MBE). **References/Text Books:**	
PHY311A	3-0-0-0-9		**Course Contents:** Introduction: examples of nonequilibrium phenomena(i) glass transition;(ii) nucleation; (iii) phase separation; experimental probes: dynamicscattering; inelastic neutron scattering, theoretical tools: two alternativetheoretical approaches (a) Langevin equation dissipation, nonlinearity andnoise; illustration with translational Brownian motion; (b) FokkerPlanck equationdiffusionand drift; illustration with (i) translational Brownian motion, (ii)rotational Brownian motion; master equation loss and gain of probabilities;concept of detailed balance . metastability and bistability: Kramers theoryof thermally activated barrier crossing applications in (i) chemical reactions(ii) rock magnetism. enhancing signals with the help of noise applicationsof stochastic resonance in (a) nonlinear optics, (b) solid state devices, (c)neuroscience, (d) molecular motors and biological locomotion; BeckerDoringtheory of homogeneous nucleation and its modern extensions applicationsin (a) condensation and (b) crystallization. unstable states: AllenCahn scenarioof interfacial dynamics and domain growth applications to domain growth inquenched magnets; LifshitzSlyozov arguments for phase separation controlledby topological defects: application to liquid crystals; theory of coarsening ofcellular patterns applications to soap froths (e.g., shaving foams); nonequilibriumsteadystates in driven system: drivensystems of interacting particles applications to vehicular traffic; drivensurfaces applications in molecular beam epitaxy (MBE). **References/Text Books:**	PHYSICS OF NON-EQUILIBRIUM PHENOMENA
PHY312	3----4		**Course Contents:** Characteristic length scales for quantum phenomena; scaling as a heuristic tool;scientific and technological significance of nanostructures and mesoscopicstructures. brief introduction to quantum view of bulk solids, introduction tokey ideas in transport and interaction of photons with material. Quantumstructures: electronic properties: science and technology realizing low dimensionalstructures; MBE, MOCVD, LangmuirBlodgett films, novel processes; electronicproperties of heterostructures, quantum wells, quantum wires, quantum dots,and superlattices, strained layer superlattices; transport in mesoscopic structures.resonant tunneling, hot electrons, conductance and transmission of nanostructures;principles of application of electronic devices. quantum structures:optical properties: optical process in low dimensional semiconductors. absorption.luminescence, excitons. application to lasers and photodetectors, transport inmagnetic field: megnetotransport: transport in magnetic field, semiclassicaldescription, quantum approach, AharonovBohm effect, Shubnikov deHaas effect; introduction to quantum Hall effect. **References/Text Books:**	QUANTUM PROCESSES IN LOW DIMENSIONAL SEMICONDUCTORS
PHY312A	3-0-0-0-9		**Course Contents:** Characteristic length scales for quantum phenomena; scaling as a heuristic tool;scientific and technological significance of nanostructures and mesoscopicstructures. brief introduction to quantum view of bulk solids, introduction tokey ideas in transport and interaction of photons with material. Quantumstructures: electronic properties: science and technology realizing low dimensionalstructures; MBE, MOCVD, LangmuirBlodgett films, novel processes; electronicproperties of heterostructures, quantum wells, quantum wires, quantum dots,and superlattices, strained layer superlattices; transport in mesoscopic structures.resonant tunneling, hot electrons, conductance and transmission of nanostructures;principles of application of electronic devices. quantum structures:optical properties: optical process in low dimensional semiconductors. absorption.luminescence, excitons. application to lasers and photodetectors, transport inmagnetic field:	QUANTUM PROCESSES IN LOW DIMENSIONAL SEMICONDUCTORS

			megnetotransport: transport in magnetic field, semiclassicaldescription, quantum approach, AharonovBohm effect, Shubnikov deHaas effect; introduction to quantum Hall effect. **References/Text Books:**	
PHY314	3-0-0--4		**Course Contents:** Examples of nanomachines in living cells; differences between macroscopic andnano machines; world of nanometer and picoNewton; stochastic dynamics ofnanomachines; experimental, computational and theoretical techniques; imagingand manipulating single machines; Power stroke versus Brownian ratchetmechanism; mechanochemistry of nanomachines; energetics and efficiency ofnanomachines; intracellular cargo transporters; nanosize unzippers; nanosizeengines for polymerization of macromolecules; exporters/importers ofmacromolecules; packaging machines; switches and latches; ion pumps; flagellarmotor; rotary motors of ATP synthesizer; molecular sensors hair cells; nanopistonsand cell crawling. **References/Text Books:**	NATURAL NANO MACHINES
PHY315	1-0-4-0-4		**Course Contents:** Modern experimental techniques with a view to demonstrate the basic conceptsin physics through experiments. this course has three components: a) onelecture per week: observation, measurements, quantification and accuraciesin physics, error analysis. experiments that changed classical physics: blackbody radiation, the discovery of electron, quantization of charge, e/m ratios,Millikans oil drop experiment, SternGerlach experiment, Rutherford scattering,Davisson Germer experiment, discovering atomic nature through opticalspectroscopy; production and measurement of high pressure and high vacuum,low and high temperatures; femtoseconds to light years. b) laboratory work(twice a week): a current list of experiments is available with the Department.c) small project/open ended experiments: These experiments will be chosenby students after brief library search in consultation with the associated faculty.These may be carried out in research labs and using central facilities. **References/Text Books:**	MODERN PHYSICS LABORATORY
PHY315A	1-0-6-0-9		**Course Contents:** Modern experimental techniques with a view to demonstrate the basic conceptsin physics through experiments. this course has three components: a) onelecture per week: observation, measurements, quantification and accuraciesin physics, error analysis. experiments that changed classical physics: blackbody radiation, the discovery of electron, quantization of charge, e/m ratios,Millikans oil drop experiment, SternGerlach experiment, Rutherford scattering,Davisson Germer experiment, discovering atomic nature through opticalspectroscopy; production and measurement of high pressure and high vacuum,low and high temperatures; femtoseconds to light years. b) laboratory work(twice a week): a current list of experiments is available with the Department.c) small project/open ended experiments: These experiments will be chosenby students after brief library search in consultation with the associated faculty.These may be carried out in research labs and using central facilities. **References/Text Books:**	MODERN PHYSICS LABORATORY
PHY399A	0-0-2-2-4		**Course Contents:** TECHNICAL COMMUNICATION **References/Text Books:**	TECHNICAL COMMUNICATION
PHY400	0-0-0-0-5		**Course Contents:** The course will expose the students to research areas being pursued in theDepartment, and issues relevant to research as a profession. Faculty membersfrom different subdisciplines would deliver lectures. Visits to Laboratoriesof the Department and relevant acilities may be arranged. Course will be zerocredits; S/X grade	INTRODUCTION TO THE DEPARTMENT

			to be given. **References/Text Books:**	
PHY400A	0-0-5-0-5		**Course Contents:** The course will expose the students to research areas being pursued in theDepartment, and issues relevant to research as a profession. Faculty membersfrom different subdisciplines would deliver lectures. Visits to Laboratoriesof the Department and relevant acilities may be arranged. Course will be zerocredits; S/X grade to be given. **References/Text Books:**	INTRODUCTION TO THE DEPARTMENT
PHY401	3-1-0-0-4		**Course Contents:** Review of Newtonian mcdnnics: Basicassumption; constraints, principle of virtual work, D'Alembert's cprinciple,generalized coordinates [3]Lagrangian mechanics: Calculu of variations, Principle of least action, Lagrange's equation, Symmetries and Noether'stheorem [8]Hamilton's equations, phase space&. phase trajectories, LiuviuUe's theorem [3]smalt oscillations, normal modes, anharmonic and nonlinear oscillators, Nonlinear dynamicsChaos (Hamiltonian systems in dissipative systems).IUu'strations using Duffing oscillator, double pendulum, three body problem, etc. [10]Continuum mechanics, Waves in continuous media, NavierStokes Eqn., Pressure waves [3]canonical transformations, Poisson brackets, Hamitton Jacobi theory, Actionangle variables(recommend: central force discussed here) [7]rigid body dynamics [6] **References/Text Books:** L. D. Landau and E. M. Lisfsitz,.Mechanics, Courses of Theoretical Physics, Oxford: Pergamon, 1976H. Goldstein, C. P. Poole, and J. L. Safko, Classical Mechanics, Addison Wesley, 2001 (Indian Ed. available).H. C. Corben and P. Stehle, Classical Mechanics, Dover, 1994T. W. B. Kibble, Classical Mechanics, Addison Wesley, 1994 .. (Indian Ed. available)H. Strogatz, Nonlinear Dynamics and Chaos, Levant, 2007 (Indian Ed.)	CLASSICAL MECHANICS
PHY401A	3-1-0-0-11		**Course Contents:** 1. Review of Newton's laws of motion, Galilean transformations, Frames of reference and pseudoforces. Symmetries in Newton's laws, Lagrangian formulation, Configuration space. Calculus of variations, Hamilton's principle of least action, EulerLagrange's equations, **Conserved quantities and Noether's theorem***. Small oscillations and normal modes, Anharmonic oscillators, **Resonances in harmonic and anharmonic oscillaors***, Parametric resonance. **Secular (regular) perturbation theory***, LindtstedtPoincare method. Rigid body dynamics. Tutorial problems: One degree of freedom (DOF) and 2 DOF simple harmonic oscillators, Doble pendulum, Motion in central force field, System of particles, Charged particle in an Elecromagnetic field, Lagrangian formulation of relativistic mechanics, etc. 2. **Fixed points and linear stability analysis*, Limit cycles*, Flow on a torus and quasiperiodicity***, Qualitative discussion of PoincareBendixon theorem (no chaos in 2D autonomous flow). Legendre transformation, Hamiltonian formulation, Phase plane, Integral invariants, Symplectic area conservation, (Generalized) Liouville's theorem, Poincare recurrence theorem, Modified Hamilton's principle. Canonical transformations, Infinitesimal canonical transformations, Poisson brackets, Active view versus passive view of canonical transformations. Principle of varying action and HamiltonJacobi theory, Opticomechanical analogy, **Actionangle variables***. 3. Lorenz system, Chaotic attractor, **Lyapunov exponents***. Qualitative discussion of nonintegrability and chaos in Hamiltonian systems. N.B.: The topics in boldface* are essential for Classical Mechanics II. **References books:** 1. J. V. Jose & E. J. Saletan, Classical Dynamics, Cambridge University Press (1998).	CLASSICAL MECHANICS I

