

Control of Mechanical Engineering Systems
EML 4312
Fall 2020, M,W,F Period 2, 8:30 AM – 9:20 AM
TUR L005

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, Zoom: <https://ufl.zoom.us/j/96961947003?pwd=UVdFeS8rWG1LNk9tL2JHMjYxdlldhdz09>
- W 2:00–3:00 PM, Zoom: <https://ufl.zoom.us/j/96961947003?pwd=UVdFeS8rWG1LNk9tL2JHMjYxdlldhdz09>
- Or via confirmed written appointment

Teaching Assistant

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

- **No textbook is required for this course.** A few are recommended, though please feel free to use an older version for this class (no problems or readings will be assigned out of these books, and they are only for reference purposes).
- 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

1. October 12th (Monday): Exam 1, held during class time (8:30-9:20am EST)
2. November 9th (Monday): Exam 2, held during class time (8:30-9:20am EST)
3. December 17th: Final exam, 7:30-9:30am

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.

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
<i>Approximate End of Coverage for Homework 1</i>		
<i>Homework 1 Due September 9th (Wednesday)</i>		
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
<i>Approximate End of Coverage for Homework 2</i>		
<i>Homework 2 Due September 21st (Monday)</i>		
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	Reference Tracking	Ch. 5.6
<i>Approximate End of Coverage for Homework 3</i>		
<i>Homework 3 Due October 5th (Monday)</i>		
14-16	PID Control	Ch. 7.6
<u>Approximate End of Coverage for Exam 1</u>		
<u>Exam 1 is on Monday October 12th during class time (8:30-9:20am EST)</u>		
17	Routh-Hurwitz Stability Criterion	Ch. 6.1, 6.2
<i>Approximate End of Coverage for Homework 4</i>		
<i>Homework 4 Due October 19th (Monday)</i>		
18	Root Locus Introduction and Rules Exam 1 (In class; February 19 th)	Ch. 7.1-3
19-20	Root Locus Examples, PID Root Locus	Ch. 7.4, 7.6, 7.11
21	Introduction to Bode Plots	Ch. 8.1, 8.2
22-23	Bode Plot Drawing Rules and Examples	Ch. 8.2
<i>Approximate End of Coverage for Homework 5</i>		
<i>Homework 5 Due November 2nd (Monday)</i>		
24-25	Converting Bode Plots to Transfer Functions	Ch. 8.3, 8.9
26-27	Gain and Phase Margin	Ch. 8.6, 8.7
<i>Approximate End of Coverage for Homework 6</i>		
<i>Homework 6 Due November 16th (Monday)</i>		
28-29	Nyquist Plots and Nyquist Criterion	Ch. 9.1-4
30	Review of Classical Control, Examples, Catch-up	Ch. 10.1, 10.2, 10.9-13, 10.15
<u>Approximate End of Coverage for Exam 2</u>		
<u>Exam 2 is on Monday November 9th during class time (8:30-9:20am EST)</u>		
31	Introduction to State Space Methods	Ch. 3.1-3
32	Review of Linear Algebra	App. E, Ch. 3.6, 3.7, 3.9
<i>Approximate End of Coverage for Homework 7</i>		
<i>Homework 7 Due November 30th (Monday)</i>		
33	Eigenvalues and Stability	Ch. 6.4
34	Controllability	Ch. 11.1, 11.2
35	Pole Placement	Ch. 11.2, 11.3
36	Solutions in State Space	Ch. 11.2
<i>Approximate End of Coverage for Homework 8</i>		
<i>Homework 8 Due December 9th (Wednesday)</i>		
37	Review for Final Exam	Ch. 11.4

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

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.**

Weekly Quizzes

Weekly quizzes are to benchmark your understanding of material so far and to help guide what to study in more depth. They are graded based on completion; answering all questions will earn a grade of 100% for that week, regardless of the correctness of answers.

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 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. 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
$93.33 \leq \%GE < 100.00 \implies$ 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 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 #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.

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/>.