Control of Mechanical Engineering Systems
EML 4312
Spring 2020, M,W,F Period 6, 12:50 PM – 1:40 PM
FLG 0230

Modifications to this syllabus may be required during the semester. Any changes that are made will be reflected in a posted version of the syllabus and announced in class.

Professor

Asst. Professor Matthew T. Hale, Ph.D.
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Office Hours

- M 2:00 – 3:00 PM, MAE-B 321
- W 2:00 – 3:00 PM, MAE-B 321
- Or via confirmed written appointment

Teaching Assistants

	Calvin Hawkins	Katherine Hendrickson
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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 control systems 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)

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.

Textbooks and Software

- Richard C. Dorf and Robert H. Bishop, "Modern Control Systems," Pearson, Ed. 12, ISBN: 9780136024583, 2011.
- MATLAB (MathWorks), any release since 2014.
- Various handout materials provided digitally on Canvas.

Materials and Supply Fees

None.

Important Dates

Homework dates will be announced in class.

February 21st: Exam 1, to be held in class
April 3rd: Exam 2, to be held in class
April 29th: Final exam, 12:30pm-2:30pm, held in the usual classroom

Attendance Policy

- The class has no attendance policy. Students are expected to attend.
- Excused absences are consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation.

Class Expectations

- Respect and Disruption: The professor and students will be respectful at all times. Classroom disruption of any kind will not be tolerated.

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.

Exam Make-Up Policy

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

Course Schedule, Approximately by Lecture Number

1	Course Introduction, Introduction to Systems	Ch. 1, 2.1, 2.2
2	Linearity, Linearization, Linear Systems	Ch. 2.3
3	Laplace Transforms	Ch. 2.4

Approximate End of Coverage for Homework 1
Homework 1 Due January 13th (Monday)

4-5	Transfer Functions and Block Diagrams	Ch. 2.5, 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 January 24th (Friday)		
8	Second-order Systems	Ch. 5.3
9	Second-order Systems	
10-11	Poles, Zeros, and Stability	Ch. 2.4, 2.9
12	Peak/Rise/Settling Time, Initial/Final Value Theorem	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 February 7th (Friday)		
15-17	PID Control	Ch. 7.6
End of Coverage for Exam 1		
18	Routh-Hurwitz Stability Criterion	Ch. 6.1, 6.2
Approximate End of Coverage for Homework 4		
Homework 4 Due February 21st (Friday)		
19	Root Locus Introduction and Rules	Ch. 7.1-3
20	Exam 1 (In class; February 19th)	
21-22	Root Locus Examples, PID Root Locus	Ch. 7.4, 7.6, 7.11
Approximate End of Coverage for Homework 5		
Homework 5 Due February 28th (Friday)		
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 6		
Homework 6 Due March 16th (Monday)		
27-28	Converting Bode Plots to Transfer Functions	Ch. 8.3, 8.9
29-30	Gain and Phase Margin	Ch. 8.6, 8.7
Approximate End of Coverage for Homework 7		
Homework 7 Due March 27th (Friday)		
31-32	Nyquist Plots and Nyquist Criterion	Ch. 9.1-4
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	Exam 2 (In class; April 2nd)	
35	Introduction to State Space Methods	Ch. 3.1-3
Approximate End of Coverage for Homework 8		
Homework 8 Due April 10th (Friday)		
36	Review of Linear Algebra	App. E, Ch. 3.6, 3.7, 3.9
37	Eigenvalues and Stability	Ch. 6.4
38	Controllability	Ch. 11.1, 11.2
39	Pole Placement	Ch. 11.2, 11.3
40	Solutions in State Space	Ch. 11.2
Approximate End of Coverage for Homework 9		
Homework 9 Due April 22 (Wednesday)		
41	Observability	Ch. 11.4
42	Separation Principle	Ch. 11.5
43	Review for Final Exam	

Evaluation of Grades and Grading Policy

Evaluation Mechanism on a Percent Basis

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

Homework

The purpose of homework is to learn and understand the material. Students who turn in fully completed homework will receive 100% credit. Partial solutions of the homework will be posted on the class website after the due date. Students are responsible for understanding the homework problems and solutions. **Students will submit solutions of the homework problems only via the course website.**

Exams

All students are expected to take all exams. If a student is unable to take an exam for unforeseeable reasons, then the other exams will count toward the percentage of the grade that makes up the exams if an appropriate DSO instructor notification is accepted.

Grade Corrections

Corrections of grades should be submitted promptly within 3 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. If a grade change is determined it may result in a lower or higher grade.

Final Grade

The final grade will be calculated by the following table. 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 professor elects to curve the entire class. Particularly inquisitive and curious students may be given higher grades at the discretion of the professor.

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

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 enumerated 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	**Coverage***
a. Apply knowledge of mathematics, science, and engineering	High
b. Design and conduct experiments, as well as analyze and interpret data	
c. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	High
d. Function on multidisciplinary teams	
e. Identify, formulate, and solve engineering problems	High
f. Understand professional and ethical responsibilities	Low
g. Communicate effectively	
h. Understand the impact of engineering solutions in a global, economic, environmental, and societal context	Medium
i. Recognize the need for and be able to engage in lifelong learning	Low
j. Understand contemporary issues	
k. Use the techniques, skills, and modern engineering tools necessary for engineering practice	Low

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of the course.

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.

Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at https://evaluations.ufl.edu/evals. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at https://evaluations.ufl.edu/results/.

Software

Students are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate.

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/.