MRE 5323: MODERN CONTROL SYSTEMS

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ADMINISTRATIVE STUFF

Topics

- The Instructor
- The Elements
- The Bottom Line

At the end of this section, students should be able to:

- Identify the instructor.
- Locate the course syllabus on Blackboard.
- Calculate current letter grade.

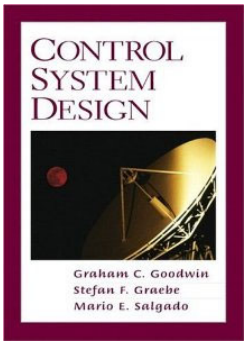
THE INSTRUCTOR

Instructor

- Dr. James Mynderse
- E-mail: jmynderse@ltu.edu
- Office: E43
- Office Hours: TBD

- BSME, MSME, PhD from Purdue University
- >10 years of research experience in Mechatronics
- >5 years of teaching experience in Mechatronics
- Program Director for Mechatronic Systems Engineering
- Research
  - Piezoelectric actuation (PZT, PVDF) with hysteresis compensation
  - UAV flight control
  - Selective laser sintering
  - Li-ion battery manufacturing

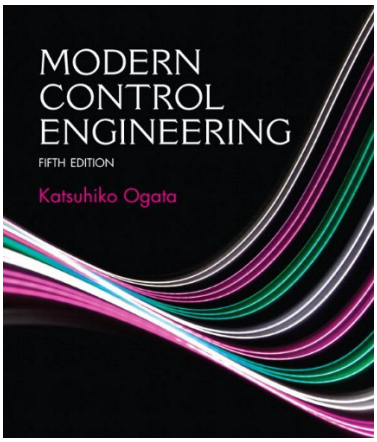
REQUIRED TEXTBOOK



Control System Design, Goodwin, Graebe and Salgado, Prentice-Hall, 2001.

http://csd.newcastle.edu.au/

REFERENCE BOOK



Modern Control Engineering, Katsuhiko Ogata, 5th edition.

GRADING POLICY

Homework	20%
Midterm Exam	35%
Final Exam	35%
(Active) Participation	10%

Active participation includes, but is not limited to: attendance in class, contributions to class discussions, asking questions when unclear, answering questions when clear, and working with partners/teams on in-class assignments

GRADING POLICY

Homework Policy

- Recommended that you work with friends
  Identify your collaborators!
- Homework is to be submitted via Canvas
  Late homework may be penalized at 5% per day
- Submit homework as a single PDF including all necessary figures
  Solutions/Figures not included in solutions PDF will not be graded

Exam Policy

- Closed book and notes
  Two letter-size single-sided hand-written "crib sheets" allowed
- There will be no make-up examinations without prior consent or medical documentation

ACADEMIC HONOR CODE (GRADUATE)

"I pledge that on all academic work that I submit, I will neither give nor receive unauthorized aid, nor will I present another person's work as my own."

- Required on **all** academic work submitted
- Write AHC on first page of your homework
- Exams will include the AHC

Group work

- It is expected that you will work in groups to finish homework: *this work is "authorized"*
- You must still complete the assignment yourself: *copying another student's work is "unauthorized"*

ACADEMIC HONOR CODE

Plagiarism

- Quoting, paraphrasing, or summarizing written material, even a few phrases, without acknowledgment.
- Failing to acknowledge the source of either a major idea or an ordering principle central to one's own paper.
- Relying on another person's data, evidence, or critical method without credit or permission.
- Using unacknowledged research sources gathered by someone else.
- Copying items from Internet websites without acknowledgment of the source.

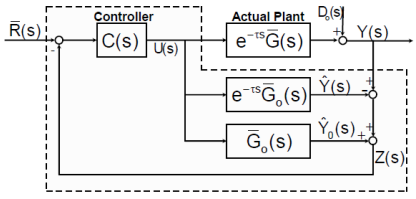
AHC Violation Penalties

- First: *Failure of the course*
- Second: *Expulsion*

THIS COURSE STARTS WITH CLASSICAL CONTROL THEORY

$$\frac{Y(s)}{R(s)} = \frac{P(s)C(s)}{1 + P(s)C(s)}$$

Review of Classical Control Design Methodologies

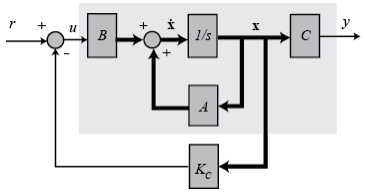


Advanced Classical Control Design Methodologies

THEN WE WILL SHIFT TO MODERN CONTROL THEORY

$$\dot{x} = Ax + Bu$$
$$y = Cx + Du$$

State Space Models and Analysis



Modern Control Design Methodologies

$$V = \frac{1}{2}\int_0^\infty [x^T Q x + u^T R u]dt$$

Linear Quadratic Regulators (LQR)

TENTATIVE CLASS SCHEDULE IS POSTED ON BLACKBOARD

Weeks		Reading 1	Case Study 1	Lecture 1	Reading 2	Case Study 2	Lecture 2
1	01/14/19	Ch. 1	Cruise Control	Introduction / Feedback Control	Ch. 2, 3	HDD Head 1	Modeling
2	01/21/19			MLK Day	4.1 - 4.6	Trickle Bed Reactor	Transfer Functions
3	01/28/19	4.7 - 4.8		Dynamic Response	4.9 - 4.10	HDD Head 2	Frequency Response
4	02/04/19	5.1 - 5.5	HDD 3 / Segway	Analysis (part 1)	5.6 - 5.10		Analysis (part 2)
5	02/11/19	Ch 7	Dextre	Pole Placement	Ch. 8		SISO Design Limitations
6	02/18/19	Ch. 8		Limitations (part 2)	Ch. 9	Inverted Pendulum	Frequency-Domain Design Limitations
7	02/25/19		Tilt Table	Summary of Design Limitations	Ch. 10	Squid	Architectural Issues
8	03/04/19	17.1 - 17.2	Airplane!	Intro to State Space			Midterm Exam
9	03/11/19			Spring Break			Spring Break
10	03/18/19			Exam Wrap-up (if needed)			Linear Algebra
11	03/25/19	3.7	Printer	State Transition Matrix	17.6, 17.8		Controllability
12	04/01/19	18.1 - 18.2		State Feedback		Robotic Welding	State Feedback
13	04/08/19	17.7		Observability	18.3		Full State Observer
14	04/15/19	18.4 - 18.5		Reduced-State Observer			Output Feedback
15	04/22/19			Tracking and Integral Control	22.1 - 22.5	Bus Suspension	Optimal Control (LQR)
16	04/29/19			More LQR			More LQR
17	05/06/19			Review			Final Exam

- Reading assignments are highly recommended
- Case studies may be presented in-class or as part of homework

MATLAB IS NECESSARY TO COMPLETE HOMEWORK; DO YOU HAVE ACCESS?

Available on E103 desktops, download from Help Desk

MATLAB Controls Tutorials: http://ctms.engin.umich.edu/CTMS/

COMING UP…

Feedback Control

- Open-loop control
- Feedback control
- Feedforward control

Modeling Physical Systems

- Why we model dynamic systems
- How we model dynamic systems
- Transfer function models
- State space models