Control of Mechanical Eng Systems

EML 4312 Section 259K
Class Periods: MWF 7
Location: CSE E220
Academic Term: Fall 2023

Instructor:
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TA's office hours will be announced during the semester.

Course Description
Theory, analysis and design of control systems, including mechanical, electromechanical, hydraulic, pneumatic, and thermal components and systems. (Credit: 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.

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.

Materials and Supply Fees
None

Relation to Program Outcomes (ABET):
This course contributes to enhancing the students' knowledge of advanced mathematics through multivariable calculus, differential equations, and linear algebra. This course also contributes to the students' 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).

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
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	Low
3. An ability to communicate effectively with a range of audiences	
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Low

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

Required Textbooks and Software

- No textbook is required. A couple of optional textbooks are listed below. No reading or problems will be assigned from these optional textbooks.
- (Required) MATLAB, any release since 2014 with Control System Toolbox.

Recommended Materials

- (Optional) Richard C. Dorf and Robert H. Bishop, "Modern Control Systems," Pearson.
- (Optional) Gene F. Franklin, et. al., "Feedback Control of Dynamic Systems," Pearson
- (Optional) Karl Johan Åström and Richard M. Murray, "Feedback Systems: An Introduction for Scientists and Engineers Book," Princeton University Press Publication date and edition

Important Dates

- Exam 1: Wednesday, October 4th, 2023. In-class
- Exam 2: Friday, November 3rd, 2023. In-class
- Exam 3: Wednesday, December 6th, 2023. In-class

Course Schedule

No.	Topics	Dorf&Bishop
1	Introduction to Systems	Ch. 1, 2.1, 2.2
2	Linearity, Linearization, Linear Systems	Ch. 2.3
3	Laplace Transforms	Ch. 2.4
4	Transfer Functions and Block Diagrams	Ch. 2.5, 2.6

Approximate End of Coverage for Homework #1 (Due Wednesday, Sep. 6)		
5	Impulse Response	Ch. 5.1, 5.2
6	First-order Systems	Ch. 2.8
7-8	Second-order Systems	Ch. 5.3
Approximate End of Coverage for Homework #2 (Due Wednesday, Sep. 20)		
9-10	Stability	Ch. 2.4, 2.9
11	Transient Analysis	Ch. 2.4, 5.3, 5.5
12-13	Reference Tracking	Ch. 5.6
14-15	PID Control	Ch. 7.6
Approximate End of Coverage for Homework #3 (Due Wednesday, Oct. 4)		
16	Routh-Hurwitz Stability Criterion	Ch. 6.1, 6.2
Approximate End of Coverage for Exam 1 Exam 1 is on Wednesday, October 4th (In-Class)		
17-19	Root Locus Introduction and Rules	Ch. 7.1-4, 7.6, 7.11
Approximate End of Coverage for Homework #4 (Due Wednesday, Oct. 20)		
20-22	Introduction to Bode Plots and Rules for Drawing	Ch. 8.1, 8.2
23	Bode Plot Examples	Ch. 8.2
24-25	Gain and Phase Margin	Ch. 8.6, 8.7
Approximate End of Coverage for Homework #5 (Due Wednesday, Nov. 1)		
26-27	Converting Bode Plots to Transfer Functions	Ch. 8.3, 8.9
Approximate End of Coverage for Exam 2 Exam 2 is on Friday, November 3rd (In-Class)		
28	Introduction to State Space	Ch. 9.1-4
29	Review of Linear Algebra	App. E, Ch. 3.6, 3.7, 3.9
30	Stability in State Space	Ch. 6.4
31	Controllability	Ch. 11.1, 11.2
32	Solutions in State Space	Ch. 11.2
Approximate End of Coverage for Homework #6 (Due Wednesday, Nov. 29)		
33	State Space Motor Control	
34	State Space Robot Control	
35	Review for Final Exam	Ch. 11.4

Attendance Policy, Class Expectations, and Make-Up Policy

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Attendance Policy

Regular class attendance (in-person) is expected but will not be monitored. This course does not have a required textbook, and all course materials will be shared through lecture notes that the instructor writes on a board in each lecture. It is students' responsibility to attend all lectures. If students may miss a lecture, it is their responsibility to notify the instructor as soon as possible and ask for resources.

Exam Make-Up Policy

Instructor notifications are required. Note that, "Professors have the right to accept or reject the notification." Students are requested to notify the instructor as earliest as possible, 3 business days before at the latest. Make-up exams will be scheduled at an earlier date than the normal exam dates.

Exam Policy
All exams are closed-book, closed-notes, closed-electronic devices. 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.

Evaluation of Grades

Assignment	**Percentage of Final Grade**
Homework Sets (6)	15%
Matlab Activities (2)	10%
Exam 1	25%
Exam 2	25%
Exam 3 (Final Exam)	25%
	100%

Grading Policy
Homework
Homework submissions must only be submitted through Canvas. Homework will be graded completion based.

Matlab Activities
Matlab activities will be given during the semester to implement the concepts taught in the lectures. It will be graded based on participation during the lecture or completion. More detail instructions will be given on Canvas.

Exams
All students are required to take all exams. If a student is unable to take an exam for unforeseeable reasons, then the instructor 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 instructor has the final determination in the grade assigned.

Final Grade
Students are 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.

Percent Range	Grade	Grade Points
$94.00 \leq$ %GE < 100.00	A	4.00
$90.00 \leq$ %GE < 94.00	A-	3.67
$87.00 \leq$ %GE < 90.00	B+	3.33
$84.00 \leq$ %GE < 87.00	B	3.00
$80.00 \leq$ %GE < 84.00	B-	2.67
$77.00 \leq$ %GE < 80.00	C+	2.33

74.00 ≤ %GE < 77.00	C	2.00
70.00 ≤ %GE < 74.00	C-	1.67
67.00 ≤ %GE < 70.00	D+	1.33
64.00 ≤ %GE < 67.00	D	1.00
61.00 ≤ %GE < 64.00	D-	0.67
0.00 ≤ %GE < 61.00	E	0.00

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

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/student-conduct-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 instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University 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. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*:* https://distance.ufl.edu/getting-help/; *https://distance.ufl.edu/state-authorization-status/#student-complaint*.