ECE 4090 Section 400 | Summer 2022

Introduction to Linear Control Systems

Class Location/Time: Monday – Friday, Online.

Instructor: Dr. Apoorva Kapadia
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Office: 307 Fluor Daniel EIB
Phone: (864) 656-3946
Office Hours: Primarily by email. Most questions can be resolved by email. However, if a phone or video conversation is deemed necessary, appointments must be made to determine a mutually acceptable time. Typically, programs such as Zoom are used for video conversations.

Teaching Assistant:
Office: Online
Email:

Course Description

Introduction to classical linear control systems. Topics include continuous and discrete descriptions of systems, time and frequency response, stability, system specification, system design of continuous and discrete systems. **Prerequisite:** ECE 3300 with a C or better

Course Objectives

The goals for this course are to provide the student with an understanding of, and a proficiency in the analysis and design of, continuous time systems. The students will: 1) Learn how to apply mathematics to the analysis of control systems for continuous time systems, 2) Learn how to apply MATLAB for analyzing and designing control systems for continuous time systems, and 3) Learn how to design time-domain and frequency-domain controllers systems to meet needs.

Required Materials

You will need a scientific calculator for this class. In particular, the calculator you use should be capable of solving simultaneous equations and inverting matrices for both real and complex numbers. Some problems on the HW or the test, however, may not involve numbers.

Textbook: *Modern Control Systems*, Dorf (useful but not mandatory)

Topical Outline

1. Laplace Transform
    a. Properties
    b. Partial Fraction Expansion
    c. Solving Differential Equations
2. System modeling in the time domain
    a. Block Diagram Simplification
    b. Mason's Rule
3. Dynamic response
    a. 2nd Order Systems
    b. 2nd Order Time Domain Specifications
4. Basic properties of feedback
5. Root-locus analysis
    a. Construction
    b. Relationships to Time Domain Specifications
6. Root-locus design
    a. Lead Compensation
    b. Lead-Lag Compensation
7. Frequency-response analysis
    a. Bode Plot Construction
    b. Nyquist Plot Construction
8. Frequency-response design
    a. Bode Analysis
    b. Nyquist Analysis
9. State-space models/controllers
    a. Matrix and Linear Algebra Review
    b. State Space Realizations
    c. State Space Solution
    d. Frequency Domain Calculations
    e. State Feedback Control
    f. State Observers
    g. State Space Regulators
    h. Similarity Transformations
10. Advanced Topics (Time Permitting)
    a. Polynomial Regulation
    b. Nonlinear Systems

Grading

Final grades will be determined by averaging the homework, exams, and the final exam based on the distribution below. *A student's lowest Midterm can be replaced by the average of the remaining Midterms and Final scores provided they were not absent for any of them or the exam score is not a 0.*

Regular Homework	10%	90% – 100%	A
2 Midterm Exams	50%	80% – < 90%	B
Comprehensive Final Exam	40%	70% – < 80%	C
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Course Grade	100%	0% – < 60%	F

Important Summer 1 dates can be found here: https://www.clemson.edu/registrar/academic-calendars/calendars.html?year=2022&semester=first_summer

Additional Policies

Logistics

To keep up with course announcements, you need to check the ECE 4090 Canvas site on a regular basis. All the material you need for the course is on the Canvas site, or linked through it. The site contains the lecture notes, homework assignments and due dates, homework answers, upcoming test dates, practice tests, test answers, and much more. Any exams cancelled due to power outages, inclement weather or similar conditions will be held at the next class meeting unless explicitly stated by me on Canvas. Any assignments due at the time of the class cancellation will be rescheduled for the next class meeting day and will be stated on Canvas.

Homework

Homework Assignments along with solutions are posted on Canvas. Students are required to work out the problems, scan them into a PDF file, and submit their individual assignments at the end of the semester as a single PDF file. Working the homework problems is essential to the learning of the material in this course; in fact, most of your learning will come from doing the homework. It is expected that your homework will represent your own work, although working in groups is allowed, and even encouraged. Late homework will not be accepted.

Exams

There will be 2 closed book midterm exams and 1 final exam. You will be allowed to have two handwritten sheets of paper for each of the midterm exams and four for the final exam on which you may write anything you wish. Exams will be multiple choice. *Exam dates are listed in the Suggested Study Pace document.*

Given the current circumstances, no proctor is needed for this class. However, students will have to sign a pledge that they have not received any assistance on any of their submissions.

If you cannot attend an exam for any reason, I should be notified ahead of time if possible, otherwise at least on the day of the exam. Except under very unusual circumstances, no makeup will be given without appropriate notification.

ECE 4090 Suggested Study Pace Summer 1 - 2022

Suggested Study Pace		
Topic	**Item**	**Cover-By Date**
Topic 1	Lecture Video 1	Tue, May 17
Topic 1	Lecture Video 2	Wed, May 18
Topic 1	Lecture Video 3	Thu, May 19
Topic 2	Lecture Video 4	Fri, May 20
Topic 2	Lecture Video 5	Mon, May 23
Topic 3	Lecture Video 6	Tue, May 24
Topic 3	Lecture Video 7	Wed, May 25
Topic 4	Lecture Video 8	Thu, May 26
Topic 4	Lecture Video 9	Fri, May 27
Memorial Day Holiday		Mon, May 30
	Midterm 1	**Tuesday, May 31 Covering Topics 1 – 3**
Topic 4	Lecture Video 10	Wed, June 1
Topic 5	Lecture Video 11	Thu, June 2
Topic 5	Lecture Video 12	Fri, June 3
Topic 6	Lecture Video 13	Mon, June 6
Topic 6	Lecture Video 14	Tue, June 7
Topic 7	Lecture Video 15	Wed, June 8
Topic 7	Lecture Video 16	Thu, June 9
Topic 7	Lecture Video 17	Fri, June 10
Topic 8	Lecture Video 18	Mon, June 13
Topic 8	Lecture Video 19	Tue, June 14
	Midterm 2	**Wednesday, June 15 Covering Topics 4 – 8**
Topic 9	Lecture Video 20	Thu, June 16
Topic 9	Lecture Video 21	Fri, June 17
Topic 10	Lecture Video 22	Mon, June 20
Topic 10	Lecture Video 23	Tue, June 21
	Comprehensive Final Exam	**Thursday June 23**