AER372 Control Systems

Syllabus and Course Information, Winter 2015

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 13:00–15:00, BA1210; Thu 17:00–19:00, GB221.
- Lab: Mon (alternating, see schedule below) 15:00–18:00, BA3114 (Labs 1–3) and MC402 (Lab 4).
- Office hours: after class and by appointment (please send an e-mail to the TAs or Prof. Schoellig); additional office hours will be offered before the term tests and final exam.

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 (**Seventh** Edition)* by G. F. Franklin, J. Da Powell, and A. Emami-Naeini, Prentice Hall, 2014.

Hand-written class notes will be made available on Blackboard; notes will typically be available for download before the lecture.

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`.

Course Topics and Syllabus

#	Date	Topic	Reading
1	Tue Jan 6	**Introduction**: Control Systems Examples	
2	Thu Jan 8	Introduction: Dynamic Modeling, Linearization	1, 2
3	Tue Jan 13	**Dynamic Response**: Laplace Transform	3.1, A.1
4	Thu Jan 15	Dynamic Response: Laplace Transform (continued), Transfer Functions, Block Diagrams	3.2
5	Tue Jan 20	Dynamic Response: Poles and Zeros, Control Specifications	3.3, 3.4
6	Thu Jan 22	Dynamic Response: Effect of Zeros, Stability	3.5, 3.6
7	Tue Jan 27	**Feedback Control**: Basic Equations of Control	4.1
8	Thu Jan 29	Feedback Control: Control of Steady-State Error	4.2
–	Tue Feb 3	*Repetition and Practice Problems (Lectures #1 to #8)*	
–	Thu Feb 5	*Term Test 1 (covers Lectures #1 to #8)*	
9	Tue Feb 10	Feedback Control: Control of Dynamic Error, PID Control	4.3
10	Thu Feb 12	**Root Locus Design**: Root Locus	5.1
–	Feb 17, 19	*Reading Week*	
11	Tue Feb 24	Root Locus Design: Sketching Guidelines	5.2
12	Thu Feb 26	Root Locus Design: Examples for Root Locus Design, Non-minimum-Phase Systems	5.3
13	Tue Mar 3	**Frequency-Response Design**: Frequency Response	6.1
14	Thu Mar 5	Frequency-Response Design: Nyquist Stability Criterion	6.2, 6.3
–	Tue Mar 10	*Repetition and Practice Problems (Lectures #9 to #14)*	
–	Thu Mar 12	*Term Test 2 (covers Lectures #1 to #14)*	
15	Tue Mar 17	Frequency-Response Design: Stability Margins (gain margin, phase margin)	6.4–6.6
16	Thu Mar 19	Frequency-Response Design: Compensation (lead, lag)	6.7
17	Tue Mar 24	Frequency-Response Design: Compensation (PID)	6.7
18	Thu Mar 26	Frequency-Response Design: Design Specifications, Sensitivity Function	6.7.7, 6.7.8
19	Tue Mar 31	**State Space Control**: State-Space Description, Controllability	7.1, 7.2, 7.4
20	Thu Apr 2	State Space Control: Full-State Feedback Design, Observability	7.5–7.7
21	Tue Apr 7	State Space Control: Observer Design, Separation Principle	7.7, 7.8
–	Thu Apr 9	*Repetition and Practice Problems (complete material)*	

Practice Problems

Problem sets will be available online for the topics covered in the lecture. The term tests and exam 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)	Thu Jan 8
2	Feedback Control, Root Locus and Frequency-Response Design (Lectures #9 to #14)	Tue Feb 10
3	Frequency-Response Design, State Space Control (Lectures #15 to #21)	Tue Mar 17

Lab Schedule

For the labs, the class will be divided into two groups, PRA0101 and PRA0102. The location of Labs 1–3 is BA3114. The location of Lab 4 is MC402.

Two students will work together on the labs. They must hand in one solution and will both receive the same grade. The lab report is due roughly one week after the lab. Please hand it in during Tuesday's lecture.

	PRA0101	**PRA0102**
Lab 1 (BA3114)	Mon Feb 2	Mon Jan 26
Lab 1 Report Due Date	Tue Feb 10	Tue Feb 3
Lab 2 (BA3114)	Mon Mar 2	Mon Feb 23
Lab 2 Report Due Date	Tue Mar 10	Tue Mar 3
Lab 3 (BA3114)	Mon Mar 16	Mon Mar 9
Lab 3 Report Due Date	Tue Mar 24	Tue Mar 17
Lab 4 (MC402)	Mon Mar 30	Mon Mar 23
Lab 4 Report Due Date	Tue Apr 7	Tue Mar 31

Grading

Grades will be assigned according to the following scheme:

- Laboratories, 16%
- In-Class Presentation of Control System Example, 4%
- Term Tests, 2×15% = 30%
  - Term Test 1: Feb 5 (during regular class period)
  - Term Test 2: Mar 12 (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