# PHY602: Review of Quantum Mechanics

## Course content:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Topics</th>
<th>No. of Lecture and Tutorial Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Problem oriented review of Quantum Mechanics. Historical development of quantum mechanics, wavepackets, Schrodinger's equation, two-level systems.</td>
<td>4</td>
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<tr>
<td>2</td>
<td>Solution (analytical and numerical) of time-independent Schrodinger equation for various physically relevant potentials; angular momentum algebra, spherical harmonics. Numerical solution of the radial Schrodinger equation for arbitrary spherically symmetric potential.</td>
<td>12</td>
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<tr>
<td>4</td>
<td>Topics in (i) scattering theory, (ii) relativistic quantum mechanics, (ii) introduction to path integral formulation, (iv) identical particles. Problems of current interest, many body physics.</td>
<td>8</td>
</tr>
</tbody>
</table>

## Reference 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
## Department of Physics

### Indian Institute of Technology Kanpur

**PHY604 : Review of Statistical Mechanics**

**Course content:**

<table>
<thead>
<tr>
<th>S. No.</th>
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<tbody>
<tr>
<td>1</td>
<td>Problem oriented review of Statistical Mechanics. Review of thermodynamics: Laws of thermodynamics; thermodynamics of phase transitions and phase diagram.</td>
<td>3</td>
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<tr>
<td>2</td>
<td>Review of Ensembles and rules of calculation: Micro-canonical, canonical, grand-canonical and other ensembles; applications to models of ideal classical and quantum gases.</td>
<td>12</td>
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<tr>
<td>3</td>
<td>Models of classical interacting systems: Ising model in 1-dimension: exact solution by transfer matrix ; Peierls-Griffiths argument for Ising model in 2-dimensions; Mean-field approximation for magnets and fluids, Landau Theory, critical exponents, upper and lower critical dimensions.</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Models of quantum interacting systems: Density matrix, Transverse Ising model, exact solution by Jordan-Wigner transformation, Heisenberg model- magnons; Mermin-Wagner theorem; general theory of quantum phase transitions.</td>
<td>9</td>
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<td>5</td>
<td>Brief overview of Non-equilibrium statistical mechanics : Random walk and diffusion, Markov processes and master equation; Systems near equilibrium- Linear Response Theory, Fluctuation-Dissipation Theorem; Escape over a barrier- relaxation phenomena; critical dynamics.</td>
<td>6</td>
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<tr>
<td>6</td>
<td>Supplementary reading materials for term papers: Momentum-space Renormalization Group, Real-space Renormalization Group, Duality in Statistical mechanics, Various types of series expansions, Boltzmann equation, Molecular hydrodynamics, BBGKY hierarchy; Random and glassy systems, Linear and branched Polymers, Percolation; XY model and vortices-superfluidity.</td>
<td>N.A</td>
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</tbody>
</table>
Reference books:


Physics Department, IIT Kanpur
PHY 624 : Magnetism in Materials (2016-17-II)

Instructor: Dr. Anjan K. Gupta (off: SL217F, email:anjankg@, Ph. 7549)
Time Table: TBA, Venue: TBA
Office Hour: On appointment (by email)

Course Web page: http://home.iitk.ac.in/~anjankg/teaching/Phy624-2017.html

Detailed description (40 Lectures):

This is a first course in magnetism in order to provide a detailed background to an undergraduate/graduate student in order to understand the state of the art research in this area. A background in electromagnetism (at Phy103 level) and quantum mechanics (at Phy431/PSO201 level) is required and some exposure to thermal/statistical/condensed-matter physics is desirable. A special emphasis will be given to the nano-magnetism as significant fraction of current research is happening this area.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Topic</th>
<th>Lects.</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction: review of magneto-statics; magnetic moments and angular momentum; Bohr-van Leeuwen theorem; quantum mechanics of spin; Bohr magneton; classical mechanics of magnetic moments;</td>
<td>8</td>
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<tr>
<td>2</td>
<td>Physics of isolated magnetic moments: Diamagnetism and paramagnetism; Adiabatic demagnetization, nuclear spins, hyperfine structure</td>
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<td>3</td>
<td>Crystal fields and Magnetic resonance techniques</td>
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<td>4</td>
<td>Interactions: Dipolar and exchange interactions</td>
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<tr>
<td>5</td>
<td>Magnetic Ordering: Ferromagnetism; Antiferromagnetism; Ferrimagnetism; Spin glasses and other random orders; Nuclear ordering; Measurements of magnetic ordering</td>
<td>4</td>
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<tr>
<td>6</td>
<td>Models of magnetic ordering: Landau theory; Heisenberg and Ising models; Symmetry breaking and phase transitions; Excitations; Domain structure and magneto-crystalline anisotropy;</td>
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<tr>
<td>7</td>
<td>Magnetism in low dimensional systems: nano-particle magnetism; one and two dimensional magnets;</td>
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</tbody>
</table>

