

## EE427 ADVANCED CONTROL SYSTEMS (Dept. Elective - IV)

### **Course Description & Objectives:**

*This course deals with state space, describing function, phase plane and stability analysis including controllability and observability. It also deals with modern control and optimal control systems.*

### **Course Outcomes:**

- I Able to formulate state space models of physical systems and analysis
- I Able to analyze non linear control systems.
- I Able to understand the stability and methods for non linear systems.
- I Able to Design controllers and optimal control systems.

### **UNIT I - State Space Analysis:**

State Space Representation, Solution of State Equation, State Transition Matrix, Canonical Forms – Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form.

Controllability and observability : Tests for controllability and observability for continuous time systems – Time varying case, minimum energy control, time invariant case, Principle of Duality, Controllability and observability form Jordan canonical form and other canonical forms.

### **UNIT II - Methods of Analysis:**

**Describing Function Analysis:** Introduction to nonlinear systems, Types of nonlinearities, describing functions, describing function analysis of nonlinear control systems.

**Phase-Plane Analysis:** Introduction to phase-plane analysis, Method of Isoclines for Constructing Trajectories, singular points, phase-plane analysis of nonlinear control systems.

**UNIT III - Stability Analysis:**

Stability in the sense of Lyapunov., Lyapunov's stability and Lyapunov's instability theorems. Direct method of Lyapunov for the Linear and Nonlinear continuous time autonomous systems.

**UNIT IV - Modal Control:**

Effect of state feedback on controllability and observability, Design of State Feedback Control through Pole placement. Full order observer and reduced order observer.

**UNIT V - Optimal Control:**

**Calculus of Variations:** Minimization of functionals of single function, Constrained minimization. Minimum principle. Control variable inequality constraints. Control and state variable inequality constraints. Euler Lagrangine Equation.

**Optimal Control:** Formulation of optimal control problem. Minimum time, Minimum energy, minimum fuel problems. State regulator problem. Output regulator problem. Tracking problem, Continuous-Time Linear Regulators.

**TEXT BOOKS:**

1. Modern Control System Theory – by M. Gopal, New Age International Publishers, 2<sup>nd</sup> edition, 1996
2. Modern Control Engineering – by K. Ogata, Prentice Hall of India, 3<sup>rd</sup> edition, 1998

**REFERENCE BOOKS:**

1. Control Systems Engineering by I.J. Nagarath and M.Gopal, New Age International (P) Ltd.
2. Digital Control and State Variable Methods – by M. Gopal, Tata Mc Graw-Hill Companies, 1997.
3. Systems and Control by Stainslaw H. Zak , Oxford Press, 2003.