San José State University
Charles W. Davidson College of Engineering
Department of Mechanical Engineering
ME 282, Nonlinear and Adaptive Control, Spring 2022

Instructor:	Saeid Bashash
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Office Hours:	Wed. 17:00-18:30 or by appointment

Class Days/Time:	Tu & Th 18:00-19:15
Classroom:	ENG-340 (A Zoom link will be provided for the online sessions)
Prerequisites:	ME 280 or equivalent

Course Description

This course presents practical considerations in control systems design including nonlinearities, parametric uncertainties, and disturbances; phase plane and Lyapunov stability methods for nonlinear systems; sliding mode, adaptive, and adaptive-sliding control design with real-world applications; nonlinear observers, and repetitive learning control.

Course Learning Outcomes

Upon successful completion of this course, students will be able to:

1. Design PID controllers with anti-windup feature
2. Design tracking controllers for linear state-space systems
3. Analyze stability of nonlinear systems using Lyapunov and phase-plane methods
4. Design stabilizing controllers for nonlinear systems
5. Design robust sliding mode controller for linear and nonlinear systems
6. Design adaptive and adaptive-sliding controllers
7. Develop and analyze nonlinear state observers
8. Develop feedforward control logics using repetitive learning method

Required Texts/Readings/Materials

There are no required textbooks for this course. Lecture notes will serve as the main reference, and they will be uploaded to Canvas on a regular basis. The following textbooks are recommended in order of relevance:

- J. J. E. Slotine and W. Li, *Applied Nonlinear Control*, Prentice Hall, 1991.
- H. K. Khalil, *Nonlinear Systems*, 3th Edition, Prentice Hall, 2001.
- H. Marquez, *Nonlinear Control Systems: Analysis and Design*, Wiley, 2003.

Required Software

MATLAB and Simulink:

Free for SJSU students via the campus-wide license: https://www.mathworks.com/academia/tah-portal/san-jose-state-university-31511582.html; A Mathworks account with a SJSU email address is necessary to access the license.

Required Toolboxes: Simulink, Control System Toolbox

Students without a strong background in MATLAB or Simulink are highly encouraged to complete the "MATLAB Onramp" and "Simulink Onramp" courses from https://matlabacademy.mathworks.com/. These courses are free, and come with a certificate upon successful completion.

Course Requirements and Assignments

Assessment for the purposes of determining your course grade will consist of evaluating your performance on homework assignments, midterm exam, term projects, and the final exam. Homework is generally due one week after it is assigned. There will be **only one allowance** for late homework submission and that will include a **20% grade penalty**. The late submission will be due 3-5 days after the original due date. All submissions will be carried out via Canvas. The late submission will be due shortly before the assignment link will expire.

Grading Information

The weighting of course assignments for determining the course grade are as follows:

- Homework: 20%
- Midterm Exam: 25%
- Project: 20%
- Final Exam: 35%
- Lecture Questions: 2% (Bonus)

The scores on your homework, projects, exams, and the lecture questions will be combined and totaled using the weighting scheme described above. A final letter grade will be determined using the following criteria:

Grade	*Points*	*Percentage*
A plus	*95 to 100*	*95 to 100%*
A	*91 to 94.9*	*91 to 94.9%*
A minus	*88 to 90.9*	*88 to 90.9%*
B plus	*85 to 87.9*	*85 to 87.9%*
B	*81 to 84.9*	*81 to 84.9%*
B minus	*78 to 80.9*	*78 to 80.9%*
C plus	*75 to 77.9*	*75 to 77.9%*
C	*71 to 74.9*	*71 to 74.9%*
C minus	*68 to 70.9*	*68 to 70.9%*
D plus	*65 to 67.9*	*65 to 67.9%*
D	*61 to 64.9*	*61 to 64.9%*
D minus	*58 to 60.9*	*58 to 60.9%*
F	*0 to 57.9*	*0 to 57.9%*

Midterm and Final Exams

Both the midterms and the final exam will be based on the topics covered in the lectures. The exams will be closed book and closed notes, but you may receive a formula sheet. Reviewing the lecture notes and homework problems will help prepare for the exams. We will also hold brief review sessions before the exams.

Classroom Protocol

I expect everyone to make their best effort to attend *all* class sessions. Please arrive to the classroom *before* the session begins, and put your cell phone on the 'silent' or 'vibrate' mode. You are encouraged to ask questions and participate in the classroom discussions, however, disrupting the class by engaging in conversation with your classmates must be avoided.

* We will follow strict masking and social distancing rules enforced by the university.

University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/.

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Tentative Course Schedule

Week	Date	Topics
1	1/27	Introduction and course overview
2	2/1, 2/3	PID control design for LTI systems
3	2/8, 2/10	Tracking control design for LTI state-space systems
4	2/15, 2/17	Feedback linearization and output tracking
5	2/22, 2/24	Fundamentals of nonlinear systems; equilibrium points
6	3/1, 3/3	State variable analysis: The phase-plane method
7	3/8, 3/10	Linearization of nonlinear systems; limit cycles
8	3/15, 3/17	Lyapunov stability and Lyapunov-based control design
9	3/22, 3/24	Invariant set theorem
11	4/5, 4/7	Midterm review **- Midterm Exam (4/7)**
12	4/12, 4/14	Sliding mode control
13	4/19, 4/21	Adaptive control
14	4/26, 4/28	Adaptive-sliding control
15	5/3, 5/5	Output tracking and internal stability of nonlinear systems
16	5/10, 5/12	Nonlinear observers , Repetitive learning control
Final Exam	**5/19/2022**	**Thursday, May 19, 2022, 5:15-7:30 pm, ENG-340**