EML 4312: Control of Mechanical Engineering Systems (Fall 2022)
M, W, F 3:00-3:50pm (Period 8)
MAE-B 229

Modifications to this syllabus may be required during the semester. Any changes will be posted on Canvas.

Instructor

Matthew T. Hale, Ph.D.
Email: matthewhale@ufl.edu

Lectures

All lectures will be held as scheduled in person.

Office Hours

- M 2–3 PM in MAE-B 321
- W 2–3 PM in MAE-B 321
- Or via confirmed written appointment

Important Dates

1. October 7th (Friday): Exam 1, during class time
2. November 18th (Friday): Exam 2, during class time
3. December 16th (Friday): Final exam, 10am-12pm

Exams

All exams are closed-book, closed-electronic devices (i.e., no calculators, no phones, etc.). Students will be permitted to bring one 8.5x11in sheet of handwritten notes (both sides) to each exam.

Textbooks and Software

- **No textbook is required.** One is recommended, though please feel free to use an older version (no problems or readings will be assigned out of these books).
- (Optional) Richard C. Dorf and Robert H. Bishop, "Modern Control Systems," Pearson.
- (Required) MATLAB, any release since 2014 with the Control System Toolbox.

Grades and Grading Policy

Evaluation Mechanism on a Percent Basis

Homework	15%
Exam 1	25%
Exam 2	25%
Final Exam	35%

Homework

Homework is graded on completion. Homework problems must only be submitted through Canvas.

Exams

All students are expected to take all exams. If a student is unable to take an exam for unforeseeable reasons, then the professor will schedule an alternative option if an appropriate instructor notification is accepted.

Grade Corrections

Corrections of grades should be submitted promptly via email within 5 business days of the grade posting in writing with a concise statement of why you believe there has been an error. Note that the professor has the final determination in the grade assigned.

Final Grade

The student is guaranteed to earn the grade point shown in the table based on their percent earned grade. For example, if a student earns 88.60% (Percent Grade Earned %GE = 88.60) then their grade point will be 3.33 (B+). %GE are rounded to the hundredths decimal place. For example, if a student earns 79.995% (Percent Grade Earned %GE = 79.995) it will be rounded up to 80.00%, and their grade will be 2.67 (B-). Higher grades can be assigned if the class is curved.

Grading Table. *%GE = Percent Grade Earned.*

Percentage Range	Grade Point
$93.33 \leq \%GE < 100.00 \Longrightarrow$ A	4.00
$90.00 \leq \%GE < 93.33 \Longrightarrow$ A-	3.67
$86.67 \leq \%GE < 90.00 \Longrightarrow$ B+	3.33
$83.33 \leq \%GE < 86.67 \Longrightarrow$ B	3.00
$80.00 \leq \%GE < 83.33 \Longrightarrow$ B-	2.67
$76.67 \leq \%GE < 80.00 \Longrightarrow$ C+	2.33
$73.33 \leq \%GE < 76.67 \Longrightarrow$ C	2.00
$70.00 \leq \%GE < 73.33 \Longrightarrow$ C-	1.67
$66.67 \leq \%GE < 70.00 \Longrightarrow$ D+	1.33
$63.33 \leq \%GE < 66.67 \Longrightarrow$ D	1.00
$60.00 \leq \%GE < 63.33 \Longrightarrow$ D-	0.67
$00.00 \leq \%GE < 60.00 \Longrightarrow$ E	0.00

Course Schedule, Approximately by Lecture Number

1	Course Introduction	Ch. 1, 2.1, 2.2
2	Linearity and Linearizations	Ch. 2.3
3	Laplace Transform	Ch. 2.4
Approximate End of Coverage for Homework 1		
Homework 1 Due September 2nd (Friday)		
4	Transfer Functions	Ch. 2.5
5	Block Diagrams	Ch. 2.6
6	Impulse Response	Ch. 5.1, 5.2
7	First-order Systems	Ch. 2.8
Approximate End of Coverage for Homework 2		
Homework 2 Due September 16th (Friday)		
8	Second-order Systems	Ch. 5.3