			2. I. C. Percival & D. Richards, Introduction to Dynamics, Cambridge University Press (1982). 3. L. D. Landau & E. M. Lifshitz, Mechanics, ButterworthHeinemann (1976). 4. H. Goldstein, Classical Mechanics, AddisonWesley (1 980). 5. J. L. McCauley, Classical Mechanics, Cambridge University Press (1997). 6. I. M. Gelfand & S. V. Fomin, Calculus of Variations, Dover Publications (2000). 7. S. H. Strogatz, Nonlinear Dynamics and Chaos, Westview Press (2001).	
PHY402A	3-1-0-0-11	PHY401A	**Course Contents:** Short summary for including in the Courses of Study Booklet: Review of essential basic concepts of Classical Mechanics I (PHY401), Integrable and superintegrable systems, Lax pairs, Bihamiltonian systems, Toda lattice; 1.5 DoF systems: Extended phase space, Rapidly oscillating systems, Adiabatic invariance, Hannay angle, Poincare map, Homoclinic tangle, Melnikov method, Chaos in horseshoe map and symbolic dynamics; 2 DoF systems: Canonical perturbation theory, Problem of small divisors, Area-preserving maps, Poincaré-Birkhoff theorem, Introduction to KAM theory, Local vs. widespread/global chaos, Chirikov resonance-overlap criterion, Canonical perturbation theory, Problem of small divisors, Area-preserving maps, Poincaré-Birkhoff theorem, Introduction to KAM theory, Local vs. widespread/global chaos, Chirikov resonance-overlap criterion; >2 DoF systems: Geometry of resonances, Overview (no proofs) of Nekhoroshev theorem and Arnold diffusion, Fermi–Pasta–Ulam-Tsingou problem, Kuramoto model and synchronization; Continuous systems: Lagrangian and Hamiltonian formulations. **Recommended Reference Books:** **I. J. V. Jose & E. J. Saletan, Classical Dynamics, Cambridge University Press (1998).** **II. H. Goldstein, C. Poole, & J. Safko, Classical Mechanics, Addison-Wesley (2001).** **III. A. Lichtenberg & M. Lieberman, Regular and Chaotic Dynamics, Springer (1992).** **IV. M. Tabor, Chaos and Integrability in Nonlinear Dynamics, Wiley-Interscience (1974).** **V. S. Wiggins, Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer (2003).** **VI. A. Goriely, Integrability and Nonintegrability of Dynamical Systems, World Scientific (2001).**	Classical Mechanics II
PHY407	3-0-0--4		**Course Contents:** Special Relativity: empirical evidence for the constancy of c, frames of reference;Lorentz transformations; relativity of simultaneity; twin and other paradoxes,transformation laws for velocity, momentum, energy; massenergy equivalence;force equations, kinematics of decays and collisions, Maxwells equationsin covariant form, representations of the Lorentz group and SL(2,C).Introduction to General Relativity: principle of equivalence; Machs principle,Riemannian geometry; Christoffel symbols, the curvature and stressenergytensors; the gravitational field equations; geodesics and particletrajectories, Schwarzchild solution; experimental tests, basic cosmology,FRW metric; cosmological expansion; cosmic microwave background; heliumabundance; anisotropies in the CMBR. **References/Text Books:**	SPECIAL & GENERAL RELATIVITY
PHY407A	3-0-0-0-9		**Course Contents:** Special Relativity: empirical evidence for the constancy of c, frames of reference;Lorentz transformations; relativity of simultaneity; twin and other paradoxes,transformation laws for velocity, momentum, energy; massenergy equivalence;force equations, kinematics of decays and collisions, Maxwells equationsin covariant form, representations of the Lorentz group and SL(2,C).Introduction to General Relativity: principle of equivalence; Machs principle,Riemannian geometry; Christoffel symbols, the curvature and stressenergytensors; the gravitational field equations; geodesics and particletrajectories, Schwarzchild solution; experimental tests, basic cosmology,FRW metric; cosmological expansion; cosmic microwave background; heliumabundance; anisotropies in the CMBR. **References/Text Books:**	SPECIAL & GENERAL RELATIVITY

PHY412	3-1-0-0-4		**Course Contents:** 1. Review of Thermodynamics, Probability theory, Random Walk, Brownianmotion, Diffusion Equation, idea of Langevin and FokkerPlanck Equations [8]2. Basic principles of Equilibrium Classical Statistical Mechanics, MicroCanonical, Canonical and Grand Canonical ensembles. [10]3. Quantum Statistical Mechanics, Density Matrix, Ideal Quantum Gases andtheir properties, BoseEinstein Condensation, Free Electron gas [10]4 a)Ising model of Magnetism, Transfer Matrix method, Mean field theory [4]b) Phase Transitions, CurieWeiss theory, Landau theory, Scaling near acritical point. [8]Reference Books: Reif, Huang, Pathria, Landau and Lifshitz, S. K.Ma, Chaudhury and Stauffer. **References/Text Books:** 1. A.C. Melissiuos and J. Napolitano, Experiments in Modern Physics, znct ed. (Academic Press,Amsterdem, 2003).2. Resource Files on Experiments maintained in the Laboratory.3. P. R. Beviugton, Data Reduction and Error Analysis for Physical Sciences (McGraw Hill, 1969).	STATISTICAL MECHANICS
PHY412A	3-1-0-0-11		**Course Contents:** 1. Review of Thermodynamics, Probability theory, Random Walk, Brownianmotion, Diffusion Equation, idea of Langevin and FokkerPlanck Equations [8]2. Basic principles of Equilibrium Classical Statistical Mechanics, MicroCanonical, Canonical and Grand Canonical ensembles. [10]3. Quantum Statistical Mechanics, Density Matrix, Ideal Quantum Gases andtheir properties, BoseEinstein Condensation, Free Electron gas [10]4 a)Ising model of Magnetism, Transfer Matrix method, Mean field theory [4]b) Phase Transitions, CurieWeiss theory, Landau theory, Scaling near acritical point. [8]Reference Books: Reif, Huang, Pathria, Landau and Lifshitz, S. K.Ma, Chaudhury and Stauffer. **References/Text Books:** 1. A.C. Melissiuos and J. Napolitano, Experiments in Modern Physics, znct ed. (Academic Press,Amsterdem, 2003).2. Resource Files on Experiments maintained in the Laboratory.3. P. R. Beviugton, Data Reduction and Error Analysis for Physical Sciences (McGraw Hill, 1969).	STATISTICAL MECHANICS
PHY421	3-1-0-0-4		**Course Contents:** Vector analysis; curvilinear coordinates; matrices and vector spaces, tensors,function spaces; Hilbert spaces; orthogonal expansions; operators ininfinite dimensional spaces, Fourier series and Fourier transform, generalizedfunctions; Dirac delta function, groups and their representations; discretegroups, Lie groups and Lie algebras, applications. **References/Text Books:**	MATHEMATICAL METHODS I
PHY421A	3-1-0-0-11		**Course Contents:** Vector analysis; curvilinear coordinates; matrices and vector spaces, tensors,function spaces; Hilbert spaces; orthogonal expansions; operators ininfinite dimensional spaces, Fourier series and Fourier transform, generalizedfunctions; Dirac delta function, groups and their representations; discretegroups, Lie groups and Lie algebras, applications. **References/Text Books:**	MATHEMATICAL METHODS I
PHY422	3-1-0-0-4		**Course Contents:** Functions of a complex variable, ordinary differential equations, special functions,differential operations and SturmLiouville theory, partial differential equations,Greens functions. **References/Text Books:**	MATHEMATICAL METHODS II
PHY422A	3-1-0-0-11	PHY421A	**Course Contents:** Functions of a complex variable, ordinary differential equations, special functions,differential operations and	MATHEMATICAL METHODS II

			SturmLiouville theory, partial differential equations,Greens functions. **References/Text Books:**	
PHY431	3-1-0-0-4		**Course Contents:** Origins of Quantum Theory, Schroedinger Equation, Applicationto OneDimensional Problems, WKB Approximation, Central Potentials, Quantum HarmonicOscillator, Hydrogen Atom, Hilbert Space Formalism for Quantum Mechanics, Synunetries inQuantum Mechanics, Angular Momentum, Addition of Angular Momenta, Identical Particles,Spin and Statistics, Pauli Exclusion Principle, Variational Method, Applications to Helium Atomand Hydrogen Molecule Ion. **References/Text Books:**	QUANTUM MECHANICS I
PHY431A	3-1-0-0-11		**Course Contents:** Origins of Quantum Theory, Schroedinger Equation, Applicationto OneDimensional Problems, WKB Approximation, Central Potentials, Quantum HarmonicOscillator, Hydrogen Atom, Hilbert Space Formalism for Quantum Mechanics, Synunetries inQuantum Mechanics, Angular Momentum, Addition of Angular Momenta, Identical Particles,Spin and Statistics, Pauli Exclusion Principle, Variational Method, Applications to Helium Atomand Hydrogen Molecule Ion. **References/Text Books:**	QUANTUM MECHANICS I
PHY432	3-1-0-0-4		**Course Contents:** Bound State Perturbation Theory, TimeDependent PerturbationTheory, Semiclassical Treatment of Radiation, Scattering Theory, Relativistic Wave Equations,Foundational Issues in Quantum Mechanics, Quantum Computation. **References/Text Books:** (1) Powell and Crasemaun(2) Feymnan Lectures vol. III(3) Merzbacher(4) Gasiorowicz(5) Schiff(6) Sakurai(7) LandauLifshitz(8) CohenTaunoudji(9) Griffiths	QUANTUM MECHANICS II
PHY432A	3-1-0-0-11	PHY431A	**Course Contents:** Bound State Perturbation Theory, TimeDependent PerturbationTheory, Semiclassical Treatment of Radiation, Scattering Theory, Relativistic Wave Equations,Foundational Issues in Quantum Mechanics, Quantum Computation. **References/Text Books:** (1) Powell and Crasemaun(2) Feymnan Lectures vol. III(3) Merzbacher(4) Gasiorowicz(5) Schiff(6) Sakurai(7) LandauLifshitz(8) CohenTaunoudji(9) Griffiths	QUANTUM MECHANICS II
PHY441	2-1-4--5	#	**Course Contents:** Review of network theorems and network analysisOperation Amplifier and negative feedbackOpAmp limitations and applicationsCircuits with OpAmps and diodesInterfacing BJT with OpAmpsMOSFETsDigital electronics: Gates, flipflops, counters, timersMicrocontroller: basics and architectureAssembly language programming with microcontroller applications **References/Text Books:** "The art of electronics" by P. Horowitz and W. Hill"Student Manual for The Art of Electronics" by T. C. Hayes and P. Horowitz"OpAmps and linear integrated circuits" by R.A. Gayakwad"Digital fundamentals" by T. L. Floyd"Digital computer electronics" by A.P. Malvino and J.A. Brown"The 8051 Microcontroller: architecture, programming and applications" by K. J. Ayala	ELECTRONICS
PHY441A	2-1-3--11		**Course Contents:**	ELECTRONICS

			Review of network theorems and network analysisOperation Amplifier and negative feedbackOpAmp limitations and applicationsCircuits with OpAmps and diodesInterfacing BJT with OpAmpsMOSFETsDigital electronics: Gates, flipflops, counters, timersMicrocontroller: basics and architectureAssembly language programming with microcontroller applications **References/Text Books:** "The art of electronics" by P. Horowitz and W. Hill"Student Manual for The Art of Electronics" by T. C. Hayes and P. Horowitz"OpAmps and linear integrated circuits" by R.A. Gayakwad"Digital fundamentals" by T. L. Floyd"Digital computer electronics" by A.P. Malvino and J.A. Brown"The 8051 Microcontroller: architecture, programming and applications" by K. J. Ayala	
PHY461	0-0-8-0-4		**Course Contents:** Experiments in General Physics, Optics, Nuclear Physics and Condensed MatterPhysics (List of current experiments available with the Physics Department inthe form of a manual). **References/Text Books:**	EXPERIMENTAL PHYSICS I
PHY461A	0-0-8-0-8		**Course Contents:** Experiments in General Physics, Optics, Nuclear Physics and Condensed MatterPhysics (List of current experiments available with the Physics Department inthe form of a manual). **References/Text Books:**	EXPERIMENTAL PHYSICS I
PHY462	0-0-8-0-4		**Course Contents:** Experiments in General Physics, Optics, Nuclear Physics and Condensed MatterPhysics (List of current experiments available with the Department in the formof a manual). **References/Text Books:**	EXPERIMENTAL PHYSICS II
PHY462A	0-0-8-0-8		**Course Contents:** Experiments in General Physics, Optics, Nuclear Physics and Condensed MatterPhysics (List of current experiments available with the Department in the formof a manual). **References/Text Books:**	EXPERIMENTAL PHYSICS II
PHY473	2-1-0-3-5		**Course Contents:** Introduction to computers, FORTRAN/C; finite difference calculus, interpolationand extrapolation, roots of equations, solution of simultaneous linear algebraicequation, least squares curve fitting, numerical integration, numerical solutionof ordinary differential equations, matrix eigenvalue problems. **References/Text Books:**	COMPUTATIONAL PHYSICS
PHY473A	2-0-2-0-8		**Course Contents:** Introduction to computers, FORTRAN/C; finite difference calculus, interpolationand extrapolation, roots of equations, solution of simultaneous linear algebraicequation, least squares curve fitting, numerical integration, numerical solutionof ordinary differential equations, matrix eigenvalue problems. **References/Text Books:**	COMPUTATIONAL PHYSICS
PHY500	0-0-8-0-4		**Course Contents:** M.Sc. Review Project I **References/Text Books:**	M SC REVIEW PROJECT I

