ME 455

Sample Syllbus

AUTOMATIC CONTROL SYSTEMS

COURSE SYLLABUS

Spring 2025

LECTURES: Delivered *in person*
Time: **Mo/We/Fr** 11:15AM - 12:05PM
Location: Hammond Bldg 307

INSTRUCTOR: **Dr. Bo Cheng**
Office: 228 Reber BLDG
E-mail: buc10@psu.edu
Office Hours: **Mo/We** 2:30 PM – 03:30 PM
or by appointment.
I can also address short questions after each lecture

GPT ASSISTANT:

ControlMaster *Link*
Office Hour: 24/7
Please only ask questions related to this course or control theory

REFERENCES: [1] Class notes *(Unfilled and filled notes will be posted in CANVAS before and after the lectures, respectively)*
[2] *Feedback Control of Dynamic Systems*, G.F. Franklin, J.D. Powell, and A. Emami-Naeini, Prentice-Hall, Inc., 5th Ed., 2006.
[3] *Feedback systems: an introduction for scientists and engineers,* K.J. Aström and R.M. Murray, Princeton University Press, 2010. Free Online Version
[4] *Automatic control systems,* F. Golnaraghi and B.C. Kuo, Wiley, 9th Ed., 2009.

READING MATERIALS:
Additional reading materials on each topic from the references will be posted in Angel.

PREREQUISITES: ME 370 and ME 450

COURSE DESCRIPTION:
This course covers classical analysis and design tools for linear feedback control systems, with an emphasis on the frequency domain techniques. By first comparing open-loop and closed-loop feedback control systems, we will illustrate, through simple examples, the advantages of feedback on improving reference tracking accuracy, disturbance rejection and robustness to modeling uncertainties. Next we will review the basics of feedback control systems including transfer functions, dynamic response, stability notions, sensitivity, steady-state error and system type. We will then provide a through treatment of feedback controller design via root-locus and frequency-domain tools (e.g., Bode plots and Nyquist plots), with the focus on the designs of lead/lag compensation and PID controller. In this process, the notions of gain-phase relationship, Nyquist stability criterion, gain and phase margins, and robust stability will be discussed.

COURSE OBJECTIVES:

1. Provide a thorough understanding of characterization of dynamic systems for analyzing, predicting and specifying the performance of a dynamic system.
2. Provide a basic understanding of feedback control theory
3. Provide a thorough treatment of classical feedback controller via root locus method.
4. Provide a thorough treatment of classical feedback controller in frequency-domain.

COURSE OUTCOMES: AFTER COMPLETING THIS COURSE, STUDENTS SHOULD BE ABLE TO:

1. Obtain the basic understanding of feedback control on improving reference tracking accuracy, disturbance rejection and robustness to modeling uncertainties.
2. Characterize the behavior and performance of LTI systems using transfer function.
3. Perform stability analysis and estimate steady-state tracking errors.
4. Understand and sketch root locus for low-order systems.
5. Understand the objectives and functions of proportional (P), integral (I) and derivative (D) feedback control.
6. Design lead/lag compensator and PID controller via root locus.
7. Understand Bode plot and identify gain margin and phase margin.
8. Understand Nyquist plot and Nyquist Stability Criterion, and identify gain margin, phase margin and stability margin.
9. Design lead/lag compensator and PID controller to meet both time- and frequency-domain specifications, including robustness criterion on phase and gain margins.

GRADING POLICY:

Homework (*Students work individually)*	50%
Class Participation (TopHat)	15%
Middle Term Practice (Participation)	2.5%
Final Practice (Participation)	2.5%
Computer Project (*2 students work as a group, one report needs to be submitted from each group*)	30%

HOMEWORK POLICY:

Homework is to be on the day it is due. *No late homework will be accepted*. Since assigned homeworks are an integral part of transferring course content to students, they are to be an **individual** effort (working together is encouraged, but homework solutions should be written up independently). Homework regrades must be requested in writing within one class period after its original return.

QUIZZES (CLASS PARTICIPATION):

Throughout the semester, there will be a series of pop quizzes during lectures using TopHat, these will be covering the lecture material with the focus on the understandings of key concepts. The quizzes will be graded based on participation only.

EXAMINATIONS: There will be no regular exams in the semester. Instead, we will have in-class midterm and final practice. During the practice class, the instructor will solve a set of problems together with the students and ask questions via TopHat. This will be also graded based on participation only.

COMPUTER USAGE:

Students will be expected to use MATLAB for some of the homework assignments. You are expected to secure a computer account having MATLAB within the first week of class.

