

<b>5<sup>th</sup> Semester</b>	<b>REL5C002</b>	<b>Control System</b>	<b>L-T-P 3-0-0</b>	<b>3 Credits</b>
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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 criterion – gain and phase margin. 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 compensation in designs.

**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