

**EML 4312: Control of Mechanical Engineering Systems**  
Spring 2021, M, W, F Period 6, 12:50 PM – 1:40 PM (Online)

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

**Instructor**

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

- M 4:00–5:00 PM, Zoom: <https://ufl.zoom.us/j/96961947003?pwd=UVdFeS8rWG1LNk9tL2JHMjYxdlhdz09>
- W 4:00–5:00 PM, Zoom: <https://ufl.zoom.us/j/96961947003?pwd=UVdFeS8rWG1LNk9tL2JHMjYxdlhdz09>
- Or via confirmed written appointment

**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)

**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**

- **No textbook is required.** A few are 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 Control System Toolbox.

**Important Dates**

1. February 26<sup>th</sup> (Friday): Exam 1, held during class time (12:50-1:40pm EST)
2. April 2<sup>nd</sup> (Friday): Exam 2, held during class time (12:50-1:40pm EST)
3. April 28<sup>th</sup> (Wednesday): Final exam, 12:30-2:30pm

## Exams

All exams are open-book, open-electronic devices. Notes, a textbook, Google, and MATLAB are all allowed. **Students must complete the exam independently; working together on exams is forbidden and considered cheating.** Posting any portion of an exam online is also forbidden and considered cheating.

## Cheating

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

## Weekly Quizzes

Each week will have a quiz on Canvas with two questions. The quiz for each week must be completed by midnight the next Monday. Grading is based on completion.

## 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 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
<b><i>Approximate End of Coverage for Homework 1</i></b>		
<b><i>Homework 1 Due January 19th (Tuesday)</i></b>		
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
<b><i>Approximate End of Coverage for Homework 2</i></b>		
<b><i>Homework 2 Due January 29th (Friday)</i></b>		
8-9	Second-order Systems	Ch. 5.3
10-11	Stability	Ch. 2.4, 2.9
12	Transient Analysis	Ch. 2.4, 5.3, 5.5
<b><i>Approximate End of Coverage for Homework 3</i></b>		
<b><i>Homework 3 Due February 12th (Friday)</i></b>		
13-14	Reference Tracking	Ch. 5.6
15-16	PID Control	Ch. 7.6
<b><i>Approximate End of Coverage for Homework 4</i></b>		
<b><i>Homework 4 Due February 19th (Friday)</i></b>		
17	Routh-Hurwitz Stability Criterion	Ch. 6.1, 6.2
<b><u>Approximate End of Coverage for Exam 1</u></b>		
<b><u>Exam 1 is on Friday February 26th during class time (12:50-1:40pm EST)</u></b>		
18-20	Root Locus Introduction and Rules	Ch. 7.1-4, 7.6, 7.11
21-22	Intro to Bode Plots and Rules for Drawing	Ch. 8.1, 8.2
<b><i>Approximate End of Coverage for Homework 5</i></b>		
<b><i>Homework 5 Due March 12th (Friday)</i></b>		

23-24	More Bode Plots	
25-26	Converting Bode Plots to Transfer Functions	Ch. 8.3, 8.9
27-28	Gain and Phase Margin	Ch. 8.6, 8.7

***Approximate End of Coverage for Homework 6***

***Homework 6 Due March 26<sup>th</sup> (Friday)***

**Approximate End of Coverage for Exam 2**

**Exam 2 is on Friday April 2<sup>nd</sup> during class time (12:50-1:40pm EST)**

29	Introduction to State Space	Ch. 9.1-4
30	Review of Linear Algebra	App. E, Ch. 3.6, 3.7, 3.9
31	Stability in State Space	Ch. 6.4
32	Controllability	Ch. 11.1, 11.2

***Approximate End of Coverage for Homework 7***

***Homework 7 Due April 9<sup>th</sup> (Friday)***

33	Pole Placement	Ch. 11.2, 11.3
34	Solutions in State Space	Ch. 11.2
35	State Space Motor Control	
36	State Space Robot Control	

***Approximate End of Coverage for Homework 8***

***Homework 8 Due April 21<sup>st</sup> (Wednesday)***

37	Review for Final Exam	Ch. 11.4
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**Evaluation of Grades and Grading Policy**

Evaluation Mechanism on a Percent Basis

Homework	15%
Weekly Quizzes	10%
Exam 1	25%
Exam 2	25%
Final Exam	25%

Homework

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

Weekly Quizzes

Weekly quizzes are to benchmark your understanding of material so far and to help guide what to study in more depth. Quizzes are graded on completion as well.

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 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

## 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
$93.33 \leq \%GE < 100.00 \implies$ A	4.00
$90.00 \leq \%GE < 93.33 \implies$ A-	3.67
$86.67 \leq \%GE < 90.00 \implies$ B+	3.33
$83.33 \leq \%GE < 86.67 \implies$ B	3.00
$80.00 \leq \%GE < 83.33 \implies$ B-	2.67
$76.67 \leq \%GE < 80.00 \implies$ C+	2.33
$73.33 \leq \%GE < 76.67 \implies$ C	2.00
$70.00 \leq \%GE < 73.33 \implies$ C-	1.67
$66.67 \leq \%GE < 70.00 \implies$ D+	1.33
$63.33 \leq \%GE < 66.67 \implies$ D	1.00
$60.00 \leq \%GE < 63.33 \implies$ D-	0.67
$00.00 \leq \%GE < 60.00 \implies$ 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 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](mailto: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/>.