Syllabus - ME460 Industrial Control Systems SP 2024

Lectures

Time: Monday and Wednesday, 11:00 AM - 12:20 PM
Location : 2045 Sidney Lu Mech Engr Bldg

Course Staff

Instructor: Prof. Naira Hovakimyan
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Course Website

Most of the course content will be disseminated through the course Canvas page, so make sure to gain access to it canvas.illinois.edu/courses/43531.

Course Information

This course offers an introductory foundation in control theory tailored for undergraduate students. It specifically delves into classical control, a compilation of techniques and methodologies developed during the era spanning the World Wars and reaching its peak around 1960. Classical control techniques continue to be widely employed due to their simplicity and the well-established nature of their design approaches. The evolution of these control systems primarily occurred in research institutions like Bell Labs, the MIT Radiation Lab, and Military Labs.

Many contemporary applications rely on classical control as their fundamental framework, driven by practical necessity and historical significance. For numerous uncomplicated scenarios, classical design methods offer a quick and straightforward route, supported by familiar performance, robustness, and stability metrics. Notably, classical control techniques have deep historical roots in fields like aerospace engineering, where they were initially utilized in aircraft design and have since persisted as valuable tools for both system description and design.

A solid grasp of classical control remains imperative for anyone working with control systems. It is far from obsolete and still finds application in numerous real-world scenarios, contributing significantly to the lexicon and metrics used to describe even the most intricate systems.

TOPICS:

1. Dynamic Systems

- introduction to dynamic systems, control systems, feedback systems
- block diagram abstraction and examples
- mathematical representation of dynamic systems
- differential equations, state-space systems, impulse response and convolution, transfer functions, frequency response, Bode diagrams, and Nyquist plots
- comparison between them and conversion in between representations
- interconnection between systems

2. Modeling
   - time-domain: first order systems and second order systems
   - frequency-domain: identification
3. Analysis
   - Stability
     - stability of systems: Poles, Routh Hurwitz arrays, Bode diagrams, Nyquist plots, Eigenvalues
     - stability of interconnection of systems: BIBO stability, internal stability
   - Performance
     - Gang of four, Gang of six, minimum phase systems
   - Robustness
     - Bode Diagrams, Nyquist criterion, Phase margin, Gain Margin, Sensitivity function
4. Control Design
   - PID control design, loop shaping, lead-lag compensators, pole-placement
   - fundamental limitations on control design

Credit Hours : 4 undergraduate hours or 4 graduate hours. Credit not given for this course and ECE 486.

Prerequisites

ME 340 and ME 360 or equivalent or consent of instructor. Some familiarity with linear algebra, as well as ordinary differential equations, is strongly recommended, although the necessary material will be reviewed in the context of the course.

Course Materials

No specific textbook is essential for the course, and students are not required to buy any textbooks or additional materials. Lecture notes, pre-recorded videos along with presentation slides, will be provided for further study. If students wish to consult a book, Modern Control Engineering, 5th Edition. Katsuhiko Ogata is recommended.

Readings

Each week some concepts will be presented through a collection of video and in-person lectures and will have assigned readings from the lecture notes. These readings will provide details about all of the concepts for the week, as well as detailed proofs and examples.

Homework Assignments

There will be homework assignments (almost) every two weeks in this course. You are encouraged to collaborate and cooperate with your peers on these assignments; however, you should only hand in your original efforts. Evidence of plagiarism will be dealt with seriously. **Late homework will not be accepted except under extenuating circumstances**. Homework assignments should be turned in on **Gradescope** (**Entry Code: ZW57BE**). Use of ChatGPT for assignments is not allowed.

Worksheet Sessions

Each Wednesday, we will work on control design problems in class, addressing the concepts discussed in the Monday's lecture. The homework assignments will closely resemble the worksheet problems, and students are encouraged to participate in Wednesday's worksheet sessions. It's important to note that solutions to the worksheets will be shared during class, and no online solutions will be made available.

Labs

The labs will take place in-person in the room 0036 LuMEB, allowing students to observe practical applications of the theories covered in the course using actual hardware. Each lab includes pre-lab and lab report assignments, and these submissions should be made on Canvas. For any queries regarding the labs, please contact the Lab TA. To access additional details, kindly explore the lab website at coecsl.ece.illinois.edu/me460/. The laboratory sessions encompass the following topics:

1. Lab 1: Dynamic Simulations with Simulink
2. Lab 2: Time Domain System Identification
3. Lab 3: Basic Control Actions
4. Lab 4: Root Locus Control Design
5. Lab 5: Frequency Identification
6. Lab 6: Closed Loop System Identification
7. Lab 7: PID Control with Trajectory Following
8. Lab 8: B&R Automation Studio Programming
9. Lab 9: Lead Compensator Design

Exams

This course will have three exams, one in Week 5 covering topics from Weeks 1-4 of the course, and one in Week 11 covering topics from Weeks 6-10, and the third one in Week 17 covering topics from Weeks 1-13. For week wise lecture details, please refer to the canvas website.

Grading

Homeworks: 20%
Labs: 10%
Exam 1: 20%
Exam 2: 20%
Final exam (comprehensive): 30%

Attendance Policy

Lecture attendance is optional, but attendance is encouraged for lab sessions. Students are encouraged to tailor their course experience to their preferred learning style, provided it does not disrupt the learning experience of their fellow students.

Diversity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of our course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. College is a time of learning and growing for all of us, and we ask everyone to be ready to learn and grow in your respect and understanding of others, in addition to your understanding of the course material.

If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, please let us know so that we can help. You can also report these behaviors to the Bias Assessment and Response Team (BART) bart.illinois.edu/. Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Academic Integrity and Honesty

Engagement in homework assignments and lab reports necessitates independent effort from each student. Collaborating with peers to comprehend problems and determine solution approaches is encouraged, as well as seeking guidance from the instructor. However, any content documented in homework and project reports must originate from the student's individual efforts. Students must actively contribute to any solutions they include, refraining from duplicating the work of others.

Proper referencing is mandatory if any information is extracted from the internet; failure to do so will be considered a breach of academic integrity. Instances of plagiarism or other violations of academic honesty within homework or projects will be subject to appropriate consequences, determined based on the seriousness of the violation. Further details can be found in Article 1, Part 4: Academic Integrity of the University of Illinois at Urbana-Champaign Student Code, accessible at studentcode.illinois.edu/.

Accommodations for Disabilities

We want everyone to be able to succeed in this class. Students who require disability-related academic adjustments and or auxiliary aids should contact the instructor and Disability Resources and Educational Services (DRES) to ensure that proper accommodations are made. To contact DRES, you can call them at 217-333-4603, email them at disability@illinois.edu, or go to their website at disability.illinois.edu.

Modifications to the Syllabus

The instructor reserves the sole right to modify any and all parts of this syllabus throughout the semester. All modifications will be made solely in the interest of time scheduling, accurately measuring the students' success, and improving the students' educational outcomes.