# Indian Institute of Technology Kanpur
# Proposal for New Courses

## Course: Intelligent Control Systems

**1. Course No:**

**2. Course Title:** Intelligent Control Systems

**3. Per Week Lectures:** 3 (L), Tutorial: 0 (T), Laboratory: 1 (P), Credits (L+T+P+A): 9

**4. Duration of Course:** Full Semester

**5. Proposing Department/IDP:** Department of Intelligent Systems

**Other Departments/IDPs interested:** Aerospace Engineering, Electrical Engineering, Mechanical Engineering, Computer Science and Engineering

**6. Proposing Instructor(s):** Prof. Salahudden

**7. Course Description**

***A) Objectives***

This course introduces modern intelligent control methodologies integrating classical and modern control approaches, adaptive systems, and Artificial Intelligence techniques for aerospace, robotic, and industrial applications.

***B) Contents***

| S. No | Broad Title | Topics | No. of Lectures |
|---|---|---|---|
| 1 | Introduction to Intelligent Control | Evolution of control systems<br>Overview of intelligent systems<br>Aerospace and robotics applications | 2 |
| 2 | System Modeling and Dynamics | Coordinate systems and reference frames<br>Modeling of system (spring-mass-damper)<br>Modeling of system (LRC circuit)<br>Modeling of system (inverted pendulum)<br>System dynamics linearization<br>Transfer function representation<br>State-space representation<br>First and second order system (solution and response analysis)<br>Open and closed loop systems<br>Stability and control relation | 6 |
| 3 | Classical Control | Time-domain and frequency-domain representation of control systems | 6 |

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|---|---|---|---|
| | | Introduction to different control techniques<br>Proportional, derivative and integral (PID) controller<br>Classical control design approach<br>(bode plot, root locus, Nyquist and Nichols)<br>Controllability and observability<br>Pole placement controller design<br>Control gain estimation<br>Control gain tuning (heuristic approach) | |
| 4 | Modern Control | Linear quadratic regulator (LQR)<br>Linear quadratic Gaussian (LQG)<br>Model predictive control (MPC)<br>Adaptive control (AC)<br>Sliding mode control (SMC)<br>Nonlinear dynamic Inversion (NDI)<br>Incremental nonlinear dynamic Inversion (INDI) | 8 |
| 5 | AI for Intelligent Control | Neural Networks (NN) for system identification and disturbance rejection<br>Reinforcement Learning (RL) for autonomous guidance and decision making<br>Gaussian Process Regression (GPR) for uncertainty estimation<br>Intelligent fault detection<br>AI-assisted trajectory optimization<br>Vision-based navigation and target tracking concepts<br>Hybrid AI + classical control architecture | 6 |
| 6 | Applications and Case Studies | UAV flight control simulations<br>Autonomous waypoint navigation<br>Dive-phase guidance and control simulation<br>Vision-based target tracking using pan–tilt systems<br>Quadrotor stabilization and trajectory tracking<br>Disturbance rejection under wind, gusts, turbulence<br>Comparative analysis of different controllers<br>Industrial robotics motion-control | 8 |

MATLAB/Simulink, ROS2/Gazebo, and PX4 simulation exercises will be included.

***C) Pre-requisites***

Basic Control Systems and Engineering Mathematics.

***D) Short Summary for Course Booklet***

An interdisciplinary course introducing intelligent control systems integrating modern control, AI-assisted control, and aerospace/robotics applications.

**8. Recommended References**

1. Katsuhiko Ogata, Modern Control Engineering, 5th Edition, Prentice Hall, Upper Saddle River, New Jersey, 2010.

2. Randal W. Beard and Timothy W. McLain, Small Unmanned Aircraft: Theory and Practice, Princeton University Press, Princeton, New Jersey, 2012.
3. Russell, S. J., and Norvig, P., Artificial Intelligence: A Modern Approach, 4th ed., Pearson, 2020.
4. Kim, P., *MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence*, Apress, Berkeley, CA, 2017.
5. Slotine, J.-J. E., and Li, W., Applied Nonlinear Control, Prentice Hall, Englewood Cliffs, NJ, 1991.
6. Tewari, A., *Modern Control Design with MATLAB and SIMULINK*, Wiley, Chichester, U.K., 2002.
7. Brian L. Stevens, Frank L. Lewis, and Eric N. Johnson, Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems, 3rd Edition, Wiley, Hoboken, New Jersey, 2015.
8. Paul Zarchan, Tactical and Strategic Missile Guidance, 7th Edition, American Institute of Aeronautics and Astronautics (AIAA), Reston, Virginia, 2012.

**9. Any other Remarks**

Evaluation Procedure

- 10% Assignments
- 30% Project Work
- 20% Mid Semester Examination
- 40% End Semester Examination

Dated: 21.05.2025

Proposer: Prof. Salahudden

Dated:

DUGC/DPGC Convener:

**The course is approved / not approved**

**Chairman SUGC/SPGC:**

**Dated:**