PHY501	0-0-9--4		**Course Contents:** M.Sc. Review Project II **References/Text Books:**	M SC REVIEW PROJECT II
PHY501A	0-0-9--9		**Course Contents:** M.Sc. Review Project II **References/Text Books:**	M SC REVIEW PROJECT II
PHY502	0-0-8-0-4		**Course Contents:** M.Sc. Review Project III **References/Text Books:**	M.SC. REVIEW PROJECT III
PHY502A	0-0-8-0-8		**Course Contents:** M.Sc. Review Project III **References/Text Books:**	M.SC. REVIEW PROJECT III
PHY502N	3-0-0-0-4		**Course Contents:** Student must carry out review of an advanced topic of current interest andmake a presentation to an Evaluation Committee. Letter Grades will be awarded.PHY 500 : M.Sc. Review Project IPHY 501 : M.Sc. Review Project IIPHY 502 : M.Sc. Review Project IIIThese projects will involve literature survey and collection of material, Detailedstudy of the material, verification of results and writing of the review. ReviewProjects will include exposure to and conduct of Experiments as required. **References/Text Books:**	M SC EXPERIMENTAL PROJECT III
PHY524	3-1-0-0-4		**Course Contents:** Atomic Physics: Review of atomic structure of H, atomic structureof two electron system, alkali system, HartreeFock method, LS coupling,molecular binding, LCAO, LCMO; molecular spectra (electronic, rotational,vibrational etc.), Raman effect, modern experimental tools of spectroscopy.Nuclear Physics: General properties of nuclei, nuclear two body problem, nuclearforce and nuclear models, nuclear decay, nuclear reaction kinematicsand classification of nuclear reactions (compound nuclear, direct etc),heavy ion reactions, nuclear fission and fusion, brief overview of ion beamapplications for materials and solid state studies, modern experimental toolsof pure and applied nuclear physics. **References/Text Books:**	INTRODUCTION TO ATOMIC AND NUCLEAR PHYSICS
PHY524A	3-1-0-0-11	PHY432A	**Course Contents:** Atomic structure: Review of one-electron atoms, Fine structure and Hyperfine structure, Spectral consequences of fine structure, Stark and Zeeman shifts, Interaction of One-electron atoms with EM Radiation, Transition rates, Dipole approximation, The Einstein coefficients, Selection rules and spectrum of one-electron atoms, Line intensities and lifetime of the excited states, Line shapes and widths, Photoelectric effect, Atom-light Hamiltonian, Density matrix, Optical Bloch equations, Electromagnetically Induced Transparency (EIT} and three level effects, Many-electron Atoms: Electron-electron interactions, Helium energy levels, Exchange interaction, Thomas-Fermi model, Hartree-Fock method, Coupled angular momentum, Molecular structure: Van der Waals and Covalance Bond, Rotational and Vibrational spectroscopy, Molecular electronic spectra, Experimental probes Raman and Infrared spectroscopy, Selection	ATOMIC, MOLECULAR AND OPTICAL PHYSICS

			rules, Molecular symmetries and their consequences. Special Topic: (one of the topics will be discussed} Atomic Bose-Einstein condensate/Non-linear optics/Nanomaterials/Quantum Dots and quantum Wells/Carbon cluster **References/Text Books:** G. K. Woodgate, Elementary atomic structure (Ciaredon Press). B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules (Pearson) M. Karplus, Atoms and Molecules (Benjamin-Cumming Pub. Co.)	
PHY526A	3-1-0-0-11		**Course Contents:** Nuclear Physics: General properties of nuclear two body problem, Nuclear force and nuclear models, Nuclear decay, Nuclear reaction kinematics, Scattering and reaction cross section, Optical Model, Classification of nuclear reactions (compound nuclear, direct etc.), BreitWigner resonance formula, Nuclear fission and fusion. Particle Physics: Natural Units, Evidence for four fundamental interactions, Leptons and hadrons, Historical introduction to the particle zoo, introduction to cross sections and decay rates, Particle accelerators and detectors, invariance principles and conservation laws of parity, Charge conjugation, Time reversal and CP, isospin, Strangeness. **References/Text Books:** 1. I. Kaplan, Nuclear Physics (Narosa). 2. S. Krane, Introduction to Nuclear Physics (Wiley). 3. D.H. Perkins, Introduction to High Energy Physics (Cambridge University Press).	NUCLEAR AND PARTICLE PHYSICS
PHY543	3-1-0--4		**Course Contents:** Free electron theory; heat capacity; transport properties; Hall effect;elementary concepts of quantum Hall effect, quantization of conductance in a metallic nanowireStructure and scattering; crystalline solids,liquids and liquid crystals; nanostructures;buckyballs,Energy band theory; Bloch's theorem; nearlyfree electron model; tightbinding model;application to graphene and nanotubes,semiclassical dynamics; notion of an electron in a DCelectric field; effective mass, holes, crystal binding; types of solids; van der Waals solids,ionic and covalent solids, metals,Phonons and heat capacity; lattice vibrations; adiabatic & harmonicapproximations, vibrations of mono and diatomic lattices, lattice heatcapacity, Einstein and Debye modelsSemiconductors; intrinsic & extrinsic semiconductors, laws of mass action, electron & holemobilities. Impurity levels, pnjunctionsSuperconductivity: experimental survey, Meissner effect,London's equation, BCS theory, GinzburgLandau theory, flux quantization,Magnetism: exchange interaction, diamagnetism, paramagnetism,ferromagnetism & antiferromagnetism, Hund's rules, Pauli paramagnetism,Heisenberg model, mean field theory, spin waves, RK.KY interaction, giant and colossalmagnetoresistance. **References/Text Books:** 1. Introduction to Solid State Physics by C. Kittel2. Solid State Physics by N. W. Ashcroft and N. D. Mermin3. Solid State Physics by H Ibach and Hans Luth	CONDENSED MATTER PHYSICS I
PHY543A	3-1-0-0-11		**Course Contents:** Free electron theory; heat capacity; transport properties; Hall effect;elementary concepts of quantum Hall effect, quantization of conductance in a metallic nanowireStructure and scattering; crystalline solids,liquids and liquid crystals; nanostructures;buckyballs,Energy band theory; Bloch's theorem; nearlyfree electron model; tightbinding model;application to graphene and nanotubes,semiclassical dynamics; notion of an electron in a DCelectric field; effective mass, holes, crystal binding; types of solids; van der Waals solids,ionic and covalent solids, metals,Phonons and heat capacity; lattice vibrations; adiabatic & harmonicapproximations, vibrations of mono and diatomic lattices, lattice heatcapacity, Einstein and Debye modelsSemiconductors; intrinsic & extrinsic semiconductors, laws of mass action, electron & holemobilities. Impurity levels, pnjunctionsSuperconductivity: experimental survey, Meissner effect,London's equation, BCS theory, GinzburgLandau theory, flux quantization,Magnetism: exchange interaction, diamagnetism, paramagnetism,ferromagnetism & antiferromagnetism, Hund's rules, Pauli paramagnetism,Heisenberg	CONDENSED MATTER PHYSICS I

			model, mean field theory, spin waves, RK.KY interaction, giant and colossalmagnetoresistance. **References/Text Books:** 1. Introduction to Solid State Physics by C. Kittel2. Solid State Physics by N. W. Ashcroft and N. D. Mermin3. Solid State Physics by H Ibach and Hans Luth	
PHY552	3-1-0-0-4		**Course Contents:** Electrostatics Laplace and' POisson equatlOhs' ciil.d "'their SOh.f. 'CToil.S,Uniqueness theorem, multipole expansion (911 lectures)Magnetostatics (12 lectures)Boundaryvalue problems involving dielectrics and magnetic materials(56 lectures)Maxwell's equations, electromagnetic waves in medium, Poynting'stheorem,momentum and angular momentum of electromagnetic fields (810 lectures)Electromagnetic radiation, retarded potentials, Lorentz and CoulombgaugeI 911 lectures)relativistic transformation of electric and magnetic fields {45lectures) **References/Text Books:** Classical Electrodynamics, John D. Jackson	CLASSICAL ELECTRODYNAMICS I
PHY552A	3-1-0-0-11		**Course Contents:** Electrostatics Laplace and' POisson equatlOhs' ciil.d "'their SOh.f. 'CToil.S,Uniqueness theorem, multipole expansion (911 lectures)Magnetostatics (12 lectures)Boundaryvalue problems involving dielectrics and magnetic materials(56 lectures)Maxwell's equations, electromagnetic waves in medium, Poynting'stheorem,momentum and angular momentum of electromagnetic fields (810 lectures)Electromagnetic radiation, retarded potentials, Lorentz and CoulombgaugeI 911 lectures)relativistic transformation of electric and magnetic fields {45lectures) **References/Text Books:** Classical Electrodynamics, John D. Jackson	CLASSICAL ELECTRODYNAMICS I
PHY553	3-1-0--4	PHY552	**Course Contents:** Special relativity, Minkowski space and four vectors, concept of fourvelocity,four acceleration and higher rank tensors, relativistic formulation ofelectrodynamics, Maxwell equations in covariant form, gauge invariance andfourpotential, the action principle and electromagnetic energy momentumtensor. LinardWeichert potentials, radiation from an accelerated charge,Larmor formula, bremsstrahlung and synchrotron radiation, multipole radiation,dispersion theory, radiative reaction, radiative damping, scattering byfree charges; applications to waveguides, fibres and plasmas. **References/Text Books:**	CLASSICAL ELECTRODYNAMICS II
PHY553A	3-1-0-0-11	PHY552A	**Course Contents:** Special relativity, Minkowski space and four vectors, concept of fourvelocity,four acceleration and higher rank tensors, relativistic formulation ofelectrodynamics, Maxwell equations in covariant form, gauge invariance andfourpotential, the action principle and electromagnetic energy momentumtensor. LinardWeichert potentials, radiation from an accelerated charge,Larmor formula, bremsstrahlung and synchrotron radiation, multipole radiation,dispersion theory, radiative reaction, radiative damping, scattering byfree charges; applications to waveguides, fibres and plasmas. **References/Text Books:**	CLASSICAL ELECTRODYNAMICS II
PHY553B	3-0-0--4		**Course Contents:** Special relativity, Minkowski space and four vectors, concept of fourvelocity,four acceleration and higher rank tensors, relativistic formulation ofelectrodynamics, Maxwell equations in covariant form, gauge invariance andfourpotential, the action principle and electromagnetic energy momentumtensor. LinardWeichert potentials, radiation from an accelerated charge,Larmor formula, bremsstrahlung and	CLASSICAL ELECTRODYNAMICS II

			synchrotron radiation, multipole radiation,dispersion theory, radiative reaction, radiative damping, scattering byfree charges; applications to waveguides, fibres and plasmas. **References/Text Books:**	
PHY555A	0-0-4-0-4		**Course Contents:** BATCHLOR OF SCIENCE PROJECT I **References/Text Books:**	BATCHLOR OF SCIENCE PROJECT -1
PHY556A	0-0-0-9-9		**Course Contents:** BATCHLOR OF SCIENCE PROJECT II **References/Text Books:**	BATCHLOR OF SCIENCE PROJECT -II
PHY563	0-0-11-0-4		**Course Contents:** Experimental project in a research laboratory: 1. Literature survey andpreparation for the project. **References/Text Books:**	M.SC. PROJECT I
PHY563A	0-0-11-0-11		**Course Contents:** Experimental project in a research laboratory: 1. Literature survey andpreparation for the project. **References/Text Books:**	M.SC. PROJECT I
PHY565	0-0-11-0-4		**Course Contents:** Experimental project in a research laboratory: 2. Development and testingof experimental setup. **References/Text Books:**	M.SC. PROJECT II
PHY565A	0-0-11--11		**Course Contents:** Experimental project in a research laboratory: 2. Development and testingof experimental setup. **References/Text Books:**	M.SC. PROJECT II
PHY566	0-0-8-0-4		**Course Contents:** Experimental project in a research laboratory: 3. Data acquisition and analysis. **References/Text Books:**	M.SC. PROJECT III
PHY568	0-0-8-0-4		**Course Contents:** Experimental project in a research laboratory: 4. Preparation of report andinterpretation of results. **References/Text Books:**	M.SC. PROJECT IV
PHY570	-0-8--4		**Course Contents:** Study of a researchoriented topic in Theoretical Physics with an aim to bringthe student in contact with a concrete research area of current interest. Solvinga small problem in this area is required, detailing the explicit statementof the problem, relevance and context, steps involved, tools employed, proposedwork plan, and results obtained. **References/Text Books:**	THEORETICAL PROJECT I
PHY571	0-0-8-0-4		**Course Contents:**	THEORETICAL PROJECT II

