MECH3610 Control Principles

Course Code: MECH 3610	**Course Title:** Control Principles
Required Course Or Elective Course: Required	**Terms Offered (Credits):** Fall, 3 credits
Faculty In Charge: Lilong Cai	**Pre/Co-Requisites:** MECH2030

Course Structure: Lecture/Tutorial/Laboratory Mix / Lecture (3),Tutorial(1), Laboratory (1)

Textbook/Required Material:

TEXTBOOK:

Modern Control Systems - Richard C. Dorf and Robert H. Bishop - 11th Edition, Pearson (previously Prentice Hall) [ISBN: ISBN-13: 9780132270281]

References:

Modern Control Engineering, - Ogata, K., Prentice-Hall.

Automatic Control Systems, Benjamin C. Kuo and Farid Golnaraghi, 8th edition, Prentice Hall

Course Description:

Analysis of systems using the Laplace transform method and transfer functions, block diagrams and signal flow graphs; Feedback control system characteristics; The performance and stability of feedback systems using root locus and frequency response methods; Time domain analysis of control systems; design and compensation of control systems.

Course Topics:

1. Introduction to control systems - overview of control systems applications, objectives of feedback control, need for modeling
2. Modeling - differential equations, nonlinear models and linearization, Laplace transform and transfer functions, Block-diagram manipulation, signal-flow graphs and Mason's gain formula
3. Introduction to the state-space approach - state-variable models, canonical forms, solution of the state-equation, relationship to input-output models via the transfer function, stability, controllability/observability and their role in state/output feedback
4. Introduction to feedback in LTI systems - sensitivity reduction & disturbance rejection, modifying system dynamics/transient response; the cost of control; performance limitations - the effect of nonminimum-phase zeros and the "waterbed effect"
5. Characterizing system performance - transient and steady-state response analysis, second order systems, time-domain specs (percent overshoot, settling time and rise-time), effects of adding third pole and a zero and further generalizations on system response; the relationship of steady-state error to the "system type"
6. Stability Analysis of Linear Systems : Types of stability, The Routh-Hurwitz Criterion, Relative stability, Design examples
7. The root-locus technique and its application to system stability and parametric sensitivity analysis
8. The frequency response - steady-state response to sinusoidal excitation, Nyquist and Bode plots, applications of the frequency response to analysis of system stability (the Nyquist criterion), relating the frequency response to transient performance specifications
9. Controller design - and P/PI/PID controllers using both the root-locus and frequency response.

Course Objectives:	This module aims to introduce concepts of modelling and control design for engineering systems. The approach is to present an engineering methodology that, while based on mathematical fundamentals, stresses

	physical systems modelling and practical control systems design with realistic system specifications. It aims to study the performance, characteristics and advantages of feedback control systems, and to introduce control design techniques based on steady state and transient response specifications. 1. Understand the difference between open-loop and closed-loop (feedback) control systems and understand both the advantages and limitations of feedback control. 2. Understand the utility of the Laplace transform and transfer functions for modeling a variety of electrical, mechanical and electro-mechanical systems. 3. Understand the relationship of the poles (and zeros) of a system's transfer function to its response, including classical time-domain transient performance specifications such as overshoot, rise-time, and settling-time. 4. Understand the relationship of a system's poles to its stability; and stability analysis using the Routh-Hurwitz test, and the root-locus and the Nyquist plot. 5. Understand the utility of the frequency-response of a system in both analysis and design; relate time-domain specifications to requirements on the frequency response, including the phase margin, gain crossover frequency etc. 6. Design P/PI/PID controllers using the root-locus and frequency-response (Bode plot) techniques.
Course Outcomes:	On successful completion of this course, students are expected to be able to: A. Explain the fundamental concepts, terminology and purpose of control engineering. B. Compose dynamic, continuous time mathematical models of various physical systems using differential equations and Laplace transform methods. C. Analyze the time domain transient and steady state response of zero, first and second order systems. D. Assess the stability of closed loop systems by means of the root location in s-plane and their effects on system performance. E. Design controllers to modify the response of negative feedback control loops to meet criteria using analytical and graphical methods in the time and Laplace domains. F. Apply PID control.
Assessment Tools:	Regular homework 15% Laboratory 5% Mid and final examinations 80%