Recommended books:
2) "Introduction to magnetic materials" by Cullity and Graham, Willey 2009.

Grading: (out of 260)
Home-Works + Attendance: 50
Mid-Sem: 40 (1 hour)
End-Sem: 120
Term paper: 50
This is a PG course intended for master and doctoral students of Physics department who wishes to pursue research career in condensed matter physics.

**Course Content:**

Production of low temperature; Cryostat Design and Experimental Techniques applied to low temperature; thermometry, specific heat, transport phenomena, thermal, electrical and magnetic properties, superconductivity, application of superconductivity, superfluidity and associated phenomena.

Textbook: Matter and Methods at Low temperature. Author: Frank Pobell.

Evaluation: Attendance, Quiz, Presentation, Mid Sem Exam, End Sem Exam. Exact grading policy (relative weightage for each component) shall be announced during the first lecture of the course.

Contact: Dr. Zakir Hossain
e-mail: zakir@iitk.ac.in
The outline of the course is as follows:

- Review of basics of Quantum Field Theory
- Particle content and interactions of the Standard Model
- Phenomenology of weak interactions
- Non-abelian gauge symmetry
- Spontaneous symmetry breaking and the Higgs mechanism
- Quarks, Meson and Baryons
- Perturbative Quantum Chromodynamics

Prerequisites:

- Special relativity
- Basics of group theory
- Desirable: basics of quantum field theory (some of this will be reviewed).

Recommended reading:

- *Introduction to Elementary Particles*: D. J. Griffiths.
- *Introduction to Quantum Field Theory*: M. Peskin and D. Schroeder.

Grading scheme:

This depends on the number of registered students. If this is within manageable proportions, I would like to do the following:

- Assignments: 30%
- Project: 70% (mid-term and end term reports and a final presentation).
Course outline:

Brief introduction to the general theory of relativity, cosmological observations, Cosmological Principle, Introduction to Big Bang cosmology. Friedmann-Robertson-Walker metric, matter content of the Universe, dark matter, dark energy, Big Bang nucleosynthesis, recombination, Inflation, different models of inflation, generation of cosmological perturbations, Boltzmann equation, evolution of perturbations, anisotropies in the cosmic microwave background radiation, large scale structures, determination of cosmological parameters.

References:
- Modern Cosmology by S. Dodelson
- Cosmology by S. Weinberg
- Introduction to the theory of the early Universe, by D. S. Gorbunov and V. A. Rubakov

Pankaj Jain
PHY690J : Group Theory and Applications to Particle Physics

Instructors : Joydeep Chakrabortty, Tapobrata Sarkar

Course Contents :

1) Basics of Groups : discrete and finite groups, conjugacy classes, isomorphism and homomorphism etc. Group representations : reducible and irreducible. [8]

2) Lie Groups and Lie Algebras : generators, product representations of SU(2), Roos and Weights. SO(3) and SU(3). Quark model and the eightfold way. The method of Young's tableaux. The Lorentz group. [8]


5) Topics in current research (time permitting).

References :

Tinkham: Group Theory & Quantum Mechanics
Georgi: Lie Algebras in Particle Physics
**PHY690L: Quantum Optics**  
2016-2017, Semester -II  
Department of Physics, I.I.T. Kanpur

**Schedule**: M -11:00 -11:50, Th and F: 10:00-10:50 Hrs : VENUE : To be announced

**Scope**: This course is geared towards appreciating quantum phenomena associated with light, and its interaction with atoms. The course will revolve around experiments and develop the necessary quantum optics machinery to understand them.