			Advanced research oriented theoretical study in continuation of project workundertaken in PHY 570, or study of another researchoriented topic in TheoreticalPhysics with an aim to bring the student in contact with a concrete researcharea of current interest. Solving a small problem in the area is required, detailingthe explicit statement of the problem, relevance and context, steps involved,tools employed, proposed work plan and results obtained. **References/Text Books:**	
PHY590	0-0-8--4	#	**Course Contents:** Details of contents will be announced when the course is offered. If the numberof students is less than 5, this may be floated as a Reading Course for studentswith CPI 8.0 or above. **References/Text Books:**	SPECIAL TOPICS IN PHYSICS
PHY590A	0-0-9-0-9		**Course Contents:** Details of contents will be announced when the course is offered. It the numbers of students is less than 5, this may be floated as a Reading Course for students with CPI 8.0 or above. **References/Text Books:**	SPECIAL TOPICS IN PHYSICS
PHY599	0-0-24-0-12		**Course Contents:** M. Sc. Project I **References/Text Books:**	M.SC.RESEARCH PROJECT II
PHY599A	0-0-27-0-27		**Course Contents:** M. Sc. Project II **References/Text Books:**	M.SC.RESEARCH PROJECT II
PHY600	3-0-0-0-5		**Course Contents:** 1. Introduction to HPC and scientific computing. Overview of major applications. 2. Supercomputing architecture; multicores; shared memory; switch etc. 3. Review of basics of C/Fortran programming. 4. Programming in Message Passing Interface (MPI). 5. Programming in OpenMP. 6. Case study on one major application. **References/Text Books:** 1. P.S. Pacheco, An Introduction to Parallel Programming, Elsevier (2011). 2. M. Quinn, Parallel Programming in C and OpenMP, McGraw Hill Education (India) (2003). 3. A. Grama, A. Gupta, G. Karypis, and V. Kumar, Introduction to Parallel Computing, Pearson (220).	INTRODUCTION TO HIGH PERFORMANCE COMPUTING FOR SCIENTISTS AND ENGINEERS
PHY601	1-3-0--4		**Course Contents:** Problem oriented review of Classical Mechanics, Newtons laws ofmotion, Galilean transformations, Particle mechanics, System ofparticles, Noninertial frames, Pseudoforces. Small oscillationsand normal modes. Lagrangian formulation, Configuration space, Hamiltons principleof least action, Symmetries and conservation laws, Rigid bodymotion, Hamiltonian formulation. Phase space, Liouvilles theorem, Canonical transformations,Poisson brackets, HamiltonJacobi theory, Actionangle variables. Integrability, Perturbation theory, Time dependent Hamiltonian,Introduction to chaos, Chaotic attractor (and repeller), Lyapunov exponent, Special relativity. **References/Text Books:** 1. J. V. Jose & E. J. Saletan, Classical Dynamics, Cambridge University Press (1998). 2. I. C. Percival & D. Richards, Introduction to Dynamics, Cambridge University Press(1982). 3. L. D. Landau & E. M. Lifshitz,	REVIEW OF CLASSICAL MACHANICS

			Mechanics, ButterworthHeinemann (1976). 4. H. Goldstein, Classical Mechanics, AddisonWesley (1980). 5. S. H. Strogatz, Nonlinear Dynamics and Chaos, Westview Press (2001). 6. M. Tabor, Chaos and Integrability in Nonlinear Dynamics, WileyInterscience (1974).	
PHY601A	1-3-0--9		**Course Contents:** Problem oriented review of Classical Mechanics, Newtons laws ofmotion, Galilean transformations, Particle mechanics, System ofparticles, Noninertial frames, Pseudoforces. Small oscillationsand normal modes. Lagrangian formulation, Configuration space, Hamiltons principleof least action, Symmetries and conservation laws, Rigid bodymotion, Hamiltonian formulation. Phase space, Liouvilles theorem, Canonical transformations,Poisson brackets, HamiltonJacobi theory, Actionangle variables. Integrability, Perturbation theory, Time dependent Hamiltonian,Introduction to chaos, Chaotic attractor (and repeller), Lyapunov exponent, Special relativity. **References/Text Books:** 1. J. V. Jose & E. J. Saletan, Classical Dynamics, Cambridge University Press (1998). 2. I. C. Percival & D. Richards, Introduction to Dynamics, Cambridge University Press(1982). 3. L. D. Landau & E. M. Lifshitz, Mechanics, ButterworthHeinemann (1976). 4. H. Goldstein, Classical Mechanics, AddisonWesley (1980). 5. S. H. Strogatz, Nonlinear Dynamics and Chaos, Westview Press (2001). 6. M. Tabor, Chaos and Integrability in Nonlinear Dynamics, WileyInterscience (1974).	REVIEW OF CLASSICAL MACHANICS
PHY602	1-3-0--4	#	**Course Contents:** Problemoriented review of basic quantum mechanics: Schrdinger equation,simple potential problems, quantum dynamics, angular momentum, perturbationtheory, scattering, applications to atoms and molecules. **References/Text Books:**	REVIEW OF QUANTUM PHYSICS I
PHY602A	1-3-0-0-9		**Course Contents:** Problem oriented review of Quantum Mechanics. Historicaldevelopment of quantum mechanics, wavepackets, Schrodinger'sequation, twolevel systems. Solution (analytical and numerical) of timeindependentSchrodinger equation for various physically relevant potentials;angular momentum algebra, spherical harmonics. Numericalsolution of the radial Schrodinger equation for arbitrary sphericallysymmetric potential. Equivalence of Heisenberg approach and Schrodinger approach;matrix mechanics. Quantization of electromagnetic field in a cavityand in free space. Approximation methods: perturbation theory andvariation principle for timeindependent problems, WKBapproximation. Timedependent Schrodinger equation. Timedependent perturbation theory and matter radiation interaction.Selection rules for dipole radiation. Adiabatic and suddenapproximations. Topics in (i) scattering theory, (ii) relativistic quantum mechanics,(ii) introduction to path integral formulation, (iv) identicalparticles. Problems of current interest, many body physics. **References/Text Books:** 1. J. J. Sakurai, Modern Quantum Mechanics. 2. L.I. Schiff, Quantum Mechanics 3. E. Merzbacher, Quantum Mechanics 4. R. Shankar, Principles of Quantum Mechanics 5. Loudon, Quantum theory of light	REVIEW OF QUANTUM MECHANICS
PHY603	1-3-0--4		**Course Contents:** Problemoriented review of electromagnetism, optics and thermodynamics:electric fields, potentials, Gausss law, dielectrics, magnetic fields, Ampreslaw, Faradays law, Maxwells equations, electromagnetic waves, interference,diffraction, polarization. **References/Text Books:**	REVIEW OF CLASSICAL PHYSICS II
PHY603A	1-3-0-0-9		**Course Contents:** Problem oriented review of Classical Electrodynamics.Electrostatics and Magnetostatics: Methods of solvingelectrostatic problems in cartesian, spherical and cylindricalcoordinates, Green's function and	REVIEW OF CLASSICAL ELECTRODYNAMICS

			Boundary value problems, bothanalytical and numerical solutions. Multipole expansion,Macroscopic media, Dielectrics and Magnetic media. Electrodynamics: Faraday's law, Displacement current, PoyntingVector, Conservation laws. Electromagnetic waves in free spaceand different media, waveguides. Radiation: Retarded potential, electric and magnetic dipole fields,linear antenna. Special Relativity: Transformation ofelectromagnetic fields. Scattering and diffraction, Resonant cavities, Optical fibers,Dispersion. **References/Text Books:** 1. J. D. Jackson, Classical Electrodynamics. 2. Landau and Lifshitz, Electrodynamics of continuous media. 3. Griffiths, Electrodynamics. 4. Zangwill, Electrdynamics. 5. Reitz, Christy and Millford, Electrodynamics.	
PHY604	1-3-0--4	#	**Course Contents:** Problemoriented survey of statistical mechanics, deuteron problem, nuclearscattering, alpha and beta decay, elementary particle phenomenology, crystalstructure, symmetry, periodic potential, bands, metals and semiconductors. **References/Text Books:**	REVIEW OF QUANTUM PHYSICS II
PHY604A	1-3-0-0-9		**Course Contents:** Problem oriented review of Statistical Mechanics. Review ofthermodynamics: Laws of thermodynamics; thermodynamics ofphase transitions and phase diagram. Review of Ensembles and rules of calculation : Microcanonical,canonical, grandcanonical and other ensembles; applications tomodels of ideal classical and quantum gases. Models of classical interacting systems : Ising model in 1dimension: exact solution by transfer matrix ; PeierlsGriffithsargument for Ising model in 2dimensions; Meanfieldapproximation for magnets and fluids, Landau Theory, criticalexponents, upper and lower critical dimensions. Models of quantum interacting systems : Density matrix,Transverse Ising model, exact solution by JordanWignertransformation, Heisenberg model magnons; MerminWagnertheorem; general theory of quantum phase transitions. Brief overview of Nonequilibrium statistical mechanics : Randomwalk and diffusion, Markov processes and master equation;Systems near equilibrium Linear Response Theory, FluctuationDissipation Theorem; Escape over a barrier relaxation phenomena;critical dynamics. Supplementary reading materials for term papers: MomentumspaceRenormalization Group, Realspace Renormalization Group,Duality in Statistical mechanics, Various types of seriesexpansions, Boltzmann equation, Molecular hydrodynamics,BBGKY hierarchy; Random and glassy systems, Linear andbranched Polymers, Percolation; XY model and vortices superfluidity. **References/Text Books:** 1. M. Kardar, "Statistical Physics of Particles" (CUP, 2007). 2. R.K. Pathria, "Statistical Mechanics" (Academic Press, 2007). 3. D. Chowdhury and D. Stauffer, "Principles of Equilibrium Statistical Mechanics"(Wiley, 2000). 4. B.K. Chakrabarti et al. "Quantum Phase Transitions in Transverse Ising Models"(Springer, 1996). 5. S.K. Ma, "Statistical Mechanics" (World Scientific, 1985). 6. L.D. Landau and E.M. Lifshitz, "Statistical Mechanics" (Academic Press, 1975) 7. K. Huang, "Statistical Mechanics" (Wiley, 1987)	REVIEW OF STATISTICAL MECHANICS
PHY605	1-3-0-0-4		**Course Contents:** Problem oriented review of Mathematical Methods in Physics.Vector spaces Discrete and continuous: orthogonality, operatoralgebra. Hermitian and unitary operators, projection operators,matrices and applications in Physics. Calculus of variations,function spaces and Hilbert spaces, Orthogonal polynomials,expansions in orthogonal polynomials, generating functions. Integraltransforms (e.g Fourier, Laplace, etc.) and applications to physics. Differential equations: General introduction to ordinary differentialequations, linear first and second order ordinary differentialequations, singular points, series solutionsFrobenius method,second solution, inhomogeneous equationsGreen's function, SturmLiouville theory, partial differential equations, characteristics,Boundary conditions. Special functions and applications in Physics. Complex analysis: CauchyRiemann conditions, CauchyGoursattheorem, Cauchy integral formula, Contour integrals, Taylor andLaurent Series, The residue theorem. Applications of complexanalysis to	REVIEW OF MATHEMATICAL METHODS IN PHYSICS

			physics problems. **References/Text Books:** 1. Sadri Hassani, Mathematical Physics: a modern introduction to its foundations (Springer) 2. Arfken, Weber Mathematical Methods for Physicists (Academic Press) 3. Tulsi Dass and S. K. Sharma, Mathematical methods in Classicaland Quantum Physics (University Press) 4. A. K. Kapoor, Complex variables (World Scientific) 5. Mathews, Walker Mathematical Methods of Physics (AddisonWesley) 6. Schaum Series Vector Analysis 7. A. W. Joshi, Matrices and Tensors in Physics (New age international)	
PHY611	3-0-0--4	PHY432	**Course Contents:** Second quantization; interaction picture; Smatrix; diagrammatic methods;manyparticle Greens functions; basic techniques in manybody physics; additionaltopics (at the discretion of the Instructor). **References/Text Books:**	ADVANCED QUANTUM MECHANICS
PHY612	3-0-0--4	#	**Course Contents:** Elements of finite groups. representation theory. applications to physicalsystems: crystal symmetries. continuous groups. Lie algebras and their elementaryapplications. global properties of groups. **References/Text Books:**	INTRODUCTION GROUP THEORY & ITS APPLICATION TO QUANTUM MECH.
PHY613	3-0-0--4	#	**Course Contents:** Equilibrium statistical mechanics, phase transitions, critical phenomena,superfluidity, super conductivity, nonequilibrium statistical mechanics, Langvinequations, FokkerPlanck equations, ergodic hypothesis and the basic postulate. **References/Text Books:**	ADVANCED STATISTICAL MECHANICS
PHY613A	3-0-0-0-9		**Course Contents:** Equilibrium statistical mechanics, phase transitions, critical phenomena, superfluidity, supercondictivity, nonequilibrium statistical mechanics, Langevin equations, FokkerPlanck equations, ergodic hypothesis and the basic postulate. **References/Text Books:**	ADVANCED STATISTICAL MECHANICS
PHY614	3-0-0--4	#	**Course Contents:** Path integral method of formulating quantum mechanics and its application toelementary quantum systems, formal scattering theory; LippmannSchwingerformulation, scattering of particles with spin, stationary states, analyticproperties of partial wave amplitudes, resonances, dispersion relations. **References/Text Books:**	SPECIAL TOPICS IN QUANTUM MECHANICS
PHY615	3-0-0--4	#	**Course Contents:** Linear response theory, FokkerPlanck and Langvin equations, master equation;nucleation and spinodal decomposition, critical dynamics, Boltzmann equation. **References/Text Books:**	NON-EQULIBRIUM STATISTICAL MECHANICS
PHY615A	3-0-0-0-9		**Course Contents:** Linear response theory, FokkerPlanck and Langevin equations, master equation; nucleartion and spinodal decomposition, critical dynamics, Boltzmann equation. **References/Text Books:**	NON-EQULIBRIUM STATISTICAL MECHANICS

