Sample Syllabus

ME 450-2: Modeling of Dynamic Systems
Course Syllabus – Spring 2021

Instructor: Dr. Qian Wang
328 Reber Bldg.
Phone: 865-8281
Email: quw6@psu.edu

Class Schedule: MWF, 1:25pm – 2:15pm,
Remote Synchronous,
You can join the meeting from Canvas/Zoom, or
Zoom link: https://psu.zoom.us/j/93299505450

Office Hours: W, 2:30pm – 3:30pm
You can join the meeting from Canvas/Zoom, or
Zoom link: https://psu.zoom.us/j/99667112806

Teaching Assistants:

- Jiaxuan Wang, jxw5675@psu.edu
  Office Hours:
  1) TuTh 11:00am – noon
     Zoom meeting ID: 966 0559 7055
  2) F 4:30- 5:30pm
     Zoom meeting ID: 932 9950 5450

- Chengyao Gao, cjg6094@psu.edu
  Office Hours:
  1) M 3:30-4:30pm;
     Zoom Link: https://psu.zoom.us/j/98471583860
  2) TuTh 3:30-4:30am;
     Zoom Link: https://psu.zoom.us/j/92607129463

Note: All Zoom meetings have been imported to Canvas/Zoom, and you can join the meetings from there.

Prerequisites: Prerequisite or concurrent: ME 345 or ME 348; Prerequisite ME 370

Text: William J. Palm III, System Dynamics, Fourth Edition (or any edition).

Grading:	Final exam	20%
	Computer project	30%
	Homework	50% (drop the worst)

Grades: 93~100 = A, 90~93 = A-, 85~90 = B+, 80~85 = B, 78~80 = B-, 74~78 = C+, 70~74 = C, 60~70 = D, < 60 = F

- Attendance is required.
- **No late assignments will be accepted.**
- Students are encouraged to work in teams for homework and computer project. Each team for homework can have up to 2 students, and each team for the computer project can have up to 4 students. Each team turns in one homework/report, and all members in a team receive the same grade.

Course Description

This course covers modeling, analysis, and control of single and multiple degree-of-freedom dynamical systems, including mechanical, electrical, thermal-fluid, and their combinations (mixed systems). The processes of energy storage and dissipation, which are common for different kinds of dynamic systems, will be emphasized in investigating general principles for modeling various dynamic systems. Basic concepts in system theory such as state variables and stability notions will be introduced. Most of the content will be restricted to linear-time-invariant systems (LTIs); however, local linearization around nominal operating points will be taught to analyze nonlinear systems. Introduction to classical control analysis and design methods will also be given.

Course Objectives

1. To model various engineering systems, including mechanical, electrical, thermal and fluid systems and their combinations (mixed systems).
2. To solve the model equations analytically and/or numerically using Matlab/Simulink.
3. To relate the solution of the model equations to the physical response of the system.
4. To acquire basic control concepts with working knowledge on transfer function, frequency response, system stability and steady-state error.
5. To perform basic design/analysis of control systems.

Course Outcomes : After completing this course, students should be able to

1. Recognize energy storing elements in an engineering system and choose appropriate state variables.

2. Develop ordinary differential equations (ODEs) that describe the dynamic behavior of lumped parameter systems including mechanical, electrical, fluid, and thermal elements.
3. Analyze nonlinear systems by local linearization around nominal operating points.
4. Draw system block diagrams from the system equations and vice versa: write system equations from block diagrams.
5. Analytically solve linear ODE's for responses to initial conditions and to given excitations such as a step input.
6. Evaluate system performance in terms of "time constant" for first-order linear time-invariant systems (LTIs) and "damping ratio" and "natural frequency" for second-order LTI systems. Understand how to estimate the asymptotes of high-order LTI systems.
7. Understand numerical methods of solutions to ODEs. Use Matlab/Simulink to implement various system models.
8. Understand the Laplace transform of linear ODEs and the concept of transfer functions. Perform frequency-response analyses for linear systems.
9. Understand the basic concepts of feedback control. Determine system stability and stability limits for certain classes of feedback systems.
10. Perform design/analysis calculations for basic linear-feedback control systems. Understand the objectives and functions of proportional (P), integral (I), and derivative (D) feedback controls. Design PID feedback controllers for simple linear systems.

