Syllabus: EE 110/ME 210 (Control Systems)
Spring 2020

Instructor: Professor Hamid R. Ossareh
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Email: `hossareh@uvm.edu`
Office Hours (V301F): Mon/Wed 12 – 12:45pm, and after class (4:45pm – 5:05pm)
Website: `uvm.edu/~hossareh`

Teaching Assistants: (Main) Mr. Joycer Osorio (EE PhD student, field of specialization: controls)
(Labs) Mr. Collin Freiheit (ME MS student, field of specialization: controls)
Office Hours (V308): Mon 5:05-5:35pm, Wed 5:05-5:35pm, Fri 9:25am-9:55am)

Class times: Room: Votey 303
Time: 3:30 pm - 4:45 pm Mon/Wed
Lab times: Room: Votey 308
Times: (1) Mon 5:05 – 7:35pm, (2) Wed 5:05 – 7:35pm, (3) Fri 9:25 – 11:55am

Overview: The goal of this course is to teach you the basics of feedback control theory with application to mechanical and electrical systems. The coursework will include elements of classical control theory such as stability analysis and PID control. A series of labs implemented on an electric motor and rotary inverted pendulum will reinforce the concepts. There will be an emphasis on design.

Learning Objectives: Upon successful completion of this course, the student should be able to:

- Identify open and closed loop systems and explain the role of feedback and its limitations.
- Use mathematical models (ODEs and Laplace transforms) to describe dynamic processes.
- Determine and calculate key concepts such as stability and tracking/disturbance rejection performance measures.
- Make hand-sketches of Root Locus, Bode, and Nyquist plots.
- Use tools such as pole placement, root locus plot, Bode plot, and Nyquist plot to analyze and design feedback control laws.
- Design logic to account for sensor noise, actuator saturation, and unstable poles/zeros.

Web Site: We will use Blackboard (for course material, HW submissions, and grades): `bb.uvm.edu`

Required Textbook: None

Recommended Textbook: Franklin, Powell, Emami-Naeini. *Feedback Control of Dynamic Systems*, 7th edition, Pearson Prentice Hall (on reserve at the UVM libeary - you can borrow for 24 hours at a time).

Recommended App (free): "Experience Controls" from Quanser, available on App Store/Google Play.

Pre-requisites: You are required to have taken either ME111 System Dynamics, or EE171 Signals & Systems, or an equivalent as a prerequisite. You are expected to know how to program in Matlab. In addition, I expect you to know how to solve integrals and ordinary differential equations (ODEs); to know complex numbers, Laplace transforms, LTI systems, and transfer functions. **Note: complex numbers are extremely important in this course!**

Additionally, here are my expectations of you:

- You will attend all lectures and, if you miss any, you will get the notes from your classmates. *You* are responsible for knowing what was covered/discussed in class. Please send me an email ahead of time if you're going to miss a class.
- You will review your notes from the previous lecture *before* coming to class.
- You will show up for class *on time* and **will not use cell phones while in class.** Please step out if you need to use your phone (even for texting).
- You will read relevant sections of the notes and textbook on your own.

I also expect everyone to actively participate during class and office hours. Active participation means asking and answering questions and being engaged. Things that you should not be doing: falling asleep, cracking jokes with your neighbors, or being on your phone/working on other courses while in class. If you feel distracted, step out and get a sip of water or fresh air.

Cross-list: EE110, ME210, and EE210 will all cover the same content and will be graded the same. EE110 is primarily for EE juniors, ME210 is for ME students, and EE210 is for EE graduate students. **The lab component is mandatory for everyone in this class.**

Grading: A breakdown of the grades is shown below.

- Exams: 60% (15% first midterm + 15% second midterm + 30% final exam)
- HW: 15% (11 HWs)
- Labs: 25% (7 Labs)

The final letter grades map to numerical percentage grades as follows:

A+	A	A-	B+	B	B-	C+	C	C-
[95,100]	[90,95)	[85,90)	[82.5,85)	[77.5,82.5)	[75,77.5)	[72.5,75)	[67.5,72.5)	[65,67.5)

D+	D	D-	F
[62.5,65)	[57.5,62.5)	[50, 57.5)	[0,50)

Important note: the final grade will <u>not</u> be curved or adjusted in this course. Grades will be recorded on the course blackboard site (`bb.uvm.edu`), so check this.

