Control of Mechanical Engineering Systems
EML 4312 Section 099H
Fall 2022, M W F, 2nd Period, 8:30 AM – 9:20 AM
LAR 330 and on Zoom:
https://ufl.zoom.us/j/94412504583?pwd=d2J0NTBHTnh4amVCejBFL0xIK3llQT09
Zoom Meeting ID: 944 1250 4583; Zoom Meeting Password: 886973
This Zoom meeting is restricted to UFL participants only

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.

Instructor

Assistant Professor **Amor A. Menezes**, Ph.D. (min-AY-zis)
Department of Mechanical and Aerospace Engineering
University of Florida, Gainesville, FL 32611-6250
WERT 489
Please contact through the Canvas website https://elearning.ufl.edu
Any emails to ufl email address must include EML 4312 in the subject line

Office Hours

- M 9:30 AM – 11:00 AM, T 3:30 PM – 5:00 PM; WERT 489 and on Zoom:
  https://ufl.zoom.us/j/94412504583?pwd=d2J0NTBHTnh4amVCejBFL0xIK3llQT09
  Zoom Meeting ID: 944 1250 4583; Zoom Meeting Password: 886973
- Or via confirmed written appointment

Undergraduate Student Teaching Assistant

Alessia Venturi
Email: alessiaventuri@ufl.edu
Office Hours: T Th 3:00 PM – 4:00 PM
Zoom: https://ufl.zoom.us/j/92768991123
Zoom Meeting ID: 927 6899 1123

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.

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.

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 by the Department of Mechanical and Aerospace Engineering. The content of this course is approximately 30% engineering design, 30% mathematics, and 40% engineering science.

Relation to Program Outcomes (ABET)

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	
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	

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

Recommended Textbooks, Software, and Hardware

- Richard C. Dorf and Robert H. Bishop, "Modern Control Systems," Pearson, 14th Ed., ISBN: 9780137307258, 2022.
- MATLAB (MathWorks), any recent release.
- Various handout materials provided digitally on Canvas.
- Scientific calculator (not your phone).
- It is important that you have your own laptop/mobile computer. Details are provided on the college and department websites:
  https://www.eng.ufl.edu/students/advising/fall-semester-checklist/computer-requirements/
  https://mae.ufl.edu/academics/undergraduate/computer-requirements/

Alternate (Reference) Textbooks

- Franklin, Powell, and Emami-Naeini, "Feedback Control of Dynamic Systems"
- Golnaraghi and Kuo, "Automatic Control Systems"
- Nise, "Control Systems Engineering"
- Ogata, "Modern Control Engineering"
- Astrom and Murray, "Feedback Systems: An Introduction for Scientists and Engineers"
- Doyle, Francis, and Tannenbaum, "Feedback Control Theory"

Important Dates

- Classes Begin: Aug 24 (Wednesday)
- Holidays/Reading Days: Sep 5 (Monday), Oct 7 (Friday), Nov 11 (Friday), Nov 23 – 25 (Wednesday – Friday), Dec 8, 9 (Thursday, Friday)
- Classes End: Dec 7 (Wednesday)
- Classes Canceled:
- Homework dates stated in this syllabus will be confirmed in class
- Midterm Exam: Oct 20 (Thursday) 8:20 PM – 10:10 PM
- Final Exam: Dec 13 (Tuesday) 10:00 AM – 12:00 PM

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

- The class has no attendance policy. Students are expected to attend.
- Absences may be excused with appropriate documentation.
- **Make-up Policy:** Instructor notifications are required in all circumstances. See https://care.dso.ufl.edu/instructor-notifications. Note that, "Instructors have the right to accept or reject the Instructor Notification."

Class Expectations

- The student is solely responsible for their education. The instructor is the guide to their understanding of the field.
- Cell phones, laptops, etc.: **under no circumstances will disruptions from electronic devices be tolerated. Students are expected to take either handwritten notes with pen/pencil and paper, or electronic notes with stylus and tablet.**
- Respect and disruption: the instructor and students will be respectful at all times. Classroom disruption of any kind will not be tolerated.
- **The principles of the Honor Code must be adhered to at all times.** Individual effort is required on homework assignments, quizzes, and exams. Groups will be treated as individuals for projects. 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, the following statement is either required or implied:

  On my honor, I have neither given nor received unauthorized aid in doing this homework/quiz/report/exam.

  The Conduct 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. You are obligated to report any academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TA.

  Course Zero-Tolerance Policy: *Any* violation or suspected violation of the Honor Code by a student may result in that student receiving a grade of E for the course.