PHY616	3-0-0-0-4		**Course Contents:** Introduction to Soft Matter, Forces, energies and timescales in soft matter, Thermodynamic aspects of intermolecular forces, van der Waals force, Hydrophobic and hydrophilic interaction, Interfacial phenomenon; wetting, adhesion and friction, Mechanical properties, Introduction to complex fluids, Fluid flow and hydrodynamic instabilities, Foams and emulsions, Polymers, colloids and Surfactants, Liquid crystals, Selfassembly in soft matter, Experimental tools for soft matter. **References/Text Books:** Books recommended:1. Intermolecular and Surface Forces by Jacob N. Israelachvili (Academic Press, 1998)2. Soft Condensed Matter by R. A. L. Jones (Oxford University Press, 2002)3. Principles of Condensed Matter Physics by P. M. Chaikin and T. C. Lubensky (Cambridge University Press, 1995)4. Hydrodynamic and hydromagnetic stability by S. Chandrashekhar (Oxford University Press, 1981)5. Structured Fluids by Thomas A. Witten (Oxford University Press, 2004)6. Structure and Rheology of Complex Fluids by Ronald G. Larson (Oxford University Press, 1999)	SOFT MATTER PHYSICS
PHY616A	3-0-0-0-9		**Course Contents:** Introduction to Soft Matter, Forces, energies and timescales in soft matter, Thermodynamic aspects of intermolecular forces, van der Waals force, Hydrophobic and hydrophilic interaction, Interfacial phenomenon; wetting, adhesion and friction, Mechanical properties, Introduction to complex fluids, Fluid flow and hydrodynamic instabilities, Foams and emulsions, Polymers, colloids and Surfactants, Liquid crystals, Selfassembly in soft matter, Experimental tools for soft matter. **References/Text Books:** Books recommended:1. Intermolecular and Surface Forces by Jacob N. Israelachvili (Academic Press, 1998)2. Soft Condensed Matter by R. A. L. Jones (Oxford University Press, 2002)3. Principles of Condensed Matter Physics by P. M. Chaikin and T. C. Lubensky (Cambridge University Press, 1995)4. Hydrodynamic and hydromagnetic stability by S. Chandrashekhar (Oxford University Press, 1981)5. Structured Fluids by Thomas A. Witten (Oxford University Press, 2004)6. Structure and Rheology of Complex Fluids by Ronald G. Larson (Oxford University Press, 1999)	SOFT MATTER PHYSICS
PHY617	3-0-0--4		**Course Contents:** Examples of subcellular nanomachines of life; difference between macroscopicand nanomachines: world of nanometer and picoNewton, stochastic dynamicsat low Reynolds number; experimental, computational and theoretical techniques:imaging and manipulating singlemolecules, fluorescence microscopy, opticaltweezers, and AFM; Langevin and FokkerPlanck equations for Brownian rectifiers;power stroke vs. Brownian ratchet mechanisms for directed movements.mechanochemistry of subcellular machines, energetics and efficiencyof isothermal chemical machines far from equilibrium cytoskeletonassociatednanomachines: intracellular motor transport; nucleoticbased machines DNA/RNA helicase/polymerase, ribosome Gproteins switches and latches; membraneboundmachines, translocation machines, molecular pumps, ATP synthase,flagellar motor; molecular sensors: hair cells; nanopistons and crawling of cells. **References/Text Books:**	PHYSICS OF NATURAL NANO-MACHINES
PHY621	4-0-0--4	PHY543	**Course Contents:** One electron model, BornOppenheimer approximation, Hartree & HartreeFockapproximation, density functional theory, local density approximation, beyondLDA. electrons in periodic solids, Blochs theorem, nearlyfree electron model,energy bands, Fermi surface, The tightbinding method, APW method,OPW method, pseudopotential method, KKR method, LMTO method, the fullpotentialmethods. applications to different types of solids; electron in disorderedsolids, meanfield theories, coherent potential approximation, KKRCPA.Applications of KKRCPA, tightbinding molecular dynamics, applications toclusters and solids, CarParinello methods and its applications to clustersand amorphous semiconductors, applications of electronic structure methodsto materials design.	ELECTRONIC STRUCTURE OF MATERIALS

			References/Text Books:	
PHY621A	3-0-0-0-9	PHY543A	**Course Contents:** One electron model, BornOppenheimer approximation, Hartree & HartreeFockapproximation, density functional theory, local density approximation, beyondLDA. electrons in periodic solids, Blochs theorem, nearlyfree electron model,energy bands, Fermi surface, The tightbinding method, APW method,OPW method, pseudopotential method, KKR method, LMTO method, the fullpotentialmethods. applications to different types of solids; electron in disorderedsolids, meanfield theories, coherent potential approximation, KKRCPA.Applications of KKRCPA, tightbinding molecular dynamics, applications toclusters and solids, CarParinello methods and its applications to clustersand amorphous semiconductors, applications of electronic structure methodsto materials design. **References/Text Books:**	ELECTRONIC STRUCTURE OF MATERIALS
PHY622	3-0-0--4	#	**Course Contents:** Fermi liquid, second quantization, interaction picture, electronelectron interaction;plasmons; electronphonon interactions; polarons, advanced methods of bandstructure calculations. Cooperative phenomena; magnetism and paramagnetism,superconductivity: experimental background, cooper pairs, BCS and GinzburgLandau theories. **References/Text Books:**	CONDENSED MATTER II
PHY624	3-0-0--4	PHY204/PHY432/PHY602	**Course Contents:** Magnetism in atoms and ions; crystal field; dia and paramagnetism, ferro andantiferromagnetism; complex orders; experimental techniques; molecular fieldsand exchange interaction; direct interaction localized and itinerant electrons,band model of ferromagnetism. indirect interactions, R.K.K.Y. theory. **References/Text Books:**	MAGNETISM IN MATERIALS
PHY627	0-0---4		**Course Contents:** FORTRAN/C programming, structured programming, errors, numerical analysis,differentiation, integration, solution of differential equations, solution ofSchrdinger equation, simulations of planetary motion, oscillatory motion,chaotic motion, molecular dynamics simulation, classical and tight bindingmolecular dynamics, simulation of Ar, density functional theory, CarParrinellosimulation, Monte Carlo simulation, simulation of Ising model, quantum MonteCarlo simulation, genetic algorithms. **References/Text Books:**	COMPUTATIONAL SIMULATION METHODS IN PHYSICS
PHY628	3-0-0--4	#	**Course Contents:** Tightbinding band structure; shallow impurities, deep impurities, densityfunctional theory, manybody theory of impurities, quantized Hall effect,metastability. **References/Text Books:**	TOPICS IN SEMICONDUCTOR
PHY629	3-0-0--4		**Course Contents:** Introduction to thin films, nucleation theories and growth processes, PVD andCVD processes, epitaxial growth, microstructure, electronic transport, opticalproperties of thin films, size effects, physics and applications of thin films inselected areas. **References/Text Books:**	PHYSICS AND TECHNOLOGY OF THIN FILMS
PHY631	3-0-0-0-4		**Course Contents:** Review of condensed matter and semiconductor physics, fabrication of quantumnanostructures, quantum structures and bandgap engineering. transportin quantum structures with applications, optical properties and	PHYSICS OF SEMICONDUCTOR NANOSTRUCTURES

			applications,quantum mechanical effects in magnetotransport, frontiers in current research. **References/Text Books:**	
PHY631A	3-0-0-0-9		**Course Contents:** Review of condensed matter and semiconductor physics, fabrication of quantumnanostructures, quantum structures and bandgap engineering. transportin quantum structures with applications, optical properties and applications,quantum mechanical effects in magnetotransport, frontiers in current research. **References/Text Books:**	PHYSICS OF SEMICONDUCTOR NANOSTRUCTURES
PHY634	3-0-0--4	#	**Course Contents:** Production of low temperatures; cryostat design and experimental techniquesapplied to low temperature; thermometry; specific heat, transport phenomena,thermal, electrical and magnetic properties; superconductivity, applications ofsuperconductivity; superfluidity and associated phenomena. **References/Text Books:**	LOW TEMPERATURE PHYSICS
PHY638	3-0-0--4	#	**Course Contents:** Different solid state physics/materials science aspects which can bestudied using nuclear techniques. Rutherford backscattering, channeling, elasticrecoil detection analysis, positron annihilation, Mssbauer spectroscopy,ESCA etc. **References/Text Books:**	NUCLEAR TECHNIQUES IN SOLID STATE STUDIES
PHY642	3-0-0--4	PHY543/PHY204/SE301	**Course Contents:** Characteristic length scales for quantum phenomena; scaling as a heuristic tool;scientific and technological significance of nanostructures and mesoscopicstructures. brief introduction to quantum view of bulk solids, introduction tokey ideas in transport and interaction of photons with material. Quantumstructures: electronic properties: science and technology realizing low dimensionalstructures; MBE, MOCVD, LangmuirBlodgett films, novel processes; electronicproperties of heterostructures, quantum wells, quantum wires, quantum dots,and superlattices, strained layer superlattices; transport in mesoscopic structures.resonant tunneling, hot electrons, conductance and transmission of nanostructures;principles of application of electronic devices. quantum structures:optical properties: optical process in low dimensional semiconductors. absorption.luminescence, excitons. application to lasers and photodetectors, transport inmagnetic field: megnetotransport: transport in magnetic field, semiclassicaldescription, quantum approach, AharonovBohm effect, Shubnikov deHaas effect; introduction to quantum Hall effect. **References/Text Books:**	CONDENSED MATTER PHENOMENA IN LOW DIMENSIONAL MATERIALS
PHY644	3-0-0--4		**Course Contents:** Semiclassical theory of lasers, single and multimode operation, gas laser theory,ring and Zeeman lasers, coherence in lasers. nonlinear optical phenomena,Feynman diagrams in multiphoton problems. **References/Text Books:**	QUANTUM ELECTRONICS
PHY644A	3-0-0-0-9		**Course Contents:** Semiclassical theory of lasers, single and multimode operation, gas laser theory,ring and Zeeman lasers, coherence in lasers. nonlinear optical phenomena,Feynman diagrams in multiphoton problems. **References/Text Books:**	QUANTUM ELECTRONICS
PHY646	3-0-0--4	#	**Course Contents:**	COHERENT OPTICS