Lecture Calendar

Week		**Date**	**Topic**	**Reading**
1	W	1/20	Introduction	
	F	1/22	System variables and elements	Chapter 4
2	M	1/25	Trans. mechanical systems	Chapter
	W	1/27	Trans. mechanical systems	Chapter 3
	F	1/29	Rot. Mechanical systems	Chapter 3
3	M	2/1	Rot. Mechanical systems	Chapter 3
	W	2/3	I/O model	Chapter 1, 2.1
	F	2/5	I/O model	Chapter 1, 2.1
4	M	2/8	State-space model	5.2, 5.5, 5.6
	W	2/10	State-space model	Chapter 8
	F	2/12	Solving 1st-order models	Chapter 8

5	M	2/15	Solving 2nd-order models	Chapter 8
	W	2/17	Third & high-order models	Chapter 8
	F	2/19	Solving state-space models	Chapter 5
6	M	2/22	Solving state-space models	Chapter 5
	W	2/24	Linearization	Notes
	F	2/26	Linearization	Notes
7	M	3/1	Numerical methods	Chapter 5
	W	3/3	Numerical methods	Chapter 5
	F	3/5	Block Diagram	Chapter 5
8	M	3/8	Matlab Simulink	Chapter 5
	W	3/10	Matlab Simulink	Chapter 5
	F	3/12	Computer Project	
9	M	3/15	Computer Project	
	W	3/17	Electrical systems	Chapter 6
	F	3/19	Electrical systems	Chapter 6
10	M	3/22	Electrical systems	Chapter 6
	W	3/24	Mixed systems	6.5
	F	3/26	Mixed systems	Notes
11	M	3/29	Mixed systems	Notes
	W	3/31	Transfer function	Chapter 2
	F	4/2	Transfer function	Chapter 9
12	M	4/5	Transfer function	Chapter 9
	W	4/7	Wellness Day – No Class	
	F	4/9	Frequency response	Chapter 9
13	M	4/12	Bode plot	12.2
	W	4/14	Bode plot	12.2
	F	4/16	Closed-loop systems	10.1, 10.2
14	M	4/19	Stability	2.2
	W	4/21	Routh-Hurwitz stability	Notes
	F	4/23	Routh-Hurwitz stability	Notes
15	M	4/26	Review for Final Exam	
	W	4/28	Other stability criteria	Notes
	F	4/30	Control systems	Notes

Disabilities Policy

Penn State welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course, contact the Office for Disability Services (ODS) at 814-863-1807 (V/TTY). For further information regarding ODS, please visit the Office for Disability Services Web site at http://equity.psu.edu/ods/.

In order to receive consideration for course accommodations, you must contact ODS and provide documentation (see the documentation guidelines at http://equity.psu.edu/ods/guidelines/documentation-guidelines). If the documentation supports the need for academic adjustments, ODS will provide a letter identifying appropriate academic adjustments. Please share this letter and discuss the adjustments with your instructor as early in the course as possible. You must contact ODS and request academic adjustment letters at the beginning of each semester.

Academic Integrity

Information pertaining to Penn State's policy on academic integrity can be found at http://www.engr.psu.edu/CurrentStudents/acadinteg.asp. In this course, students are permitted to work together on homework assignments, but each student is required to submit his or her own original work. Students are required to work together on class projects and should submit reports completed by the group. Students may not work together or cheat in any way on exams.

Counseling & Psychological Services (CAPS)

CAPS can help students resolve personal concerns that may interfere with their academic progress, social development, and satisfaction at Penn State. Some of the more common concerns include anxiety, depression, difficulties in relationships (friends, roommates, or family); sexual identity; lack of motivation or difficulty relaxing, concentrating or studying; eating disorders; sexual assault and sexual abuse recovery; and uncertainties about personal values and beliefs.

You can contact CAPS by calling the Main CAPS number/Appointment Scheduling: 814-863-0395 (Please call between the hours of 8am and 5pm, Monday-Friday to schedule an appointment) or visit us at our office location, 5th Floor Student Health Center.

Disability Accommodation

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus

(http://equity.psu.edu/sdr/disability-coordinator). For further information, please visit Student Disability Resources website (http://equity.psu.edu/sdr/).
In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines (http://equity.psu.edu/sdr/guidelines). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Online Resources for Relaxation

It's important to take care of yourself. There are a number of valuable online resources that you can use for relaxation and stress reduction. Learn how stress impacts your health and life, as well as some self-help strategies for managing it through the PSU Student Affairs EDGE online workshop. Check out other stress management resources available, including a guided program called Stress Recess. There are also a number of relaxation, visualization, and mindfulness resources at the Mind Body Spa. You can also download mindfulness meditations here. If winter has got you down and you need an upbeat song to listen to, check this out.

Sexual Assault and Relationship Violence Hotline

A hotline has been established for victims and observers of sexual assault and relationship violence. Trained counselors on the hotline will help students access appropriate resources. Penn State students from any campus can call 1 (800) 560-1637 to access the 24 hour a day, seven day a week hotline.

Reporting Educational Equity Concerns through the Report Bias Site

Consistent with University Policy AD29, students who believe they have experienced or observed a hate crime, an act of intolerance, discrimination, or harassment that occurs at Penn State are urged to report these incidents as outlined on the University's Report Bias webpage (http://equity.psu.edu/reportbias/).