# San José State University
# Charles W. Davidson College of Engineering
# Department of Mechanical Engineering
# ME 282, Nonlinear and Adaptive Control, Spring 2020


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| **Instructor:** | Saeid Bashash |
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| **Office Hours:** | Tu & Th 17:00-18:00<br>or by appointment |
| **Class Days/Time:** | Tu & Th 18:00-19:15 |
| **Classroom:** | ENG-301 |
| **Prerequisites:** | ME 280 (or EE 231, or AE 200) |


## 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

Lecture notes will be uploaded to Canvas on a regular basis. There is no required textbook for this course. The following references are recommended, particularly the first reference:

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

**Required Software**

MATLAB and Simulink

Full MATLAB package is available on the ME computer lab machines at ENG-215. However, since most of the assignments and projects will be MATLAB-based, it is highly recommended to purchase the Student Suite (without any additional toolboxes) from:

https://www.mathworks.com/store/link/products/student/SV?s_tid=ac_buysuite_sv_bod

**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. You must turn in the hardcopy at the *beginning* of the lecture period. There will be **only one allowance** for late homework submission and that will include a **20% grade penalty**. The late submission will be due at the beginning of the next class period.

**Grading Information**

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

- Homework: 20%
- Midterm Exam: 25%
- Project: 20%
- Final Exam: 35%

The scores on your homework, projects, and exams 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 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, so that others are not disturbed by your entry after instruction has begun. If you normally keep a cell phone activated and with you, put your cell phone on 'silent' or 'vibrate' before you enter the classroom. You are encouraged to ask questions and participate actively in the classroom discussions raised during the lectures, however, disrupting the class by engaging in conversation with your classmates must be avoided.

### 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/.

# ME-282 / Nonlinear and Adaptive Control, Spring 2020

**Tentative Course Schedule**

| Week | Date | Topics |
|---|---|---|
| 1 | 1/23 | Introduction and course overview |
| 2 | 1/28, 1/30 | PID control design for LTI systems |
| 3 | 2/4, 2/6 | Tracking control design for LTI state-space systems |
| 4 | 2/11, 2/13 | Feedback linearization of nonlinear systems |
| 5 | 2/18, 2/20 | State variable analysis: The phase-plane method |
| 6 | 2/25, 2/27 | State variable analysis: Limit cycles |
| 7 | 3/3, 3/5 | Lyapunov stability and Lyapunov-based control design |
| 8 | 3/10, 3/12 | Invariant set theorem |
| 9 | 3/17, 3/19 | Sliding mode control |
| 10 | 3/24, 3/26 | **Midterm Exam Review (3/24) and Midterm Exam (3/26)** |
| 12 | 4/7, 4/9 | Adaptive control |
| 13 | 4/14, 4/16 | Adaptive-sliding control |
| 14 | 4/21, 4/23 | Output tracking and internal stability |
| 15 | 4/28, 4/30 | Nonlinear observers |
| 16 | 5/5, 5/7 | Repetitive learning control |
| **Final Exam** | **5/14/2020** | **Thursday, May 14, 2020, 5:15-7:30 pm, ENG-301.** |