			Fourier transforms, diffraction theory, coherence theory, twodimensional systemstheory, optical processing, holography, holographic interferometry and itsapplications; astronomical correlation interferometry, optical resonators, nonlinearoptics, phase conjugation. **References/Text Books:**	
PHY647	2-1-4--5		**Course Contents:** Survey of network theorems and network analysis, basic differential amplifiercircuit, op amp characteristics and applications, simple analog computer, analogintegrated circuits, PLL, etc., digital electronics, gates, flipflops, counters etc.,transducers, signal averaging, lockin amplifier, D/A & A/D converter, multichannelanalyzer etc., introduction to microprocessors. **References/Text Books:**	ELECTRONICS
PHY647A	2-1-3--11		**Course Contents:** Survey of network theorems and network analysis, basic differential amplifier circuit, op amp characteristics and applications, simple analog computer, analog integrated circuits, PLL, etc. digital electronics, gates, flipflops, counters etc., transducers, signal averaging, lockin amplifier, D / A & A/D converter, multichannel analyzer etc., introduction to microprocessors. **References/Text Books:**	ELECTRONICS
PHY660	3-0-0--4	#	**Course Contents:** Machs principle. Riemanniangeometry. energymomentum tensor and Einsteinsequations. Schwarzschild metric and singularities of space time. postNewtonianapproximations. spherically symmetric solutions of Einstein equations. Introductionto cosmology. **References/Text Books:**	GENERAL RELATIVITY & COSMOLOGY
PHY660A	3-0-0-0-9		**Course Contents:** Machs principle. Riemanniangeometry. energymomentum tensor and Einsteinsequations. Schwarzschild metric and singularities of space time. postNewtonianapproximations. spherically symmetric solutions of Einstein equations. Introductionto cosmology. **References/Text Books:**	GENERAL RELATIVITY & COSMOLOGY
PHY680	3-0-0--4		**Course Contents:** Natural units; evidence for 4 fundamental interactions, leptons and hadrons,historical introduction to particle zoo, relativistic kinematics, Lorentzinvariantphase space, calculation of 2 and 3body phase space, Dalitz plot, Mandelstamvariables, crossing symmetry, isospin, flavour SU(2), strangeness & flavourSU(3), product representations and Young tableaux, the GellMann eightfold way,prediction of ?, quark model, construction of hadronic wave functions, magneticmoment of the neutron, statistics of baryons & concept of colour; discoveryof weak interactions, Fermi theory. IVB hypothesis, parity violation,mass problem, and decay; gauge theory, local U(1) gauge theory andMaxwell equations, YangMills theories, SU(2) and SU(3) gauge theories,construction of SU(2)xU(1) gauge theory, gauge boson selfinteractions,spontaneous breaking of gauge symmetry, Abelian and nonAbelian cases,Goldstone theorem, Higgs mechanism, GinzburgLandau theory, construction ofthe GlashowSalamWeinberg model (outline only). **References/Text Books:**	PARTICLE PHYSICS
PHY680A	3-0-0-0-9		**Course Contents:** Natural units; evidence for 4 fundamental interactions, leptons and hadrons,historical introduction to particle zoo, relativistic kinematics, Lorentzinvariantphase space, calculation of 2 and 3body phase space, Dalitz plot,	PARTICLE PHYSICS

			Mandelstamvariables, crossing symmetry, isospin, flavour SU(2), strangeness & flavourSU(3), product representations and Young tableaux, the GellMann eightfold way,prediction of ?, quark model, construction of hadronic wave functions, magneticmoment of the neutron, statistics of baryons & concept of colour; discoveryof weak interactions, Fermi theory. IVB hypothesis, parity violation,mass problem, and decay; gauge theory, local U(1) gauge theory andMaxwell equations, YangMills theories, SU(2) and SU(3) gauge theories,construction of SU(2)xU(1) gauge theory, gauge boson selfinteractions,spontaneous breaking of gauge symmetry, Abelian and nonAbelian cases,Goldstone theorem, Higgs mechanism, GinzburgLandau theory, construction ofthe GlashowSalamWeinberg model (outline only). **References/Text Books:**	
PHY681	3-0-0--4	PHY432	**Course Contents:** Lorentz and Poincar groups; relativistic wave equations; Lagrangian formalismfor fields; symmetry transformations and Nthers theorem; quantizationof fields; divergences and renormalization; YangMills fields, spontaneousbreakdown of symmetries and Goldstone theorem; Higgs phenomenon; unifiedmodels of fundamental interactions. **References/Text Books:**	QUANTUM FIELD THEORY
PHY681A	3-0-0-0-9	PHY432A	**Course Contents:** Lorentz and Poincar groups; relativistic wave equations; Lagrangian formalismfor fields; symmetry transformations and Nthers theorem; quantizationof fields; divergences and renormalization; YangMills fields, spontaneousbreakdown of symmetries and Goldstone theorem; Higgs phenomenon; unifiedmodels of fundamental interactions. **References/Text Books:**	QUANTUM FIELD THEORY
PHY690	3-0-0--4		**Course Contents:** The course will deal with specialized topics of current interest in solid state,theoretical physics, molecular physics, or structure of matter. Detailed contentswill be given by the instructor when the course is announced. If the numberof students is less than 5, this may be floated as a Reading Course with thepermission of DPGC.Every new course, other than Reading Courses, offered is numbered PHY 690A,PHY 690B, and so on, until PHY 690Z is reached. After that the cycle repeatsfrom PHY 690A onwards. **References/Text Books:**	SPECIAL TOPICS IN PHYSICS
PHY690A	3-0-0-0-9		**Course Contents:** The course will deal with specialized topics of current interest in solid state,theoretical physics, molecular physics, or structure of matter. Detailed contentswill be given by the instructor when the course is announced. If the numberof students is less than 5, this may be floated as a Reading Course with thepermission of DPGC.Every new course, other than Reading Courses, offered is numbered PHY 690A,PHY 690B, and so on, until PHY 690Z is reached. After that the cycle repeatsfrom PHY 690A onwards. **References/Text Books:**	GREEN NANOTECHNOLOGIES
PHY692	3-0-0--5		**Course Contents:** Typical experiments in various areas is physics; vacuum techniques; transducers:temperature, pressure, charge particles, photons, etc; electronic noise; surveyof analog and digital I/Cs; signal processing, data acquisition andcontrol systems; data analysis evaluation. **References/Text Books:**	MEASUREMENT TECHNIQUES
PHY692A	3-0-3-0-12		**Course Contents:**	MEASUREMENT

			Typical experiments in various areas is physics; vacuum techniques; transducers:temperature, pressure, charge particles, photons, etc; electronic noise; surveyof analog and digital I/Cs; signal processing, data acquisition andcontrol systems; data analysis evaluation. **References/Text Books:**	TECHNIQUES
PHY781	3-0-0--4	#	**Course Contents:** Current topics in Particle Physics and quantum field theory. **References/Text Books:**	HIGH ENERGY PHYSICS II
PHY781A	3-0-0-0-9		**Course Contents:** Current topics in Particle Physics and quantum field theory. **References/Text Books:**	HIGH ENERGY PHYSICS II
PHY799	----		**Course Contents:** To be registered by Ph,D. students from Semester I itself, and by M.ScPh.D.(DualDegree) students from Semester V onwards. **References/Text Books:**	RESEARCH
PHY799.	0----4		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PH D THESIS
SE301	3-1-0-0-4		**Course Contents:** Origin of quantum theory and related experiments, WaveParticle duality forphotons and material particles, Wave function and its born interpretation,Relation with measurement of dynamical variables, dfunction as definiteposition and plane wave as definite momentum wave function, Wavepacket assuperposition of dfunctions and of plane waves, Positionmomentum UncertaintyPrinciple, Gaussian wave packets, Applicability of classical physics on the basisof uncertainty product. Operator formulation, commuting operators, simultaneouseigenfunctions, degenerate eigenfunctions. Schrodinger equation for timeevolution, Stationary states, Spread of free particle wave packets, Time energyuncertainty, Natural line width of spectral lines. Probability currents and theirrelation with the flux in beams of particles. Square well potentials, Practicalexamples like metalvacuum interface, Contact potential between metals, Bilayerand sandwiched thin film etc., Bound states in deep potential well and finitepotential well, Double well potentials and examples like Ammonia inversion, Deltafunction potentials and examples like electron sharing in covalent bonds. KronigPenny model of 1D crystals and formation of energy bands. Linear harmonicoscillator, outline of getting stationary states, Molecular vibrations andspectroscopy. Barrier Tunneling, Examples of adecay, nuclear fission, fusion inthe Sun, Cold emission, Scanning tunneling microscope, principle of tunnel diodeetc.; Angular momentum operators, eigenvalues and eigenfunctions, Spinangular momentum, hydrogen atom using Coulomb interaction, structure of Haline due to ls interaction (derivation not needed). **References/Text Books:**	QUANTUM PHYSICS
SE305	3-1-0--4		**Course Contents:** INTRODUCTION: Examples of nonequilibrium phenomena(i) Glass transition; (ii)Nucleation; (iii) Phase separation; Experimental probes: Dynamic scattering;inelastic neutron scattering, THEORETICAL TOOLS: Two alternative theoreticalapproaches (a) Langevin equationdissipation, nonlinearity and noise; Illustrationwith translational Brownian motion; (b) FokkerPlanck equationdiffusion anddrift; Illustration with (i) translational Brownian motion, (ii) rotational Brownianmotion. Master equationloss and gain of	PHYSICS OF NON-EQUILIBRIUM PHENOMENA

			probabilities; concept of detailedbalance . METASTABILITY AND BISTABILITY: Kramers theory of thermallyactivated barrier crossingapplications in (i) chemical reactions (ii) rockmagnetism. Enhancing signals with the help of noise applications ofstochastic resonance in (a) nonlinear optics, (b) solid state devices, (c) neuroscience,(d) molecular motors and biological locomotion. BeckerDoring Theoryof homogeneous nucleation and its modern extensionsapplications in (a)condensation and (b) crystallization. UNSTABLE STATES: AllenCahn scenario ofinterfacial dynamics and domain growthapplications to domain growth inquenched magnets; LifshitzSlyozov arguments for phase separation and itsgeneralizationsapplications to (a) alloys, (b) fluid mixtures, (c) polymer mixtures.Theory of phase separation controlled by topological defects application to liquidcrystals. Theory of coarsening of Cellular Patterns applications to soap froths(e.g., shaving foams). NONEQUILIBRIUM STEADYSTATES IN DRIVEN SYSTEM:Driven systems of interacting particles applications to vehicular traffic; Drivensurfaces applications in molecular beam epitaxy (MBE). **References/Text Books:**	
SE305A	3-1-0-0-11		**Course Contents:** INTRODUCTION: Examples of nonequilibrium phenomena(i) Glass transition; (ii)Nucleation; (iii) Phase separation; Experimental probes: Dynamic scattering;inelastic neutron scattering, THEORETICAL TOOLS: Two alternative theoreticalapproaches (a) Langevin equationdissipation, nonlinearity and noise; Illustrationwith translational Brownian motion; (b) FokkerPlanck equationdiffusion anddrift; Illustration with (i) translational Brownian motion, (ii) rotational Brownianmotion. Master equationloss and gain of probabilities; concept of detailedbalance . METASTABILITY AND BISTABILITY: Kramers theory of thermallyactivated barrier crossingapplications in (i) chemical reactions (ii) rockmagnetism. Enhancing signals with the help of noise applications ofstochastic resonance in (a) nonlinear optics, (b) solid state devices, (c) neuroscience,(d) molecular motors and biological locomotion. BeckerDoring Theoryof homogeneous nucleation and its modern extensionsapplications in (a)condensation and (b) crystallization. UNSTABLE STATES: AllenCahn scenario ofinterfacial dynamics and domain growthapplications to domain growth inquenched magnets; LifshitzSlyozov arguments for phase separation and itsgeneralizationsapplications to (a) alloys, (b) fluid mixtures, (c) polymer mixtures.Theory of phase separation controlled by topological defects application to liquidcrystals. Theory of coarsening of Cellular Patterns applications to soap froths(e.g., shaving foams). NONEQUILIBRIUM STEADYSTATES IN DRIVEN SYSTEM:Driven systems of interacting particles applications to vehicular traffic; Drivensurfaces applications in molecular beam epitaxy (MBE). **References/Text Books:**	PHYSICS OF NON-EQUILIBRIUM PHENOMENA
SE307	3-0-0--4		**Course Contents:** Course Outline: Characteristic length scales for quantum phenomena; Scalingas a heuristic tool; Scientific and Technological significance of nanostructuresand mesoscopic structures. Brief introduction to quantum view of bulk solids,Introduction to key ideas in transport and interaction of photons with material.Quantum Structures: Electronic Properties: Science and technology realizing lowdimensional structures; MBE, MOCVD, LangmuirBloddgett films, novel processes;Electronic properties of Heterostructures, Quantum wells, Quantum wires,Quantum dots, and superlattices, Strained Layer Superlattices; Transport inMesoscopic Structures. Resonant Tunneling, Hot Electrons, Conductance andTransmission of Nanostructures. Principles of application of electronic devices.Quantum Structures: Optical Properties: Optical process in low dimensionalsemiconductors. Absorption. Luminescence, Excitons. Application to lasers andphotodetectors, Transport in Magnetic Field: Megnetotransport: Transport inMagnetic Field, Semiclassical description, Quantum Approach, AbaranovBohmeffect, Subnikov de Haas effect; Introduction to Quantum Hall effect. **References/Text Books:**	QUANTUM PROCESSES IN LOW DIMENSIONAL SEMICONDUCTORS
SE308	3-0-0--4		**Course Contents:** Indian and global energy resources, current energy exploitation, energy demand,energy planning, renewable	ENERGY

