

Required Course	EE-432 Control Systems (3-1)
Catalog Description:	Credit 4, Class 2. Continuous-time system description (the feedback concept and modeling, transfer functions and stability, block diagrams, signal flow graphs), Continuous-time system response (response of first-order systems, response of second-order systems, higher-order system response, stability testing, parameter shifting), Performance Specification (analyzing tracking systems, forced response, power-of-time error performance, time-domain compensation), Root locus analysis (pole-zero plots, root locus for feedback systems, root locus construction, design concepts), Root locus design (second order plant models, different fixed structure compensations, pole placement and algebraic compensation, fixed-structure pole placement, robust control), Frequency response analysis (frequency response computation, Bode plots, Nyquist methods, gain margin, phase margin), Frequency response design (relationship between root locus, time domain and frequency domain, compensation using bode plots, design of fixed-structure compensations), State-space analysis (state space representation, state transformations and diagonalization, eigen values and eigen vectors, time response from state equations, controllability and observability), State-space design (state feedback control and eigen value placement, tracking problems, integral control, trajectory pre-shaping filter, observer design, reduced-order observer design), Digital control (computer processing, A/D and D/A conversion, discrete-time signals, sampling, reconstruction of signals from samples, stability, controllability and observability).
Prerequisite:	EE-112 Network Analysis, BS-132 Mathematics-II, BS-242 Mathematics-IV. Course assumes a working knowledge of MATLAB®.
Corequisite:	Nil
Text Books:	R. T. Stefani, C. J. Savant, B. Shahian and G. H. Hostetter, Design of Feedback Control Systems, 4 th Edition, Saunders College Publishing.
Reference Books:	1. R. C. Dorf, R. H. Bishop, Modern Control Systems, Prentice-Hall, 2001 2. G. Franklin, J.D. Powell, A. E. Naeini, Feedback Control of Dynamic Systems, Prentice Hall, 2006 3. N. S. Nise, Control Systems Engineering, John Wiley & Sons Inc, 2004 4. K. Ogata, Modern Control Engineering, Prentice Hall, 2002
Course Objectives:	<i>To familiarize students with the:</i> <ol style="list-style-type: none">1. Subject that sits in the roots of industrialization and automation.2. Underlying knowledge of the classical and modern systems and control theories both.3. Concepts in systems modeling and the classical tools used therein, understanding the modeling procedures for systems in different domains, analysis procedure and thereof categorizing a system's natural and forced response.4. Use of control system analysis and design program to evaluate the performance of a feedback control system.5. Classical tools of root locus and frequency domain analysis and employing them for a control system analysis and design.6. Modern time domain tools for analysis and design of control systems.
Course Outcomes:	<i>After completion of this course students should be able to:</i> <ol style="list-style-type: none">1. Understand and visualize how systems work and how they are modeled. [a, d, k]2. Develop working knowledge of open-loop and closed-loop control. [b, c]3. Understand concepts of natural and forced response in control systems. [b, c]4. Evaluate the closed-loop stability and performance of a system. [c, e]5. Design controllers for different transient and steady-state behaviors. [c, e]6. Identify and compare different control techniques. [c, e]7. Work in a team to analyze an industrial organization and develop a comprehensive report. [d, g]

Topics:

1. Systems and modeling (05 Periods)
 - a. Linear systems and differential equations
 - b. Laplace transform and transfer functions
 - c. The feedback concept
 - d. Open-loop versus closed-loop
 - e. Mathematical modeling of system
 - f. Block diagram and signal flowgraphs
 - g. Routh Hurwitz stability testing
2. Continuous-time system analysis (10 Periods)
 - a. Special inputs and responses (impulse, step, ramp, sinusoidal)
 - b. First-order systems (time constant, final value)
 - c. Second-order systems (under-damped, critically-damped and over-damped responses)
 - d. Higher order systems and order reduction
 - e. Steady state errors and system type
 - f. Input tracking and disturbance rejection
 - g. Design specifications (tracking performance, disturbance rejection, noise reduction, reduced sensitivity to parameter variations)
3. Root locus analysis and design (08 Periods)
 - a. The concept of root locus
 - b. Rules for sketching root locus plots
 - c. Performance and stability analysis using root locus
 - d. Design of fixed structure compensators like PI, Lag, Lead, Lag-Lead, Rate Feedback and PID through root locus
 - e. Algebraic compensations, pole placement, fixed structure pole placement designs
4. Frequency response analysis and design (06 Periods)
 - a. Frequency response of linear systems
 - b. Performance specification in frequency domain
 - c. Nyquist methods for frequency domain analysis
 - d. Stability analysis in frequency domain
 - e. Bounded Input-Bounded Output (BIBO) stability
 - f. Gain and phase margins
 - g. Design of different fixed structure compensations in frequency domain
5. State space analysis and design (10 Periods)
 - a. State variable representation of dynamic systems
 - b. Time response and state transition matrix
 - c. Concepts of controllability and observability
 - d. State feedback control and pole placement
 - e. Integral control
 - f. Advanced state-space concepts
6. Digital control (06 Periods)
 - a. A/D and D/A conversion
 - b. Discrete-time signals, sampling, reconstruction of signals from samples
 - c. Stability, controllability and observability

Evaluation Methods: Projects, quizzes, assignments, two sessional examinations, and one final exam.

Professional Component: Systems Engineering, Feedback Control Systems' Design

Prepared by: Dr. Khalid Munawar

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