Control Systems Engineering - EGR 362
Block 7, 2020-2021

Professor: Niloofar Kamran
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Office Phone: 319-895-4360
Office hours: M, T, W 2:30-3:30 pm.
Class location: the course is taught via virtual instruction

Textbook: *Modern Control Engineering, 5th Edition*, by Katsuhiko Ogata, Publisher: Pearson, Print ISBN: 9780136156734, 0136156738, eText ISBN: 9780133002256, 013300225X.

Prerequisite: MAT 221, EGR 231, and EGR 311.

Daily Schedule: 9-11 am, 12:30-2 pm, Zoom Link.

Attendance: Your attendance in this class is mandatory, I will ask questions throughout the class to assess your level of understanding of the materials. Not being on the class results in loosing activity point and failing the class.

Course Description: This is a four-semester credit, selected elective class. The goal of Control System Engineering is to apply control theory (classical or modern) to analyze and design systems with desired behavior. The objective of this course is to introduce the student to the topic of feedback control design with applications on various systems. This course covers the mathematical modeling of mechanical and electrical systems, the transient and steady-state response analysis, Root-Locus and frequency response methods, lead and lag compensators, PID controllers, and control systems analysis in state space. In this course Matlab/Simulink and Octave are used to practice modeling and the controller design.

Course Objectives: This course supports the Educational Priorities and Outcomes of Cornell College with emphases on knowledge, inquiry, reasoning, and communication. Upon completion of this course, students will have a good understanding of the following concepts:

1- Introduction to Control Systems.
2- Mathematical Modeling of Control Systems, mechanical, electrical and fluid systems.
3- Transient and Steady-State Response Analyses.
4- Control Systems Analysis and Design by the Root-Locus Method.
5- Control Systems Analysis and Design by the Frequency-Response Method.
6- PID Controllers and Modified PID Controllers.

This course supports the students outcomes in Criterion 4 of ABET for baccalaureate level programs including: 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics, 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 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Ethics project: Work in groups of two. Choose one article from this list. Write a report and explain the paper in your own words and comment on the argument of the paper. Make a presentation and explain the article to the class. Confirm your teammate and the article with me and make sure your article is not already taken. Cover the following consideration if applicable to your case: 1) Analyze the ethical implications of an engineering problem, 2) Proposes a solution or critiques a proposed solution to an engineering problem which impacts the world.

PID Controller Project: It's and hands-on project with a written report.
Phase one: Derive the equation of motion for the ball-beam system. Include the details. Don't forget citations.
Phase two: Explain the role of the sensors and actuators in the system. The explanation must include the theoretical concepts and technical information on the hardware. Include the block diagram of the system.
Phase three: Explain a PID controller and the role of each component.
Phase four: Describe your attempt at designing the PID controller, explain the details of choosing gains. Describe your path in learning the materials in this class, talk about the learning experience from the beginning till now. Did you learn anything new about yourself? What might be done to make your experience better overall?
General expectation: Go beyond the materials introduced in the class and cite at least two external sources in your report that you learned something new/interesting from. Having some historical background is a bonus.
Presentation: It is a short presentation including your experience doing the project and what you learned from it.

Assignments: There are homework assignments for almost every day. You are expected to work on them and reach an understanding of the problem and have a good idea on how they are being solved, and the best is when you solve a problem to the end. We discuss the problems the day after. You need to come to class ready and bring your questions regarding the problems, I don't solve and explain the problems from the scratch.

You need to upload your homework assignments by 5 pm each day in the shared folder. Name your file like this: your last name–Ch#–# of homework from that chapter, example: Kamran-Ch2–2.

I grade your homework based on two criteria: 1) the work that you have done before coming to the class, 2) the work you turn in after we went over your homework questions.

Grades: The exams might have an oral part that I'll ask you to explain the reasoning behind your solution(s).

