II Year II Semester **L T P C**

Code: 20EE4006 **3 0 0 3**

CONTROL SYSTEMS

Preamble: To provide an introduction and practice of control systems engineering. The knowledge emphasizes the practical application of the subject to the analysis and design of feedback control systems.

Course Objectives: At the end of the course, the students are supposed to

1. Develop a mathematical model of Linear Time-Invariant (LTI) systems either by using transfer function/ state-space approach.
2. Analyse the time and frequency response of the LTI system and predict the absolute, asymptotic and relative stability of the system.
3. Design a controller for the given LTI system to meet the desired time/frequency-domain specifications
4. Justify whether the given state-space representation of an LTI system is controllable/stabilizable.

Course Outcomes: At the end of the course, the students are able to

1. Determine the transfer function/state-space model for linear time-invariant (LTI) electrical, mechanical and electro-mechanical systems by extracting their differential equations
2. Illustrate the second-order LTI system time and frequency responses and anticipate their stability based upon the characteristics and specifications
3. Design a classic compensator/controller to improve the dynamic performance of the LTI system
4. Analyze the state-space models of an LTI system and justify their suitability towards the compensator design.

CO – PO & CO – PSO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 2	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-
CO 3	3	-	1	-	-	-	-	-	-	-	-	-	-	2	-
CO 4	3	1	-	-	-	-	-	-	-	-	-	-	-	2	-

1 – Weak, 2 – Moderate and 3 – Strong

Unit – I: Introduction to control systems and mathematical modelling **14 Hours**

System &Control Systems, Classifications of control systems, Types of feedback control systems, Industrial control system examples, Control components and their models: Potentiometers, Synchro's, Servo motors, Magnetic and Servo Amplifiers.

Transfer function, modelling of electrical, mechanical & electro-mechanical systems, systems representing in the block diagram, signal flow graph and their reduction properties.

Unit – II: Time response and Stability analysis of dynamical Systems 14 Hours

Standard Test Signals, Time response of the first and second-order system, Steady-state errors and error constants for different test signals, Transient response of a standard second-order system and its performance specifications.

BIBO Stability, Zero-input and Asymptotic Stability, Routh-Hurwitz Criterion, Root-Locus Technique and Construction of Root-Loci

Unit – III: Frequency response analysis 10 Hours

Frequency domain specifications, Stability analysis using the Bode plots, Polar and Nyquist Plots. Nyquist Stability Criterion. Correlation between the time and frequency response specifications.

Unit – IV: Introduction to controller design in frequency-domain 12 Hours

Effect of adding Poles and Zeros to the system transfer function, Error analysis of P, PI, PD, PID controllers. Lead Compensator, Lag Compensator, Lag-Lead Compensator, Design of compensators using Root-locus approach and Bode plot.

Unit – V: Introduction to state space analysis 10 Hours

State-Space modelling of physical systems, Significance of state-space representation, Correlation between transfer function and state-space models, Diagonalization of State Matrix, State transition matrix: significance and properties, Solution to state equations, Controllability and Observability. Principle of duality.

Text Books:

1. *Benjamin C. Kuo*, Farid Golnaraghi., Automatic Control Systems, Prentice-Hall of India Pvt Ltd., New Delhi, 6th edition.
2. Ogata K., Modern Control Engineering, Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition.
3. M. Gopal, "Control Systems: Principles and Design", Tata McGraw Hill, 3rd Edition.
4. Nagrath I.J and Gopal M, "Control Systems Engineering", New Age Publishers, 5th Edition, 2009.

Reference Books:

1. Norman S. Nise, "Control System Engineering", John Wiley & Sons, 6th Edition.
2. Dorf, R.C and Bishop, R.H, "Modern Control Systems", Addison-Wesley, 12th Edition, 2011.