Exams: There are three exams in this course:

1. Exam 1. Tentative date: Feb 26, in class.
2. Exam 2. Tentative date: Apr 8, in class.
3. Final Exam. May 4, 2020 from 4:30pm to 7:15pm in Votey 303

The exams are closed book, closed notes, no-calculator exams. You will be allowed to bring one A4-size page (front and back) of handwritten notes with you to each exam.

Homework: Homework assignments highlight important topics from lecture and allow the student to understand the kind of problems they are expected to be able to solve. Homework is meant to be for practice and not worth as many points as exams. Please don't copy someone else's work — it does not help with the learning process.

- Homeworks will be assigned weekly and must be submitted online (via Blackboard) before the deadline. You can type your solutions, or scan/take pictures of your handwritten solutions. That said, everything you submit must be legible and you should show your work to receive credit. Please submit early to avoid technical issues.
- If the assignment requires MATLAB code, include your own commented code that comments each step of the logic. You MUST include your name in the comments.
- Each problem of the HW will be graded as follows:
  - THREE (3) points if the problem is perfectly correct or nearly so. Of course, "nearly so" is a subjective evaluation. I don't consider a numerical mistake to be important if it doesn't change the basic problem nor lead to greatly simplified reasoning. I am always concerned about conceptual errors. Please CIRCLE your final answer.
  - TWO (2) points if there are several minor errors or at least one major error, but it is clear that the person had a good idea of how to work the problem.
  - ONE (1) point if the problem was attempted, but the reasoning is wrong, incomplete, or if the solution was unreadable (illegible writing, undefined notation, etc.)
  - ZERO (0) points only if the problem was not attempted or if the solution is completely unacceptable.
- Some homework problems are mandatory for graduate students but optional for undergraduates. In that case, they usually carry a large bonus for the undergraduates! So try them out!
- Your lowest two HW scores will be dropped.
- You may discuss homework with each other at a conceptual level, but not at a detailed level: e.g., you may discuss the procedural steps whereby you solve a problem, but do not share equations or Matlab code. I suggest you try working it out yourself first on your own and then meet with your colleagues (or use the discussion board) to argue the validity of your approach and iterate. If you use MATLAB for your assignment, you must include your printed code and outputs.

Labs: Labs based upon a rotary inverted pendulum will illustrate the concepts learned in this course. There will be a total of 7 labs. For the first 3 labs, you will work independently and get familiar with Simulink. For the final 4 labs, You will work in groups of 3-4 to implement your control logic on a DC motor/inverted pendulum experiment. You must submit a lab report for all 7 labs. You will form groups later in the course. Some labs are worth more than other labs so please pay attention to this. The following is a breakdown of the weights (percentages denote the percentages of the final grade).

Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Total
1%	2%	4%	4%	4%	4%	6%	25%

Late policy - IMPORTANT: In general, late submissions will **not** be accepted. There are two exceptions to this rule: (1) you have a valid reason and you know ahead of time that you will miss a deadline, in which case you must coordinate with me ahead of time; (2) you had a valid, documented emergency after the deadline, in which case you must provide a letter from student services. Note: for labs done in groups, no late submission will be accepted.

In general, do NOT wait until the last minute. Submit early! "Blackboard glitched at the last minute" is not a valid reason for missing a deadline.

Regrading policy: Per the EBE department policy: All graded work should be reviewed promptly by the students. Any questions in regards to potential grading errors should be brought to the attention of the instructor within **one week's time** after the assignment grade is assigned or before the last day of classes, whichever is sooner. **After this, no score adjustments will be made.**

While final exams will not be returned to the students, students are welcome to review their work against a solution. **Other than in the case of grading errors on the final exam, no final course grades assigned will be altered**. Throughout the semester, the course instructor will endeavor to keep you abreast of your standing in the class. Students requiring more feedback should contact the instructor.