Midterm exam (second Wednesday)	100	Homework	30
Final exam (fourth Tuesday, ***Cumulative***)	140	Participation in class	30
PID Controller project	100		
Ethics project	50	**Total grade out of**	**450**

The grades are assigned roughly based on this table:

A	93-100		C	74-76
A-	90-92		C-	70-73
B+	87-89		D+	67-69
B	84-86		D	64-66
B-	80-83		D-	60-63
C+	77-79		F	<60

Ch2	Control Systems in Practice Brian Douglas on MATLAB YouTube MATLAB Tech Talks: Control Systems Taylor series Solve: 2-1, 2-6, 2-8, 2-9, 2-11, 2-13
Ch3	Solve: 3-3, 3-5, 3-8, 3-10, 3-12
Ch4	How a Industrial Pneumatic Systems Works Basic Principles of Hydraulics Explained What is Hydraulic System and its Advantages Solve: 4-2, 4-12
Ch5	Servo Basic Concepts Solve: 5-2, 5-3, 5-5, 5-7, 5-11, 5-13, 5-16, 5-18, 5-19 Routh-Hurwitz Criterion by Brian Douglas: part I, part II, part III Solve: 5-20, 5-22, 5-23, 5-26, 5-28 PID controller part I, part II, part III, part IV, part V, part VI, part VII, by Brian Douglas on MATLAB YouTube
Ch6	Walter Richard Evans who developed root-locus method Brian Douglas on root-locus: Introduction, Sketching Part 1, Sketching Part 2, Q&A, Root Locus Plots using Matlab Root-locus more resources: Erik Cheever, David Corrigan, MIT, Kyle Webb Some discussions on minimum phase systems: link I, link II Brian Douglas: Lead-lag compensator, designing lead compensator by root-locus, designing lag compensator by root-locus Experience Controls App Solve: 6-2 (by hand and by Octave), 6-6 (by hand and by Octave) root-locus drawing, 6-7, 6-16, root loci and stability 6-13, 6-17, 6-18, lead compensator design, ~~6-19: compare the step and ramp responses for the original and compensated systems and comment on them lag compensator design 6-21 solve it using the second method, see example 6-9,~~ 6-23: take the dominant poles to be at s= -4±j4 and start designing the compensator from $G_c(s) = \frac{(s+1)(s+4)}{s+p}$ first see the behavior of the uncompensated system then start the designing process, then check the specifications for the compensated system, 6-24: start with assuming the dominant poles in form of $s = x \pm j\sqrt{3}$x, what is maximum overshoot and settling time? 6-28
Ch7	Bode plot by Brian Douglas Decibel Scale from Khan Academy Solve: 7-1, 7-2, 7-3, 7-4, 7-5 Nyquist stability by Brian Douglas: part I, part II Solve: 7-13, 7-14, 7-16, 7-17 Gain and Phase Margins by Brian Douglas Designing lead compensator by Bode plot, designing lag compensator by Bode plot by Brian Douglas Lead, Lag, PID Controllers in Bode plot MATLAB Tech Talk Solve: 7-23, 7-24, 7-26
Ch8	PID controller and examples by Brian Douglas PID in 4 minutes by Stephen Zahra PID Self Driving Cars PID Balance+Ball

	Ball and Beam Rowan Univeristy Ball and Beam Rowan Systems Ball Balancing Beam-Control Theory Project PID temperature controller

Students with disabilities: Cornell College makes reasonable accommodations for persons with disabilities. Students should notify the Coordinator of Academic Support and Advising and their course instructor of any disability related accommodations within the first three days of the term for which the accommodations are required, due to the fast pace of the block format. For more information on the documentation required to establish the need for accommodations and the process of requesting the accommodations, see http://www.cornellcollege.edu/academic-support-and-advising/disabilities/index.shtml.

Academic Honesty: Cornell College expects all members of the Cornell community to act with academic integrity. An important aspect of academic integrity is respecting the work of others. A student is expected to explicitly acknowledge ideas, claims, observations, or data of others, unless generally known. When a piece of work is submitted for credit, a student is asserting that the submission is her or his work unless there is a citation of a specific source. If there is no appropriate acknowledgement of sources, whether intended or not, this may constitute a violation of the College's requirement for honesty in academic work and may be treated as a case of academic dishonesty. The procedures regarding how the College deals with cases of academic dishonesty appear in The Compass, our student handbook, under the heading "Academic Policies – Honesty in Academic Work."

March 22	M	
23	T	
24	W	Confirm your teammate and the paper for Ethics
25	Th	
26	F	
29	M	Turn in phase one of PID project
30	T	
31	W	**Midterm**
April 1	Th	12:30-1:30 pm Guest Speaker
2	F	Turn in Ethics report
5	M	Turn in phase two of PID project
6	T	Ethics Project presentation group 1
7	W	Ethics Project presentation group 2
8	Th	
9	F	
12	M	Turn in phase three of PID project
13	T	**Final Exam**
14	W	Turn in final report for PID project PID project presentation