**Textbooks**


**Course contents**

1. Field quantization and photon states
2. Classical and Quantum Coherence
3. Interferometers and Beam Splitters
4. Quantum Jumps
5. Nonclassical light
6. Atom field interaction
7. Reservoir and Decoherence
8. Quantum Measurement Theory
9. Cavity QED: Atoms and Ions

**Instructor:**
Harshawardhan Wanare, Office: SL-217D, Ph. 7885, Email: hwanare@iitk.ac.in
S. A Ramakrishna, Office: SL-217A, Ph. 7449, Email: sar@iitk.ac.in
Indian Institute of Technology Kanpur  
Department of Physics

**COURSE INFORMATION**  
Course number: **PHY690V**, Credits: 9 (3-0-0)  
Course title: **Photonic Devices**  
Instructor: **Prof. R. Vijaya**  
Pre-requisites: Background of Electromagnetic theory (as decided by the instructor)

**COURSE OVERVIEW**  
The course aims at providing the knowledge base of modern photonic devices through an in-depth analysis of the underlying physical concepts and the necessary discussions on technological challenges. The course is targeted at the students who are inclined towards practical aspects of photonics along with the basics.

**COURSE HIGHLIGHTS**  
* Strong emphasis on the theoretical basics of Photonics  
* Introduction to modern photonic technologies  
* Sufficient importance to active and passive photonic devices  
* Discussion on practical aspects and challenges in characterization

**COURSE CONTENTS**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Broad theme</th>
<th>Contents</th>
<th>Lectures (of 50 min. duration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Light-matter interaction – a review</td>
<td>Maxwell’s equations, wave equation, dispersion in dielectrics, interference and diffraction</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Periodic structures as optical devices</td>
<td>Optical multi-layers, diffraction gratings, photonic crystals</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Fiber optic devices</td>
<td>Modal theory, devices for wavelength-, direction- and polarization-selectivity, Bragg gratings</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Integrated-optic devices</td>
<td>Coupled-mode theory, waveguides and couplers in silicon platform</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Light source</td>
<td>Semiconductor laser physics</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Electro-optic and optoelectronic devices</td>
<td>Modulators, photodetectors and solar cells</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Novel devices</td>
<td>Plasmonic sensors, slow light devices</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Device characterization</td>
<td>Measurement techniques related to time- and spectral-domain</td>
<td>5</td>
</tr>
</tbody>
</table>

**Short summary for including in the Courses of study booklet:**  
Light-matter interaction – a review, periodic structures such as Bragg reflectors, gratings and photonic crystals, fiber-optic devices, integrated-optic devices, active devices, sensors, measurement and characterization techniques.

**Recommended books:**
2. R. Menzel, Photonics, Springer (2001)
Introduction to Spintronics: PHY693
Instructor: Tarun Kanti Ghosh

Objectives: This course is systematically developed from basic principles to an advanced level including spin-based device applications. We will introduce the essential theoretical formalism at an accessible level with illustrations of experimental results. It will be presented in a comprehensive but rigorous way. This course will be useful for PG as well as advanced UG students.

Course Contents:


- Review of Condensed Matter Physics: Low-dimensional electron/hole systems (two-dimensional electron/hole systems, quantum dots and quantum wires), Boltzmann transport equation, Quantum Hall effect, Heisenberg exchange interaction, Heisenberg and Stoner-Wohlfarth models of ferromagnetism.


- Spin Relaxation: D’yakonov-Perel’ mechanism, Elliott-Yafet mechanism, Bir-Aronov-Pikus mechanism and hyperfine interactions with nuclear spins, Spin galvanic effect, Spin relaxation in a quantum dot.

- Spin Transport in Solids: The drift-diffusion model for charge and spin, Spatial and temporal decay of spin polarization, Spin injection, Spin accumulation, Spin diffusion, Spin extraction, Spin relaxation length and time, Spin Hanle effect.

- Spin-based Devices: Spin valves, Spin filters, Magnetic tunnel junction, Giant magnetoresistance (GMR), Spin transfer torque, Spin field effect transistor (SPINFET), Topics on recent achievements in the field.

Text Book and References:

- Introduction to Spintronics by S. Bandyopadhyay and M. Cahay, CRC Press, 2008