If you are going through hardship or longer-than-expected family or health issues, you must get a letter from ACCESS or CEMS student services documenting your situation. Only if you provide such a letter will you be allowed to make up for lost work. You can always discuss your situation with me to see if such letter is needed.

Academic Integrity: It is expected that everything that you submit with your name on is your own work. Anything that is not 100% your own work should be clearly labeled as such (credit your sources, group members, etc.). Students who submit others' work as their own will not pass the course and will be referred to the Center for Student Ethics and Standards for further discipline. The UVM policy on academic integrity is a useful guide:
`https://www.uvm.edu/policies/student/acadintegrity.pdf`.

Please take the Academic Integrity Quiz on Blackboard. Your grades will not be recorded until you take this quiz.

University Attendance Policy: The lecture notes will form the bulk of materials, so attendance is important. Please refer to the most recent UVM Catalogue: *"Students are expected to attend all regularly scheduled classes. The instructor has the final authority to excuse absences."*

If you miss lectures, please send me an email ahead of time.

Student Learning Accommodations: In keeping with University policy, any student with a documented disability interested in utilizing accommodations should contact ACCESS, the office of Disability Services on campus. ACCESS works with students to create reasonable and appropriate accommodations *via an accommodation letter to their professors as early as possible each semester.*
Contact ACCESS: A170 Living/Learning Center - 802-656-7753 - `access@uvm.edu`.

Religious Holidays: Students have the right to practice the religion of their choice. If you need to miss class to observe a religious holiday, *please submit the dates of your absence to me in writing by the end of the second full week of classes.* You will be permitted to make up work within a mutually agreed-upon time.

Extra Help: Do not hesitate to come to my office hours or see my in my office by appointment to discuss a homework problem or any aspect of the course. Blackboard discussion boards are also available if you want to discuss course content with me and your peers.

Approximate Course Schedule: subject to change

Topics	
1	The essence of feedback (ca. 1 week)
2	Mathematical models and representations of systems (ca. 2 weeks)
3	Stability and time domain analysis of control systems (ca. 2 weeks)
4	Performance measures and PID controllers (ca. 1 week)
5	Root locus based analysis of stability and performance (ca. 2 weeks)
6	Controller design based on the root locus (ca. 2 weeks)
7	Frequency domain analysis techniques (ca. 2 weeks)
8	Controller design based on the Bode plot (ca. 2 weeks)

Use of Alcohol/Cannabis: As a faculty member, I want you to get the most you can out of this course. You play a crucial role in your education and in your readiness to learn and fully engage with the course material. It is important to note that alcohol and cannabis have no place in an academic environment. They can seriously impair your ability to learn and retain information not only in the moment you may be using, but up to 48 hours or more afterwards. It is my expectation that you will do everything you can to optimize your learning and to fully participate in this course.

ABET Matrix: In all outcomes listed below, a contribution of 0 means little or no contribution, 1 means moderate contribution, 2 means high level of contribution.

Outcome (1): An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. **Contribution: 2**

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. **Contribution: 1**

Outcome (3): An ability to communicate effectively with a range of audiences. **Contribution: 1**

Outcome (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. **Contribution: 0**

Outcome (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. **Contribution: 2**

Outcome (6): An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. **Contribution: 1**

Outcome (7): An ability to acquire and apply new knowledge as needed, using appropriate learning strategies. **Contribution: 1**

EE Criterion (A): The curriculum must include probability and statistics, including applications appropriate to the program name; mathematics through differential and integral calculus; sciences (defined as biological, chemical, or physical science); and engineering topics (including computing science) necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components. **Contribution: 1**

EE Criterion (B): The curriculum for programs containing the modifier electrical, electronic(s), communication(s), or telecommunication(s) in the title must include advanced mathematics, such as differential equations, linear algebra, complex variables, and discrete mathematics. **Contribution: 2**