			energy sources, wind energy, energy from water,solar energy, energy from mineral oils, nuclear energy, energy for sustainabledevelopment, environmental concerns. **References/Text Books:**	
SE309	3-0-0--4		**Course Contents:** Gaussian Optics, Optical Resonators and their Mode Structure; Atomic levels,Absorption, Spontaneous and Stimulated emission, Einstein coefficients; RateEquations, Population Inversion, Gain media, 3 and 4 level lasers; CW & PulsedLasers, QSwitching, modelocking, Short pulses; Ar+, CO2, Nd:YAG, diode lasers,etc.; Metrology, Optical Communication, Materials Processing, Holography,Medical Applications. **References/Text Books:**	PRINCIPLES OF LASERS & THEIR APPLICATIONS
SE311	3-0-0-0-4		**Course Contents:** Astronomical observations and instruments, Photometry; Stellar spectra andstructure; Stellar evolution, nucleosynthesis and formation of elements; Variablestars; Compact stars (white dwarfs. Neutron stars, black holes; Star clustersand Binary stars; Galaxies, their evolution and origin; Active galaxies andquasars; Big bang model of the universe, early history of the universe, cosmicmicrowave background radiation. **References/Text Books:**	PHYSICS OF UNIVERSE
SE312	3-0-0-0-4		**Course Contents:** Dynamical Systems; Nonlinear dynamics of one dimensional flows, Fixed point,linear stability analysis, bifurcations; Nonlinear dynamics of two dimensionalflows, Phase space, equilibrium, Limit cycle, stability, bifurcations; Periodicity,disturbed periodicity; Nonlinear dynamics of 1D and 2D maps, fixed point,stability, Poincare section ; Routes to chaos Period doubling, quasiperiodicityand intermittency, Universality, Renormalization; Measurement of chaos,Lyapunovexponent, entropy; Strange attractors, fractal geometry and fractal dimension;Examples from Sciences and Engineering. **References/Text Books:**	ORDER AND CHAOS
SE312A	3-0-0-0-9		**Course Contents:** Dynamical Systems; Nonlinear dynamics of one dimensional flows, Fixed point,linear stability analysis, bifurcations; Nonlinear dynamics of two dimensionalflows, Phase space, equilibrium, Limit cycle, stability, bifurcations; Periodicity,disturbed periodicity; Nonlinear dynamics of 1D and 2D maps, fixed point,stability, Poincare section ; Routes to chaos Period doubling, quasiperiodicityand intermittency, Universality, Renormalization; Measurement of chaos,Lyapunovexponent, entropy; Strange attractors, fractal geometry and fractal dimension;Examples from Sciences and Engineering. **References/Text Books:**	ORDER AND CHAOS
SE313	3-0-0--4		**Course Contents:** Review of Maxwells and electromagnetic wave equations; Wave propagationin anisotropic media; Polarized light; Diffraction from circular aperture andconcept of resolution; Fourier transforms and Fourier optics, Spatial filtering,and Image Processing; Coherence, Holography; Optical Waveguides and integratedoptics; Optical fibres, Optical sources (LED, Lasers etc.) and detectors, andoptical communication; Electro and magneto optic effects; Lasermatterinteraction. **References/Text Books:**	MODERN OPTICS
SE314	3-0-0--4		**Course Contents:** Review of the Newtonian mechanics; Lagrangian Mechanics, Generalizedcoordinates, constraints, Principle of virtual work, Lagranges equation, Calculusof variations; Central forces, Collisions, Scattering; Small	CLASSICAL MECHANICS

			oscillations, Anharmonicoscillators, Perturbation theory, Forced oscillators; Hamiltons Equations, phasespace & phase trajectories, canonical transformations, Poisson brackets, HamiltonJacobi theory; Rigid body dynamics; Nonlinear Dynamics. **References/Text Books:**	
SE314A	3-0-0-0-9		**Course Contents:** Review of the Newtonian mechanics; Lagrangian Mechanics, Generalizedcoordinates, constraints, Principle of virtual work, Lagranges equation, Calculusof variations; Central forces, Collisions, Scattering; Small oscillations, Anharmonicoscillators, Perturbation theory, Forced oscillators; Hamiltons Equations, phasespace & phase trajectories, canonical transformations, Poisson brackets, HamiltonJacobi theory; Rigid body dynamics; Nonlinear Dynamics. **References/Text Books:**	CLASSICAL MECHANICS
SE315	3-0-0-0-4		**Course Contents:** Special Relativity, Empirical evidence for the constancy of c, Frames ofreferences; Lorentz transformations; relativity of simultaneity; twin and otherparadoxes; Transformation laws for velocity, momentum, energy; Massenergyequivalence; force Equations; Kinematics of decays and collisions; Maxwellsequations in covariant form; Representations of the Lorenz Group and SL(2,C);Introduction to General Relativity; Principle of equivalence; Machs principle;Riemannian geometry; Christoffel symbols, the curvature and stressEnergytensors; the gravitational field equations; Geodesics and particle trajectories;Schwarzchild solution; Experimental tests; Basic cosmology; FRWmetric;Cosmological expansion; Cosmic Microwave background; Helium abundance;anisotropies in the CMB. **References/Text Books:**	SPECIAL & GENERAL RELATIVITY
SE315A	3-0-0-0-9		**Course Contents:** Special Relativity, Empirical evidence for the constancy of c, Frames ofreferences; Lorentz transformations; relativity of simultaneity; twin and otherparadoxes; Transformation laws for velocity, momentum, energy; Massenergyequivalence; force Equations; Kinematics of decays and collisions; Maxwellsequations in covariant form; Representations of the Lorenz Group and SL(2,C);Introduction to General Relativity; Principle of equivalence; Machs principle;Riemannian geometry; Christoffel symbols, the curvature and stressEnergytensors; the gravitational field equations; Geodesics and particle trajectories;Schwarzchild solution; Experimental tests; Basic cosmology; FRWmetric;Cosmological expansion; Cosmic Microwave background; Helium abundance;anisotropies in the CMB. **References/Text Books:**	SPECIAL & GENERAL RELATIVITY
SE316	3-1-0--4		**Course Contents:** Review of Thermodynamics 2. Basic Principles and Applications of StatisticalMechanics 3. Ideal Quantum Gases 4. Interacting Systems5. Theories of PhaseTransitions 6. Computer Simulations 7. Elementary Concepts of NonequilibriumStat. Mechanics **References/Text Books:**	STATISTICAL MECHANICS
SE316A	3-1-0-0-11		**Course Contents:** Review of Thermodynamics 2. Basic Principles and Applications of StatisticalMechanics 3. Ideal Quantum Gases 4. Interacting Systems5. Theories of PhaseTransitions 6. Computer Simulations 7. Elementary Concepts of NonequilibriumStat. Mechanics **References/Text Books:**	STATISTICAL MECHANICS

SE317	3-1-0--4		**Course Contents:** Quantum mechanics of one and two electron atoms, Many electron atoms, Centralfield approximation, ThomasFermi approximation, Molecular binding, LCAO,LCMO and VB methods, Hydrogen molecules, Molecular spectra, Raman effect,Lasers. **References/Text Books:**	INTRODUCTION TO ATOMIC & NUCLEAR PHYSICS
SE321	3-1-0-0-4		**Course Contents:** Principles of thermodynamics (with applications to simple fluids), applicationsof thermodynamics: concept of thermodynamic state, extensive and intensive variables; heat and work, internal energy function and the first law of thermodynamics; fundamental relation and equations of state; concepts of entropy and temperature as conjugate pair of variables; second law of thermodynamics, entropy maximum and energy minimum principles; thermodynamic potentials: enthalpy, Helmholtz potential, Gibbs potential;conditions of equilibrium, concepts of stable, metastable and unstable equilibrium;components and phases, GibbsDuhem relations; firstorder phase transitions and ClausiusClapeyron equation; concepts associated with critical and multicritical phenomena, some chosen applications from surfaces and interfaces, chemical reactions (magnetic, dielectric and superconducting); heat engines and black body radiation; elementary kinetic theory of gases: equilibrium properties pressure and equation of state; transport processes momentum transport and viscosity, energy transport and thermal conductivity, charge transport & electrical conductivity (without using Boltzmann transport equation); entropy, multiplicity and disorder: entropy measures multiplicity rather than disorder, illustration with simple examples; Maxwells demon; qualitativejustifications of laws of thermodynamics (without introducing ensembles), thermodynamics of irreversible processes: entropy production. **References/Text Books:**	THERMAL PHYSICS
SE322	3-0-0--4		**Course Contents:** Examples of nanomachines in living cells; differences between macroscopic andnano machines; world of nanometer and picoNewton; stochastic dynamics ofnanomachines; experimental, computational and theoretical techniques; imagingand manipulating single machines; Power stroke versus Brownian ratchetmechanism; mechanochemistry of nanomachines; energetics and efficiency ofnanomachines; intracellular cargo transporters; nanosize unzippers; nanosizeengines for polymerization of macromolecules; exporters/importers ofmacromolecules; packaging machines; switches and latches; ion pumps; flagellarmotor; rotary motors of ATP synthesizer; molecular sensors hair cells; nanopistonsand cell crawling. **References/Text Books:**	NATURAL NANO MACHINES
***** Department of PSE *****				
PSE601	3-0-0-0-4		**Course Contents:** Photonics deals with light generation, amplification, guiding, manipulation, and detection forharvesting information. This course introduces some of the fundamental aspects of photonicsexcluding generation and detection.Maxwell Equations, Wave Equations, Dielectric Media, Constitutive RelationsElectromagnetic Waves Gaussian Beams, Absorption and DispersionSpatial and Temporal CoherenceBoundary conditions, Fresnels equations and coefficients, Brewster and critical angles, **References/Text Books:** * E. Hecht, Optics, 4th ed., Pearson Education (2001).* G. R. Fowles, Introduction to Modern Optics, Dover (1989).* Smith, F.G. & King, T.A. Optics and Photonics: An introduction, John Wiley and Sons(2007)	INTRODUCTION TO PHOTONICS
PSE601A	3-0-0-0-9		**Course Contents:** Photonics deals with light generation, amplification, guiding, manipulation, and detection forharvesting information. This course introduces some of the fundamental aspects of photonicsexcluding generation and	INTRODUCTION TO PHOTONICS

