

6th Semester	REL5C001	Control System	L-T-P 3-0-0	3 Credits
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Module I: **(5 hours)**

Industrial Control examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time-invariant systems. Feedback Control: Open-Loop and Closed-loop systems. Benefits of Negative Feedback. Block diagram algebra. Signal Flow Graph and Mason's Gain formula.

Module II: **(10 hours)**

Standard test signals. Time response of first and second order systems for standard test inputs. Application of initial and final value theorem. Design specifications for second-order systems based on the time-response. Concept of Stability. Routh-Hurwitz Criteria. Relative Stability analysis. Root-Locus technique. Construction of Root-loci.

Module III: **(7 hours)**

Relationship between time and frequency response, Polar plots, Bode plots. Nyquist stability criterion. Relative stability using Nyquist stability criterion – gain and phase margins. Closed-loop frequency response: Constant M Circle, Constant N Circle, Nichols Chart.

Module IV: **(10 hours)**

Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Tuning of PID controllers, Lead and Lag and Lag-Lead compensator design.

Module V: **(10 hours)**

Concepts of state variables. State space model. Diagonalization of State Matrix. Solution of state equations. Eigenvalues and Stability Analysis. Concept of controllability and observability. Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

Books:

- [1] I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009.
- [2] K. Ogata, "Modern Control Engineering", Prentice Hall, 1991
- [3] M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, 1997.
- [4] B. C. Kuo, "Automatic Control System", Prentice Hall, 1995.

Digital Learning Resources:

Course Name: Control System Engineering
 Course Link : <https://nptel.ac.in/courses/108/102/108102043/>

Course Instructor : Prof. M Gopal, IIT Delhi