Disabilities Policy

In compliance with the Americans with Disabilities Act (ADA), all qualified students enrolled in this course are entitled to "reasonable accommodations." Please notify me during the first week of class of class of any accommodations needed for the course. Also, you must contact a staff member for Disabled Student Services (Student Disability Resources — Educational Equity (psu.edu)).

Academic Integrity

In this course, students are permitted to work together on homework assignments, but each student is required to submit his or her own original work. Students are required to work together on class projects and should submit reports completed by the group. Students may not work together or cheat in any way on exams.

Course grades are the sole basis on which the College of Engineering certifies your degree with the assumption that your course grades are a valid assessment of your own knowledge and abilities. If you have cheated, you have falsified that credential. Therefore, we must have academic integrity expectations to ensure the validity of your grade and your degree.

ME 455 TENTATIVE COURSE OUTLINE

Date	Week	Topics and Labs	Major Assignements Due
Jan 13	Week 1	L01: Course Intro - Syllabus, Introduction to Feedback Control	
Jan 15		L02: Introduction to Feedback Control: Open-Loop versus Closed-loop I	Teaming and paper selection
Jan 17		L03: Introduction to Feedback Control: Open-Loop versus Closed-loop II	
Jan 20	Week 2	**Martin Luther King Day - No Classes**	
Jan 22		L04: Sensitivity	
Jan 24		L05: Sensitivity	HW1 Out
Jan 27	Week 3	L06: Dynamic Response	
Jan 29		L07: Dynamic Response II	
Jan 31		L08: Effects of Poles and Zeros I	
Feb 3	Week 4	L09: Effects of Poles and Zeros II	
Feb 5		L10: Effects of Poles and Zeros III	
Feb 7		L 11: Nominimum phase system	HW2 Out
Feb 10	Week 5	L 12: Stability	
Feb 12		*Reserved for makeup class, weather cancellation, or travel, otherwise no class*	
Feb 14		L 14: Steady State Error and System Type I	
Feb 17	Week 6	L 15: Steady State Error and System Type II	HW3 Out
Feb 19		L 16: Root Locus – Principle and Sketching I	
Feb 21		L 17: Root Locus – Principle and Sketching II	
Feb 24	Week 7	L 18 :Root Locus – Feedback Controller Design I	
Feb 26		L 19 :Root Locus – Feedback Controller Design II	
Feb 28		L 20: Root Locus – Dynamic (Lead-Lag) Compensation I	
Mar 3	Week 8	L 21: Root Locus – Dynamic (Lead-Lag) Compensation II	HW4 Out
Mar 5		Midterm Practice (TopHat)	
Mar 7		*Reserved for makeup class, weather cancellation, or travel, otherwise no class*	
Mar 10	Week 9	**Spring Break - No Class**	
Mar 12			
Mar 14			
Mar 17	Week 10	L 23: Basics of Frequency Response I	
Mar 19		L 24: Basics of Frequency Response II	
Mar 21		Nyquist plot and Nyquist stability criterion	
Mar 24	Week 11	Nyquist plot and Nyquist stability criterion	
Mar 26		Stability Margins: Gain and Phase margins	
Mar 28		Stability Margins: Gain and Phase margins	HW5 Out
Mar 31	Week 12	CL Frequency Response	
Apr 2		Performance Specifications in Frequency Domain	
Apr 4		Performance Specifications in Frequency Domain	
Apr 7	Week 13	No Class (Dr. Cheng travel for a Seminar)	
Apr 9		Control System Design - Final Project	
Apr 11		PID Controller or Compensator Design via Frequency Methods - Loop Shaping (tentative)	
Apr 14	Week 14	PID Controller or Compensator Design via Frequency Methods - Loop Shaping (tentative)	
Apr 16		PID Controller or Compensator Design via Frequency Methods - Loop Shaping (tentative)	HW6 Out
Apr 18		*Reserved for makeup class, weather cancellation, or travel, otherwise no class*	
Apr 21	Week 15	*Reserved for makeup class, weather cancellation, or travel, otherwise no class*	
Apr 23		Course Review	
Apr 25		Final Practice (TopHat)	
Apr 28	Week 16	Work on final project (Dr. Cheng holding office hour for discussion)	
Apr 30		Work on final project (Dr. Cheng holding office hour for discussion)	
May 2		Work on final project (Dr. Cheng holding office hour for discussion)	
May 5	Week 17		
May 7		Final Project Report Due	Final report of the project
May 9			