ME398M: Introduction to Automatic Control

Lectures:

Time: Anytime!

Location: Your Choice (within reason)

Course Overview: The concept of feedback is central in the study of systems and control. Feedback loops are common in nature, even in the most basic biological phenomena from the macroscopic (i.e. population dynamics, climate, etc.) to microscopic (i.e. regulation of glucose levels, temperature regulation, etc.) scales. In engineering, feedback plays a critical role in mechanical, electronic, chemical and digital systems. More generally, systems theory and feedback are central to understanding, analyzing, and designing systems with interconnected components. It is important to understand not only if a system can be controlled, but also for what frequency range and under what conditions.

The purpose of this class will be to gain a basic intuition for and understanding of linear feedback systems and develop the mathematical tools to understand the basics of design and analysis of single-input single-output feedback control systems.

Official Course Description: Analysis of linear automatic control systems in time and frequency domains; stability analysis; state variable analysis of continuous-time and (to less extent) discrete-time systems. Important topics we will cover include:

Course Outline:

- **Part 1 – Fundamentals: Modelling and simulation**
  - What is a dynamical system? Control? Feedback?
  - State space representation of linear systems.
  - Mathematical tools
    - Linear algebra review
    - Solving ODEs (numerically & analytically)
    - Convolution
    - Using MATLAB
- **Part II – State feedback systems**
  - Controllability and state feedback
  - Observability and output feedback
  - Design of state/output feedback systems
  - Performance measures: stability, disturbance rejection, noise attenuation, and tracking (overshoot, steady state error, rise time, etc.)
- **Part III & IV Frequency Response & Design**
  - Transfer functions
  - Block diagrams
  - Proportional Integral Derivative (PID) Control
  - Frequency response design: Bode, Root Locus and Polar plots
  - Stability & gain/phase margins in the frequency domain
  - Common real-world control issues
  - Control design strategies

A significant amount of time will be used to present interesting examples illustrating the basic concepts from many disciplines in order to develop a broad and general perspective on the applicability and impact of feedback control principles.

Course Prerequisites: The primary prerequisite for this class are a linear algebra and differential equation courses. Most other items will be covered in some detail when necessary. Much of what we cover in this class is cumulative. As this class draws heavily on previous work in linear algebra, transforms (primarily Laplace), and differential equations, though we will quickly review the necessary material. In addition to these, **many assignments will require use of MATLAB**. You do not need to have prior exposure to MATLAB, but knowledge of basic programming will be helpful. If you have any concerns, please contact the instructor.

Homework and Exams: In this class, there will be approximately 8-10 homework assignments; three midterm exams, and a final exam. Homework is emphasized, as ***the best way to learn controls is to create controllers***. The exams are designed to ensure you have gained a baseline level of fluency in the material by completing a timed exam of material that requires – at most – a simple calculator. The weighting will be as follows:

- Homework: 50%
- 3 Midterm Exams: 10% each
- Final Exam: 20%

Text and References: Students may find either the following textbooks useful. **Both are optional**.

• *Feedback Systems: An Introduction for Scientists and Engineers*, by Karl J. Astrom and Richard M. Murray. The FBS book is *free,* but a hardcopy can be purchased from the vendor or your choice.

www.fbsbook.org

www.cds.caltech.edu/~murray/amwiki/Main_Page

These websites are for the 2nd and 1st Edition respectively. I link to both in case there is any useful information that has yet to be ported over from the old website. The book's version is currently v3.1.5 and there are occasional updates, which students should be cognizant of since we may not immediately catch them and update reference in our material. If you see something that should be updated, please let us know.

• *Dynamic and control of engineering systems* by Bohdan Kulakowski, John Gardner, and Lowen Shearer, Cambridge, 3rd Edition.

This book is NOT free but has many practice problems and is complementary the main text if you prefer a more traditional textbook format. For this reason, some students prefer it to FBS.

• *Schaum's outline for Feedback and Control Systems* by Joseph Distefano III, Allen Stubberud, and Ivan Williams, 2nd Edition. Tons of examples and very affordable.

If you find either the Matrix algebra or numerical solver lectures based on material you've long forgotten, or you just want to learn more, then there are many great texts on both of these subjects. But two good ones are:

- *Linear Algebra Done Right* by Sheldon Axler.
- *Numerical Methods for Engineers with MATLAB* by Chapra and Canal

Course Policies: *Collaboration* with other students is acceptable. All work submitted for credit, however, must be your own. This includes any MATLAB code required for the assignments. ***Any evidence of plagiarism or other forms of scholastic dishonesty will be grounds for a failing grade in the course.*** *Homework assignments* are a significant portion of the class grade **as an understanding of controls is facilitated by creating controllers**.

Disabilities: The University of Texas at Austin provides, upon request, appropriate academic adjustments for qualified students with disabilities. The University of Texas at Austin provides, upon request, appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4241 TDD or the College of Engineering Director of Students with Disabilities at 471-4382.