9	Second-order Systems	
10-11	Poles, Zeros, and Stability	Ch. 2.4, 2.9
12	Transient Analysis	Ch. 2.4, 5.3, 5.5
13-14	Reference Tracking, System Types	Ch. 5.6
Approximate End of Coverage for Homework 3		
Homework 3 Due September 30th (Friday)		
15-17	PID Control	Ch. 7.6
Approximate End of Coverage for Exam 1		
18	Routh-Hurwitz Stability Criterion	Ch. 6.1, 6.2
19	Exam 1 (in class on October 7th)	
20	Root Locus Introduction and Rules	Ch. 7.1-3
Approximate End of Coverage for Homework 4		
Homework 4 Due October 14th (Friday)		
21	Root Locus Examples	
22	Root Locus Examples, PID Root Locus	Ch. 7.4, 7.6, 7.11
23	Introduction to Bode Plots	Ch. 8.1, 8.2
24-26	Bode Plot Drawing Rules and Examples	Ch. 8.2
Approximate End of Coverage for Homework 5		
Homework 5 Due October 28th (Friday)		
27-28	Converting Bode Plots to Transfer Functions	Ch. 8.3, 8.9
29-30	Gain and Phase Margin	Ch. 8.6, 8.7
31-32	Nyquist Plots and Nyquist Criterion	Ch. 9.1-4
Approximate End of Coverage for Homework 6		
Homework 6 Due November 11th (Friday)		
33	Review of Classical Control, Examples, Catch-up	Ch. 10.1, 10.2, 10.9-13, 10.15
Approximate End of Coverage for Exam 2		
34	Introduction to State Space Methods	Ch. 3.1-3
35	Review of Linear Algebra	App. E, Ch. 3.6, 3.7, 3.9
36	Exam 2 (in class on November 18th)	
37	Eigenvalues and Stability	Ch. 6.4
38	Controllability	Ch. 11.1, 11.2
Approximate End of Coverage for Homework 7		
Homework 7 Due December 7th (Wednesday)		
39	Pole Placement	Ch. 11.2, 11.3
40	Solutions in State Space	Ch. 11.2
41	Observability	Ch. 11.4
42	Separation Principle	Ch. 11.5

Course Objectives

By the end of this course, you should be able to do the following:

- Write differential equations describing the behavior of engineering systems.
- Use the Laplace transform to describe the transfer function of engineering systems and determine the time domain response to a wide range of inputs.
- Use state-variable equations to model engineering systems and determine their time response to a wide range of inputs.

- Describe the advantages of feedback control.
- Analyze the performance of control systems.
- Determine the stability of control systems using root locus and Bode methods.
- Design feedback controllers using frequency domain, root locus, and state-variable methods.

Course Description

Course Catalog: "Theory, analysis and design of control systems, including mechanical, electromechanical, hydraulic, pneumatic and thermal components and systems." (Credits: 3)

Cheating

All instances of cheating will be referred to Honor Court. Anyone found to have cheated will receive an E grade for the course.

Exam Make-Up Policy

Instructor notifications are required. See https://care.dso.ufl.edu/instructor-notifications. Note that, "Professors have the right to accept or reject the notification."

Course Pre-Requisites / Co-Requisites

EGM 3401 (Engineering Mechanics – Dynamics), EGM 3344 (Introduction to Numerical Methods of Engineering Analysis), and MAP 2302 (Elementary Differential Equations) with minimum grades of C.

Professional Component (ABET)

This course contributes to enhancing the student's knowledge of advanced mathematics through multivariable calculus, differential equations, and linear algebra. This course also contributes to the student's ability to work professionally in mechanical and aerospace systems areas including design and analysis of such systems. The course supports several program outcomes in the Mission Statement of the Department of Mechanical and Aerospace Engineering. Specific ME and AE program outcomes supported by this course include:
(1) Using knowledge of advanced mathematics through multivariate calculus and differential equations (ME and AE Program Outcomes M2 and A2);
(2) Be familiar with linear algebra (ME and AE Program Outcome M3 and A3);
(3) Possess knowledge of stability and controls (AE Program Outcome A5).
The content of the course is 30% engineering design, 30% mathematics, and 40% engineering science.

Relation to Program Outcomes (ABET)

- Outcome #1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (strongly supported)

- Outcome #2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors (minimally supported)

- Outcome #7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies (minimally supported)

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://drc.dso.ufl.edu/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the professor or TAs in this class.

Health and Wellness

- U Matter, We Care: If you or a friend is in distress, please contact umatter@ufl.edu or 352-392-1575 so that a team member can reach out to the student.
- Counseling and Wellness Center: https://counseling.ufl.edu/, and 352-392-1575; and the University Police Department: 352-392-1111 or 9-1-1 for emergencies.
- Sexual Assault Recovery Services (SARS), Student Health Care Center, 352-392-1161.
- University Police Department at 352-392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.