ENG ME 404: Dynamics and Control of Mechanical Systems

Instructor

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Meeting Time and Place

Tuesdays and Thursdays, 10–12, PHO 202

Description

Although you might not realize it, you use feedback control systems every day. They are 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, analysis, 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 (except when there is a midterm). 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 two midterms covering approximately the first and second thirds of the course, and a final covering all of the course material. The two midterm exams 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. The final exam will be scheduled by the registrar during finals 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:

Problem sets	30%
Midterm 1	15%
Midterm 2	15%
Flying wing lab	10%
Final exam	30%

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 10/09/2012.
The last day to *withdraw* from the class (with a W appearing on your transcript) is 11/09/2012.

Textbooks

Required:
G. F. Franklin, J. D. Powell, and A. Emami-Naeini, *Feedback control of dynamic systems*, 6th Edition, Prentice Hall, 2010.

Optional:
S. Sundaram, *ECE 380: Control Systems Course Notes*, Department of Electrical and Computer Engineering, University of Waterloo, 2012. (Available on blackboard.)
N. S. Nise, *Control Systems Engineering*, 6th Edition, Wiley, 2011.
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	Notes
9/4 T	Introduction and overview	Ch. 1	
9/6 R	System modeling	Ch. 2	PS 1 out
9/11 T	Laplace transforms, Transfer functions	Ch. 3.1	
9/13 R	LTI systems, Block diagrams	Ch. 3.2	PS 2 out, PS 1 due
9/18 T	LTI system response	Ch. 3.3–3.4	
9/20 R	LTI response, Stability, Feedback	Ch. 3.4–3.6	PS 3 out, PS 2 due
9/25 T	Feedback control, System type	Ch. 4.1–4.2	
9/27 R	PID control	Ch. 4.3	PS 4 out, PS 3 due
10/2 T	Root locus intro	Ch. 5.1–5.2	
10/4 R	Root locus plotting rules	Ch. 5.2–5.3	PS 5 out, PS 4 due
10/9 T	No class, Monday schedule	Ch. 5.2–5.3	
10/11 R	Review and examples	Ch. 1–5.3	PS 5 due
10/16 T	Midterm exam 1	Ch. 1–5.3	
10/18 R	Root locus system analysis	Ch. 5.2–5.3	PS 6 out
10/23 T	Root locus control design	Ch. 5.4–5.5	
10/25 R	Bode plot intro	Ch. 6.1–6.2	PS 7 out, PS 6 due
10/30 T	Bode plotting rules	Ch. 6.4–6.6	
11/1 R	Bode plot stability margins	Ch. 6.4–6.6	PS 8 out, PS 7 due
11/6 T	Bode plot lead-lag compensation	Ch. 6.7	
11/8 R	Bode plot PID design	Ch. 6.7	PS 9 out, PS 8 due
11/13 T	Nyquist plot and stability	Ch. 6.2–6.3	
11/15 R	Review and examples	Ch. 5–6	PS 9 due
11/20 T	Midterm exam 2	Ch. 5–6	
11/22 R	No class, Thanksgiving break	Ch. 7.1–7.3	PS 10 out
11/27 T	State space modeling	Ch. 7.1–7.3	
11/29 R	State space analysis	Ch. 7.4	PS 11 out, PS 10 due
12/4 T	No class or alternative arrangements	Ch. 7.5	Instructor gone on travel
12/6 R	State space full state feedback	Ch. 7.5	PS 12 out, PS 11 due
12/11 T	No class or alternative arrangements	Ch. 7.5	Instructor gone on travel
12/13 R	Review and examples	Ch. 1–7	PS 12 due
12/17–12/21	Finals week, schedule to be determined		