Homework

The purpose of homework is to learn and understand the material. **Students are responsible for performing and understanding the homework problems and solutions on their own.**

Software and Copyrighted Material Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing the use of software and the use of copyrighted material. 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 UF community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Exams

All exams are closed-book, closed-notes, closed-electronic devices. A scientific calculator (that is **not** your cell phone or laptop) will be permitted. Laplace transform tables will be provided, as well as select formulae at the discretion of the instructor.

Honorlock: Consistent with UF policy, Honorlock may be used for course assessments and will be confirmed by the instructor in advance. Please see https://distance.ufl.edu/proctoring/ for more information.

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center (https://disability.ufl.edu/students/get-started/). Students should share their accommodation letter with their instructor and discuss their access needs as early as possible in the semester.

HyFlex Course Delivery

To account for the ongoing COVID-19 pandemic, HyFlex technology that includes the Zoom videoconferencing platform will permit the instructor to interact with students who are face-to-face and online at the same time. Course delivery updates will be provided by the instructor. Lecture recordings may be made (see below).

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

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 Undergraduate Program Coordinator, advising@mae.ufl.edu
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@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

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

Instructor-Initiated Course Recording

Lectures and office hours may be audio visually recorded by the instructor or TA for students who are unable to attend live, and for student reference. Online students who participate with their camera engaged or who utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to have your video or profile image recorded, ensure that your camera is off and that you do not use a profile image.

Likewise, online students who un-mute themselves to orally participate during class are agreeing to have their voices recorded. If you are unwilling to have your voice recorded, ensure that your mute button is activated and that you communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. Similar to the above, in-class students who orally participate are also agreeing to have their voices recorded.

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.

Health and Wellness

U Matter, We Care

Your well-being is important to UF. 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.

COVID-19

- You are expected to follow guidance from the Centers for Disease Control and Prevention (CDC) regarding the wearing of approved face coverings during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

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 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 (https://titleix.ufl.edu/), 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, 352-392-1161.

University Police Department
352-392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning Technical Support
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, 352-392-1601. 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, 352-392-2010 or 352-392-6420. General study skills and tutoring.
https://teachingcenter.ufl.edu/

Writing Studio
302 Tigert Hall, 352-846-1138. Help brainstorming, formatting, and writing papers.
https://writing.ufl.edu/writing-studio/.

Students Complaints: On-Campus
https://ombuds.ufl.edu/student/

Students Complaints: Distance Learning
https://distance.ufl.edu/state-authorization-status/#student-complaint

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/.

Evaluation of Grades and Grading Policy

Information on the UF grading policy is available at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Evaluation Mechanism on a Percent Basis

Homeworks (6)	20%
Midterm Exam	35%
Final Exam	45%

Homework

Students will submit solutions of the homework problems only via the course website. Students who turn in homework before the due date and time will have their homework graded. Not all homework problems may be graded, and a selection of problems may be randomly chosen for grading after the homework due date and time. Submitted homework that is partially- or fully-missing solutions to these chosen problems will not be eligible for partial or any credit for those problems, respectively, even if other non-chosen homework problems were completed. **Grading will be on completeness, not correctness.** It is the student's responsibility to check their solutions against posted homework solutions.

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.

Final Grade

Final grades may be calculated by the following table. For example, if a student earns 86.60% (Percent Grade Earned %GE = 86.60) then their grade point will be 3.33 (B+). %GE are rounded to the hundredths decimal place. For example, if a student earns 77.995% (Percent Grade Earned %GE = 77.995) it will be rounded up to 78.00%, and their grade point will be 2.67 (B-). Shifts in the grading table are at the discretion of the instructor.

Table 1. Grading Table. *%GE = Percent Grade Earned.*

Percentage Range	Grade Point
$92.00 \leq$ %GE $< 100.00 \Longrightarrow$ A	4.00
$88.00 \leq$ %GE $< 92.00 \Longrightarrow$ A-	3.67
$85.00 \leq$ %GE $< 88.00 \Longrightarrow$ B+	3.33
$81.00 \leq$ %GE $< 85.00 \Longrightarrow$ B	3.00
$78.00 \leq$ %GE $< 81.00 \Longrightarrow$ B-	2.67
$74.00 \leq$ %GE $< 78.00 \Longrightarrow$ C+	2.33
$71.00 \leq$ %GE $< 74.00 \Longrightarrow$ C	2.00
$67.00 \leq$ %GE $< 71.00 \Longrightarrow$ C-	1.67
$64.00 \leq$ %GE $< 67.00 \Longrightarrow$ D+	1.33
$61.00 \leq$ %GE $< 64.00 \Longrightarrow$ D	1.00
$60.00 \leq$ %GE $< 61.00 \Longrightarrow$ D-	0.67
$00.00 \leq$ %GE $< 60.00 \Longrightarrow$ E	0.00

Grade Corrections

Grade corrections should be submitted promptly in writing within three business days of the grade posting. Include a concise statement of why you believe that there has been an error. The instructor has the final determination in the assigned grade; if a grade change is made, the grade may be lower or higher.

