ME 404: Dynamics and Control of Mechanical Systems

Instructor
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Meeting Time and Place

Tuesdays and Thursdays, 10am–12pm, PHO 202

Description

Although you might not realize it, you use feedback control systems every day. Feedback control is essential to the function of cars, airplanes, computers, communication networks, manufacturing processes, gene networks, neuromuscular systems, and even social interactions. Feedback control is the magic that allows these systems to regulate themselves in order to provide stable, predictable behavior. The goal of this course is to introduce you to the fundamental concepts of feedback control, and to provide you with a set of tools to analyze and design controllers. We will focus on the core concepts of classical (frequency domain) control including Laplace transforms, transfer functions, time response of LTI systems, root locus, Bode plots, Nyquist plots, stability margins, PID control, and lead-lag compensators. We will also introduce the basics of modern (state space) control, including state space modeling and full state feedback control.

Prerequisites

All students should have taken ME 302: Engineering Mechanics II, as well as the standard math sequence. Familiarity with Matlab will be helpful as well.

Structure and Expectations

The course will be have four main components: lectures, problem sets, exams, and a lab.

Lectures Students will be expected to attend lectures and to have read the assigned reading prior to the lecture. Student participation will be encouraged in the lectures in the form of questions and interactive problem exercises.

Problem sets Problem sets will be assigned approximately weekly. You are welcome to discuss the problems with your fellow students, but the solutions that you hand in should contain your *own original work*. Copied solutions are not acceptable. Please make your solutions neat, complete, and legible. The easier it is for the grader to read and understand your solutions, the more likely they will be to give you points. Problem sets should be handed in at the beginning of class on the date they are due. Extensions will only be considered under exceptional circumstances.

Exams We will have one midterm covering approximately the first half of the course, and a final covering all of the course material. Both the midterm and the final will be in class on the dates indicated on the schedule below. If you absolutely cannot make those dates, please let me know as early as possible to arrange a make-up exam. There will not be a final during final exam week.

Lab There will be a single lab that will involve designing and testing a PID controller for a flying wing test rig. It will be performed outside of class at a time to be arranged later. You will form teams of three or four students to perform the lab, and each team will be responsible for submitting a lab report.

Grading

The final course grade will be assigned according to the following weighting:

Homeworks	30%
Midterm	20%
Flying wing lab	10%
Final exam	40%

Course Website

All course materials will be disseminated on the blackboard course website. A link to blackboard can be found at `http://www.bu.edu/students/`.

Drop and Withdrawal Dates

The last day to *drop* the class (without a W appearing on your transcript) is 10/07/2013.
The last day to *withdraw* from the class (with a W appearing on your transcript) is 11/08/2013.

Textbooks

Required:
N. S. Nise, *Control Systems Engineering*, 6th Edition, Wiley, 2011.
S. Sundaram, *ECE 380: Control Systems Course Notes*, Department of Electrical and Computer Engineering, University of Waterloo, 2012. (Available for free on blackboard.)

Optional: G. F. Franklin, J. D. Powell, and A. Emami-Naeini, *Feedback Control of Dynamic Systems*, 6th Edition, Prentice Hall, 2010.
K. Ogata, *Modern Control Engineering*, 5th Edition, Prentice Hall, 2010.
K. J. Åström and R. M. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, 2008. (Available for free online.)

Planned Schedule

Date	Topic	Reading	Homeworks
9/3 T	Introduction and overview	Ch. 1	
9/5 R	System modeling	Ch. 2.1, 2.4–2.9	HW 1 out
9/10 T	Modeling, LTI systems	Ch. 2.4–2.9, 2.11	
9/12 R	Laplace transforms, Partial fractions	Ch. 2.2–2.3	HW 1 due, HW 2 out
9/17 T	Transfer functions, Block diagrams	Ch. 2.2–2.3, 5.2–5.3	
9/19 R	Poles and zeros, 1st order step response	Ch. 4.1–4.3	HW 2 due, HW 3 out
9/24 T	2nd order step response	Ch. 4.4–4.6	
9/26 R	Zeros, Higher order systems, Stability	Ch. 4.7–4.11	HW 3 due, HW 4 out
10/1 T	Feedback, Open loop/Closed loop	Ch. 5.3, 6	
10/3 R	Input tracking, System type	Ch. 7.1–7.7	HW 4 due, HW 5 out
10/8 T	P, PI, PID Control	Sundaram Ch. 12	Form lab groups
10/10 R	Midterm review	Ch. 1–7	HW 5 due, HW 6 out
10/15 T	No class (Monday schedule)		
10/17 R	Midterm		HW 6 due
10/22 T	Root locus method	Ch. 8.1–8.3	Lab time sign up
10/24 R	Root locus plotting rules	Ch. 8.4–8.10	HW 7 out
10/29 T	Root locus control design, PI/Lag	Ch. 9.1–9.2	
10/31 R	Root locus design, PD/Lead, Lead-Lag	Ch. 9.2–9.6	HW 7 due, HW 8 out
11/5 T	Frequency response, Bode plots	Ch. 10.1–10.2	
11/7 R	Bode plotting rules	Ch. 10.2	HW 8 due, HW 9 out
11/12 T	Stability margins	Ch. 10.7–10.13	
11/14 R	Bode control design, Lag	Ch. 11.1–11.3	HW 9 due, HW 10 out
11/19 T	Bode control design, Lead, Lead-lag	Ch. 11.4–11.5	
11/21 R	Nyquist plots	Ch. 10.3	HW 10 due, HW 11 out
11/26 T	Nyquist plotting, Stability margins	Ch. 10.4–10.5	
11/28 R	No class (Thanksgiving break)		
12/3 T	State space control	Ch. 12	HW 11 due, HW 12 out
12/5 R	Final review	Ch. 1–12	Lab reports due
12/10 T	In class final exam		HW 12 due