			detection.Maxwell Equations, Wave Equations, Dielectric Media, Constitutive RelationsElectromagnetic Waves Gaussian Beams, Absorption and DispersionSpatial and Temporal CoherenceBoundary conditions, Fresnels equations and coefficients, Brewster and critical angles, **References/Text Books:** Course Reference : * E. Hecht, Optics, 4th ed., Pearson Education (2001).* G. R. Fowles, Introduction to Modern Optics, Dover (1989).* Smith, F.G. & King, T.A. Optics and Photonics: An introduction, John Wiley and Sons(2007)	
PSE602	3-0-0-0-4		**Course Contents:** Introduction to light sources, Lasers, principle of lasingOptical cavities, longitudinal, transverse modes, StabilityInteraction of radiation with matter, Spontaneous emissionAbsorption and stimulated emission, line broadening mechanismsPopulation inversion, absorption and gain coefficientsPumping schemes (Rate equation based Lasing model)Three and four level lasersCW and pulsed lasers, Qswitching and modelocking **References/Text Books:** *Principles of Lasers, O. Svelto and D. C. Hanna,5th edition, 2010*Laser Physics, Peter W. Milonni and Joseph H. Eberly, Wiley, 2nd edition, 2010*Lasers, Anthony E. Siegman, University Science Books; 1st edition, 1986*Laser Electronics, Joseph T. Verdeyen, Prentice Hall; 3rd edition, 1995*Laser spectroscopy, W. Demtroder, 3rd edition, 2004	PRINCIPLES OF LASERS AND DETECTORS
PSE602A	3-0-0-0-9		**Course Contents:** Introduction to light sources, Lasers, principle of lasingOptical cavities, longitudinal, transverse modes, StabilityInteraction of radiation with matter, Spontaneous emissionAbsorption and stimulated emission, line broadening mechanismsPopulation inversion, absorption and gain coefficientsPumping schemes (Rate equation based Lasing model)Three and four level lasersCW and pulsed lasers, Qswitching and modelocking **References/Text Books:** Course Reference : *Principles of Lasers, O. Svelto and D. C. Hanna,5th edition, 2010*Laser Physics, Peter W. Milonni and Joseph H. Eberly, Wiley, 2nd edition, 2010*Lasers, Anthony E. Siegman, University Science Books; 1st edition, 1986*Laser Electronics, Joseph T. Verdeyen, Prentice Hall; 3rd edition, 1995*Laser spectroscopy, W. Demtroder, 3rd edition, 2004	PRINCIPLES OF LASERS AND DETECTORS
PSE603	3-0-0-0-4		**Course Contents:** Linear algebra: matrices, matrix inversion; QR, Singular value decomposition, systems ofequations, eigenvalues, eigenvectors, orthonormalization, condition numberLaplace and Fourier transformsVector calculus, Cartesian tensorsOrdinary differential equations, series solution, Fourier series, Special functionsIterative and direct methods for linear algebraic equations; generalized inverses, least squaresNumerical differentiation and integration; Numerical solution of 1st and second order ODEs,RungeKutta method, stability, stiff systemsPartial differential equations, second order equations, classification, separation of variables, **References/Text Books:** * E. Kreyszig, Advanced Engineering mathematics, 8th edition, McGrawHill, New York,2000.* M.D. Greenberg, Advanced Engineering Mathematics, Prentice Hall, New Jersey,International edition, 1998.* I. P. Castro, An Introduction to the Digital Analysis of Stationary Signals, Taylor andFrancis , (1989).	NUMERICAL METHODS IN OPTICS
PSE603A	3-0-0-0-9		**Course Contents:** Linear algebra: matrices, matrix inversion; QR, Singular value decomposition, systems ofequations, eigenvalues, eigenvectors, orthonormalization, condition numberLaplace and Fourier transformsVector calculus, Cartesian tensorsOrdinary differential equations, series solution, Fourier series, Special functionsIterative and direct methods for linear algebraic equations; generalized inverses, least squaresNumerical differentiation and integration; Numerical solution of 1st and second order	NUMERICAL METHODS IN OPTICS

			ODEs,RungeKutta method, stability, stiff systemsPartial differential equations, second order equations, classification, separation of variables, **References/Text Books:** Course Reference : * E. Kreyszig, Advanced Engineering mathematics, 8th edition, McGrawHill, New York,2000.* M.D. Greenberg, Advanced Engineering Mathematics, Prentice Hall, New Jersey,International edition, 1998.* I. P. Castro, An Introduction to the Digital Analysis of Stationary Signals, Taylor andFrancis , (1989).	
PSE604	3-0-0-0-4		**Course Contents:** Principles and Applications of Solid State Laser SystemsLaser diode Structures, Mechanism of photon emission in semiconductor laser, Tunablesemiconductor diode laser, Rare earth doped lasers, NdGlass/NdYag/Erdoped/VdYag Lasers,Transition metal lasers, Ruby/TiSaphire lasers, High Power Diode lasers, DPSS Lasers,Quantum cascade Laser.Principles and Applications of Liquid and Gas Laser SystemsDye laser, Tunable Lasers, Frequency stabilization, Tuning Techniques, Ar+ lasers, HeNe laser,CO2 lasers. **References/Text Books:** * Kjell J. Gasvik, Optical Metrology, 3rd Edition, John Wiley and Sons, 2002* O. Svelto and D C Hanna, Principles of lasers, 4th Ed., 1998* R W Boyd, Nonlinear optics, Academic Press, 2nd Ed, 2003* M. H. Niemz, Laser Tissue Interaction Fundamentals and Applications,	PHOTONICS SYSTEMS AND APPLICATIONS
PSE604A	3-0-0-0-9		**Course Contents:** Principles and Applications of Solid State Laser SystemsLaser diode Structures, Mechanism of photon emission in semiconductor laser, Tunablesemiconductor diode laser, Rare earth doped lasers, NdGlass/NdYag/Erdoped/VdYag Lasers,Transition metal lasers, Ruby/TiSaphire lasers, High Power Diode lasers, DPSS Lasers,Quantum cascade Laser.Principles and Applications of Liquid and Gas Laser SystemsDye laser, Tunable Lasers, Frequency stabilization, Tuning Techniques, Ar+ lasers, HeNe laser,CO2 lasers. Course Reference : * Kjell J. Gasvik, Optical Metrology, 3rd Edition, John Wiley and Sons, 2002* O. Svelto and D C Hanna, Principles of lasers, 4th Ed., 1998* R W Boyd, Nonlinear optics, Academic Press, 2nd Ed, 2003* M. H. Niemz, Laser Tissue Interaction Fundamentals and Applications, **References/Text Books:**	PHOTONICS SYSTEMS AND APPLICATIONS
PSE605	3-0-0-0-4		**Course Contents:** *Electrooptic effect using LiNbO3 crystal* Acoustooptic modulator* Study of effects of loss, dispersion, amplifier noise on 10Gbps links* 40Gbps QAM modulation and coherent demodulation* Nonlinearities in fiber: Fourwave mixing, Raman scattering etc.* SHG generation and OPO using Nd:YAG laser* OPO using BBO crystal* Fresnel and Fraunhofer Diffraction* HeNe laser beam parameters* Laser diode characteristics: LI characteristic, beam profile measurement, modes andspectrum using FP cavity* Michelson interferometer: setup, refractive index measurement* Nd:YAG laser characteristics* Fiber MachZehnder interferometer* Holography **References/Text Books:**	PHOTONICS LAB TECHNIQUES
PSE605A	1-0-6-0-9		**Course Contents:** *Electrooptic effect using LiNbO3 crystal* Acoustooptic modulator* Study of effects of loss, dispersion, amplifier noise on 10Gbps links* 40Gbps QAM modulation and coherent demodulation* Nonlinearities in fiber: Fourwave mixing, Raman scattering etc.* SHG generation and OPO using Nd:YAG laser* OPO using BBO crystal* Fresnel and Fraunhofer Diffraction* HeNe laser beam parameters* Laser diode characteristics: LI characteristic, beam profile measurement, modes andspectrum using FP cavity* Michelson interferometer: setup, refractive index measurement* Nd:YAG laser characteristics* Fiber MachZehnder interferometer*	PHOTONICS LAB TECHNIQUES

			Holography **References/Text Books:**	
PSE606	3-0-0-0-4		**Course Contents:** Biophotonics, nanobiophotonics,Optical communication, Quantum cryptographyNonlinear opticsTomographyQuantum dots, photonic crystalsLaser manufacturing and materials processingLaser instrumentation, PIV, thermography, micro]scale imagingSatellite imaging,Clouds, aerosols, Lidar spectroscopyMultiphoton imaging. **References/Text Books:**	RESEARCH IN PHOTONICS AND LASERS
PSE606A	0-0-9-0-9		**Course Contents:** Biophotonics, nanobiophotonics,Optical communication, Quantum cryptographyNonlinear opticsTomographyQuantum dots, photonic crystalsLaser manufacturing and materials processingLaser instrumentation, PIV, thermography, micro]scale imagingSatellite imaging,Clouds, aerosols, Lidar spectroscopyMultiphoton imaging. **References/Text Books:**	RESEARCH IN PHOTONICS AND LASERS
***** Department of SPEC *****				
PE101	0-0-0--0		**Course Contents:** There are two components in this course, namely: 1. Physical exercise2. Personality Development Activities.Activities under physical exercise: First Phase of physical fitness test. Warming up exercises:jogging, running, stretching, simple exercises and specific exercises. Formal and informal games.Exercises for development of physical fitness components like: 1. Strength 2. Speed 3.Endurance 4. Flexibility 5. Coordinate Activities. Intramural Athletics Meet. Final phase ofphysical fitness test.Personality development activities: There are five streams in this component: 1. Games andsports 2. Yoga 3. NSS 4. TaeKwonDo and 5. NCC. The students have to opt for one of theabove five streams. In Games and sports, the students choose one of the following 12 sports: 1.Atheletics 2. Badminton 3. Cricket 4. Hockey 5. Table Tennis 6. Tennis 7. Football. 8.Swimming 9. Basket ball10. Volleyball11. Weightlifting 12. Squash.Fundamental skills are taught in the streams mentioned above. **References/Text Books:**	MORNING EXERCISE
PE101A	0-0-3-0-3		**Course Contents:** There are two components in this course, namely: 1. Physical exercise2. Personality Development Activities.Activities under physical exercise: First Phase of physical fitness test. Warming up exercises:jogging, running, stretching, simple exercises and specific exercises. Formal and informal games.Exercises for development of physical fitness components like: 1. Strength 2. Speed 3.Endurance 4. Flexibility 5. Coordinate Activities. Intramural Athletics Meet. Final phase ofphysical fitness test.Personality development activities: There are five streams in this component: 1. Games andsports 2. Yoga 3. NSS 4. TaeKwonDo and 5. NCC. The students have to opt for one of theabove five streams. In Games and sports, the students choose one of the following 12 sports: 1.Atheletics 2. Badminton 3. Cricket 4. Hockey 5. Table Tennis 6. Tennis 7. Football. 8.Swimming 9. Basket ball10. Volleyball11. Weightlifting 12. Squash.Fundamental skills are taught in the streams mentioned above. **References/Text Books:**	MORNING EXERCISE
PE102	0-0-0-0-0		**Course Contents:** There are two components in this course, namely: 1. Physical exercise2. Personality Development Activities.Activities under physical exercise: Warming up exercises: jogging, running, stretching,	EVENING EXERCISE

			simpleexerCises and specific exercises. Formal and informal games. Exercises for development ofphysical fitness components like: 1. Strength 2. Speed 3. Endurance 4. Flexibility 5. CoordinateActivities. Intramural activities: Group sports.Personality development activities: There are five streams in this component: 1. Games andsports 2. Yoga 3. NSS 4. TaeKwonDo and 5. NCC. The students have to opt for one of theabove five streams. In Games and sports, the students choose one of the following 12 sports: 1.Atheletics 2. Badminton 3. Cricket 4. Hockey 5. Table Tennis 6. Tennis 7. Football. 8.Swimming 9. Basket ball10. Volleyball11. Weightlifting 12. Squash.Fundamental skills are taught in the streams mentioned above. **References/Text Books:**	
PE102A	0-0-3--3		**Course Contents:** There are two components in this course, namely: 1. Physical exercise2. Personality Development Activities.Activities under physical exercise: Warming up exercises: jogging, running, stretching, simpleexerCises and specific exercises. Formal and informal games. Exercises for development ofphysical fitness components like: 1. Strength 2. Speed 3. Endurance 4. Flexibility 5. CoordinateActivities. Intramural activities: Group sports.Personality development activities: There are five streams in this component: 1. Games andsports 2. Yoga 3. NSS 4. TaeKwonDo and 5. NCC. The students have to opt for one of theabove five streams. In Games and sports, the students choose one of the following 12 sports: 1.Atheletics 2. Badminton 3. Cricket 4. Hockey 5. Table Tennis 6. Tennis 7. Football. 8.Swimming 9. Basket ball10. Volleyball11. Weightlifting 12. Squash.Fundamental skills are taught in the streams mentioned above. **References/Text Books:**	EVENING EXERCISE
***** Department of STA *****				
STA799	0-0-0--		**Course Contents:** Ph. D. Thesis **References/Text Books:**	PH.D THESIS
STA800	----		**Course Contents:** RESEARCH **References/Text Books:**	RESEARCH