**ELE 375.3 Control Systems (3-1-2)**

| | Theory | Practical | Total |
|---|---|---|---|
| Sessional | 30 | 20 | 50 |
| Final | 50 | - | 50 |
| Total | 80 | 20 | 100 |

**Course Objectives :**

1. To provide knowledge of feedback Control Principles.
2. To design and implement PID control system.

**Course Contents :**

**1. Concept of Control System** **(3 hrs)**

Introduction to control system, History of automatic control system, Open-loop and closed-loop control system (feedback control systems), Human control system, Effect of feedback on gain, System stability and sensitivity, External noise to the system, Types of feedback control system, Liner versus non-linear and Time-invariant versus Time-variant systems.

**2. Mathematical Modeling of Physical System** **(4 hrs)**

Complex variables and the s-plane, poles and zeros locations and their significance, Differential equations of physical systems, Classical and Laplace transforms methods in solutions of differential equations, Modeling of electrical and mechanical system elements, Modeling of thermal, Fluid and fluidic component, Mixed systems modeling, Sensors, Encoders and DC Motors in control system, Linearized approximations of non-linear characteristics.

**3. System Transfer Functions and Responses** **(5 hrs)**

Combinations of components to physical systems, Block diagram and SFG algebra, Impulse response and transfer function of linear single-input single-output systems and multivariable systems, Laplace transform analysis of systems with standard input functions-steps, Ramps, Impulses, Sinusoids, Initial and final steady-state equalibria of systems, Principles and effects of feedback on steady-state gain, Bandwidth, Error magnitude, Dynamic responses, Decomposition of transfer functions.

4. **State-Variable Analysis** **(4 hrs)**

Vector-matrix representation of state equations, State transition matrix and equations and their relationships with higher order differential equations, State-space Formulation of a system, Relationship between state equations and transfer functions, Characteristic equation, Eigenvalues and eigen vectors.

5. **Stability** **(4 hrs)**

Heuristic interpretation of the conditions for stability of a feedback system, BIBO, Characteristic equation, Complex plane interpretation of stability, Root locations and stability, Routh-Hurwitz criterion, Eigenvalue criterion, Setting loop gain using the R-H criterion, Relative stability from complex plane axis shifting, Stability test, BIBO, Zero-input.

6. **Time-Domain Analysis of Control Systems** **(5 hrs)**

Time response of continuous system, Unit-step response and time-domain specifications, Steady-state error, Transient response of second order system, Time-domain analysis of a position-control system, Effects of adding poles and zeros on transfer function, Dominant poles of transfer function.

7. **Root Locus Technique** **(6 hrs)**

Relationship between Root-Loci and time responses of systems, Rules for construction of Root-Loci diagrams, Computer solutions for Root-Loci plotting, Polynomial root finding and repeated eigenvalue methods, Derivative feedback compensation design with Root-Locus, Setting controller parameters using root locus, Parameter change sensitivity analysis by root locus method.

8. **Frequency Domain (Response) Method** **(5 hrs)**

Frequency domain characterization of systems, Relationship between real and complex frequency response, Bode amplitude and phase plots, Effects of time constants on Bode plot, Stability analysis from the Bode plot, Correlation between Bode plots and real time response : gain and phase margins, Damping ratio, Effets of adding poles and zeros on frequency response, Nyquist stability criterion with minimum phase transfer function, Correlation between Nyquist diagrams and real time response of systems : stability, Relative stability, Gain and phase margin, Damping ratio, The Nichols chart and its application, Sensitivity studies.

9. **Control System Simulation Using MATLAB* and TUTSIM(2 hrs)**

Role of simulation, Linear and non-linear simulations, MATLAB and TUTSIM as a simulation tools.

10. **Performance Specifications for Control Systems (2 hrs)**

Time domain specifications : steady state errors, Response rates, Error criteria, Hard and soft limits on responses, Damping ratio, Log decrement, Frequency domain specifications : Band width, Response amplitude ratio.

11. **Design of Control System (5 hrs)**

Application of Root-Locus, Frequency Response and computer simulation in control system design, Meeting steady-state error criteria, Feedback compensation, Lead, Lag, and Lead-lag compensation, Design of PID controllers, Pole-Zero cancellation design of Robust control system, Forward and feed forward controllers.

*** With Control System Toolbox.**

**Laboratory :**

1. Identification of control system components
   - establish transfer function and block diagram of a servo system for position and velocity control.
2. Open and closed loop performance of servo position control system
   - check effects of loop gain on response
   - compare results with theory
3. Open and closed loop performance of servo velocity control system

- check effects of loop gain on response
- compare results with theory

4. Simulation study of feedback system using TUTSIM
   - simulation model of a servo system using TUTSM
5. Design a PID controller
   - design of a PID controller for position control servo
   - verify design with TUTSIM
6. Non-electrical control system
   - study of a hydraulic or pneumatic servo system

**Text Books :**

1. K. Ogata, *Modern Control Engineering,* 2nd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1990.
2. B. C. Kuo, *Automatic Control Systems,* Prentice Hall of India.