AER372 Control Systems

Syllabus and Course Information, Winter 2014

Objective

This course is an introduction to feedback control. Topics include the modelling of physical systems, the analysis of their dynamic behavior (dynamic response and stability), and the design of feedback controllers to achieve a desired closed-loop system behavior.

The objective of this course is to provide a solid foundation of the concepts and methods of classical control theory so that students will have the ability to design and analyze linear feedback systems involving a single input and single output. Additionally, state-space methods are introduced so that students will have the background for future, more detailed studies of this topic.

Instructor

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Teaching Assistants

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Schedule

- Lecture: Tue 11:00–13:00, WB130; Thu 12:00–14:00, WB342
- Lab: Wed (alternating, see schedule below) 15:00–18:00, BA3114 (Lab 1–3) and MC402 (Lab 4)
- Office hours: after class and by appointment (please send an e-mail to the TAs or Prof. Schoellig)

Website

We will use Blackboard for course administration:

`http://portal.utoronto.ca/`.

Reference Material

We will use the course textbook:

Feedback Control of Dynamic Systems (Sixth Edition) by G.F. Franklin, J.D. Powell, and A. Emami-Naeini, Prentice Hall, 2009.

Hand-written class notes will also be made available; notes will typically be ready for download on Friday for the lectures of the upcoming week.

A standard software tool for control systems design and analysis is Matlab/Simulink. We will use Matlab/Simulink for labs and exercises. The software is available to students through ECF – check!

Additional recommended reference material is

> *Course Notes on Classical Control* by B.A. Francis, Electrical and Computer Engineering Department, University of Toronto, `http://www.scg.utoronto.ca/~francis/main.pdf`

and

> *Control Tutorials for Matlab - University of Michigan*, `http://ctms.engin.umich.edu/CTMS/`.

Course Topics and Syllabus

#	Date	Topic	Reading
1	Tue Jan 7	**Introduction**: Control Systems Examples	
2	Thu Jan 9	Introduction: Dynamic Modeling, Linearization	1, 2
3	Tue Jan 14	**Dynamic Response**: Laplace Transform	3.1
4	Thu Jan 16	Dynamic Response: Laplace Transform (continued), Transfer Functions, Block Diagrams	3.2
5	Tue Jan 21	Dynamic Response: Poles and Zeros, Control Specifications	3.3, 3.4
6	Thu Jan 23	Dynamic Response: Effect of Zeros, Stability	3.5, 3.6
7	Tue Jan 28	**Feedback Control**: Basic Equations of Control	4.1
8	Thu Jan 30	Feedback Control: Control of Steady-State Error	4.2
–	Tue Feb 4	*Repetition and Practice Problems (Lectures #1 to #8)*	
–	Thu Feb 6	*Term Test 1 (covers Lectures #1 to #8)*	
9	Tue Feb 11	Feedback Control: Control of Dynamic Error, PID Control	4.3
10	Thu Feb 13	**Root Locus Design**: Root Locus	5.1
–	Feb 18, 20	*Reading Week*	
11	Tue Feb 25	Root Locus Design: Sketching Guidelines	5.2
12	Thu Feb 27	Root Locus Design: Examples for Root Locus Design, Non-minimum-Phase Systems	5.3
13	Tue Mar 4	**Frequency-Response Design**: Frequency Response	6.1
14	Thu Mar 6	Frequency-Response Design: Nyquist Stability Criterion	6.2, 6.3
–	Tue Mar 11	*Repetition and Practice Problems (Lectures #9 to #14)*	
–	Thu Mar 13	*Term Test 2 (covers Lectures #1 to #14)*	
15	Tue Mar 18	Frequency-Response Design: Stability Margins (gain margin, phase margin)	6.4–6.6
16	Thu Mar 20	Frequency-Response Design: Compensation (lead, lag)	6.7
17	Tue Mar 25	Frequency-Response Design: Compensation (PID)	6.7
18	Thu Mar 27	Frequency-Response Design: Design Specifications, Sensitivity Function	6.7.7, 6.7.8
19	Tue Apr 1	**State Space Control**: State-Space Description, Controllability	7.1, 7.2, 7.4
20	Thu Apr 3	State Space Control: Full-State Feedback Design, Observability	7.5–7.7
21	Tue Apr 8	State Space Control: Observer Design, Separation Principle	7.7, 7.8
–	Thu Apr 10	*Repetition and Practice Problems (complete material)*	

Practice Problems

We will make sets of problems available online for the topics covered in the lecture. The term tests and exam for the course will contain some questions that are highly similar to practice problems provided. It is the student's responsibility to solve the problems and understand the material. *Talk to each other and work together!*

Questions can be asked in the office hours. Some of the problems might also be covered during the repetition classes.

#	Covers	Available on
1	Introduction, Dynamic Response, Feedback Control (Lectures #1 to #8)	Fri Jan 10
2	Feedback Control, Root Locu and Frequency-Response Design (Lectures #9 to #14)	Tue Feb 11
3	Frequency-Response Design, State Space Control (Lectures #15 to #21)	Tue Mar 18

Lab Schedule

For the labs the class will be divided into two sections, Section A and B. All Aero-option students must be in Section A because of the scheduling of other course activities.

Two students will work together on the labs. They have to hand in one solution and will both receive the same grade.

	Lab Section A	Lab Section B
Lab 1 (BA3114)	Wed Jan 29	Wed Feb 5
Lab 1 Report Due Date	Wed Feb 12	Wed Feb 26
Lab 2 (BA3114)	Wed Feb 12	Wed Feb 26
Lab 2 Report Due Date	Wed Mar 5	Wed Mar 12
Lab 3 (BA3114)	Wed Mar 5	Wed Mar 12
Lab 3 Report Due Date	Wed Mar 19	Wed Mar 26
Lab 4 (MC402)	Wed Mar 19	Wed Mar 26
Lab 4 Report Due Date	Tue Apr 1	Tue Apr 8

Grading

Grades will be assigned according to the following:

- Laboratories, 20%
- Term Tests, 2×15% = 30%
  - Term Test 1: Feb 6 (during regular class period)
  - Term Test 2: Mar 13 (during regular class period)
- Final Exam, 50%

Allowed aid for the term tests is a single sheet of paper (letter size). Students may enter on both sides of the aid sheet any information they desire, without restriction, except that nothing may be affixed or appended to it. Allowed aid for the final exam are two (2) single sheets of paper (letter size) and a non-programmable calculator.

"Education is not the filling of a pail, but the lighting of a fire."
– Plutarch