Course Schedule, Approximately by Lecture Number

1	Aug 24	Course Introduction, Introduction to Systems	Ch. 1, 2.1, 2.2
2	Aug 26	Linearity, Linearization, Linear Systems	Ch. 2.3
3	Aug 29	Laplace Transforms	Ch. 2.4
4	Aug 31	Transfer Functions	Ch. 2.5
5	Sep 2	Block Diagrams	Ch. 2.6
Approximate End of Coverage for Homework 1			
6	Sep 7	Impulse Response	Ch. 5.1, 5.2
7	Sep 9	First-order Systems	Ch. 2.8
Homework 1 Due Sep 9 (Friday), 11:59 PM			
8	Sep 12	Second-order Systems	Ch. 5.3
9	Sep 14	Second-order Systems	Ch. 5.3
10	Sep 16	Poles, Zeros, and Stability	Ch. 2.4, 2.9
11	Sep 19	Stability, Dominant Pole, Final Value Theorem	Ch. 2.4
Approximate End of Coverage for Homework 2			
12	Sep 21	Initial Value Theorem, Peak/Rise/Settling Time	Ch. 5.3, 5.5
13	Sep 23	Reference Tracking	Ch. 5.6
14	Sep 26	System Types	Ch. 5.6
Homework 2 Due Sep 26 (Monday), 11:59 PM			
15	Sep 28	PID Control	Ch. 7.6
16	Sep 30	PID Control	Ch. 7.6
17	Oct 3	Routh-Hurwitz Stability Criterion	Ch. 6.1, 6.2
18	Oct 5	Root Locus Introduction and Rules	Ch. 7.1-3
19	Oct 10	Root Locus Examples	Ch. 7.4, 7.11
Approximate End of Coverage for Homework 3			
20	Oct 12	PID Root Locus	Ch. 7.6
End of Coverage for Midterm Exam			
21	Oct 14	Introduction to Bode Plots	Ch. 8.1, 8.2
22	Oct 17	Drawing Bode Plots	Ch. 8.2
Homework 3 Due Oct 17 (Monday), 11:59 PM			
23	Oct 19	Drawing Bode Plots	Ch. 8.2
Midterm Exam Oct 20 (Thursday), 8:20 PM			
24	Oct 21	Converting Bode Plots to Transfer Functions	Ch. 8.3, 8.9
25	Oct 24	Converting Bode Plots to Transfer Functions	Ch. 8.3, 8.9
26	Oct 26	Filters	Ch. 8.4
27	Oct 28	Filters	Ch. 8.4
Approximate End of Coverage for Homework 4			
28	Oct 31	Gain and Phase Margin Design	Ch. 8.6, 8.7
29	Nov 2	Gain and Phase Margin Design	Ch. 8.6, 8.7
30	Nov 4	Nyquist Criterion	Ch. 9.1-4
31	Nov 7	Nyquist Criterion	Ch. 9.1-4
32	Nov 9	Phase Lead Controllers	Ch. 10.3-5
33	Nov 14	Phase Lead Controllers	Ch. 10.3-5
Homework 4 Due Nov 14 (Monday), 11:59 PM			
34	Nov 16	Phase Lag Controllers	Ch. 10.3, 10.7, 10.8
Approximate End of Coverage for Homework 5			
35	Nov 18	Introduction to State Space Methods	Ch. 3.1-3
36	Nov 21	Review of Linear Algebra	App. E
37	Nov 28	Review of Linear Algebra, Solving State Equations	App. E, Ch. 3.3, 3.6, 3.7
38	Nov 30	Transfer Functions from State Space, Stability	Ch. 3.7, 6.4
Homework 5 Due Nov 30 (Wednesday), 11:59 PM			
39	Dec 2	Controllability and State Feedback	Ch. 11.1-3
40	Dec 5	Pole Placement	Ch. 11.3

41	Dec 7	Pole Placement	Ch. 11.3

Approximate End of Coverage for Homework 6
End of Coverage for Final Exam
Homework 6 Due Dec 7 (Wednesday), 11:59 PM
Final Exam Dec 13 (Tuesday), 10:00 AM