ELEC 3500 CONTROL SYSTEMS (3) Analysis of closed-loop control systems using state variable techniques, frequency response, and root locus. Stability analysis of transfer functions and state variable systems. Discrete-time systems design. System modeling, identification, and control design based on analytic and computer methods.

- **Course Objectives**
    - To provide students with basic background in Linear Feedback Control Systems analysis and design.
    - To train students in the use of MATLAB for *system design and simulation* for the workplace.
    - To understand tools for system analysis including *differential equations*, *transfer functions*, and *state variable systems*.
    - To provide an introduction to basic analysis and design methods in *state variable systems*.
    - To lay the foundations of classical control design including *root locus*, *Bode plots*, *stability* and system properties.

Class hours: Mon Wen Fri 9am-950am, Broun Hall 125

Instructor: Dr. Bosen Lian

Office hours: Wen Fri 950am-1150am, Broun Hall 221

Grader/GTA: TBD

Suggested Textbook: Feedback Control of Dynamic Systems, by Franklin, Powell, and Emami-Naini, 7th edition.

Student Edition of Matlab, windows version

Also recommended: Schaum's Outline in Feedback Control

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HW/Exam

Homework/Exam	Topic	**Assigned**	**Due Date**
HW 1	Simulation, MATLAB, System Response		
HW 2	Block Diagrams, System Response		
HW 3	State Variables and Block Diagrams		
Exam 1			
HW 4	Feedback Design and Steady-State Error		
HW 5	Optimal Control, Discretization of Controllers		
HW 6	Root Locus and Bode Design		
Exam 2			

Grading Policy:

Homework	50%	
Exam I	20%	(1 sheet both sides)
Exam II	30%	(2 sheets both sides)

Rubric: Detailed solutions for each homework assignment, including the corresponding mark allocations, will be provided. If solutions are not available, please refer to the rubric outlined below. When solutions are provided, prioritize them over the rubric for reference.

One week to discuss the grading if any problem.

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COURSE OUTLINE

Updated: August 14, 2025

History of Control Systems

PART I- ANALYSIS AND SIMULATION OF DYNAMICAL SYSTEMS

- State variable systems
  - nonlinear state equation
  - linear state equation
- Computer simulation of nonlinear dynamical systems
  - MATLAB review on Mathworks website
  - MATLAB tutorial - M file (by Steve Scully)
- MATLAB simulation
  - ODE
  - State phase-plane plots
- Review of Linear Systems
  - Laplace transform and properties
  - Inverse Laplace transform and PFE
  - Transfer function, poles, zeros, impulse response, step response
  - Second-order systems
  - Dominant mode design and nonminimum phase systems
  - Block diagram and Mason's Formula
- System Identification based on step response and impulse response
- State variable analysis
  - frequency response and transfer function
  - time response
  - Relative degree and zeros of state-space systems
  - Realization and canonical forms
- Stability of Linear Systems
  - Stability of Input/Output Systems
  - Routh-Hurwitz stability test
  - Stability of State-Variable Systems

Exam I

PART II- DESIGN OF FEEDBACK CONTROL SYSTEMS

- Feedback Control Systems
  - Stabilization
  - Pole Placement
  - Disturbance Rejection
  - Steady-State Error

- *Not covered but good for more review*
  - *Closed-loop systems and return difference*
  - *Sensitivity*
  - *disturbance rejection*
  - *Using feedback to position the poles*
  - *Steady-state error and system type*

- State-variable feedback
  - Reachability
  - Ackermann's Formula for Pole Placement
  - Linear quadratic regulator
- Discrete-time systems and digital control design
  - Z-Transform basics and Difference equations
  - Digital design by discretization of continuous-time controllers
  - Digital PID controller
- Root locus design
  - Computing magnitude and phase of rational complex functions
  - Root locus design technique
  - RL Examples
  - PID/lead/lag controllers
  - Rate loop/position loop design
- Bode design
  - Bode plot rules of thumb
  - Bode plot performance specifications
  - Phase lead design of compensator using Bode plot
- Nyquist design

Exam II