San José State University
Charles W. Davidson College of Engineering
Department of Mechanical Engineering
ME 280, Automatic Control Engineering, Fall 2016

Instructor:	Saeid Bashash
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Office Hours:	Tuesday 17:00-18:00 Thursday 13:00-14:00 Or by appointment
Class Days/Time:	Tu-Th 18:00-19:15
Classroom:	Engineering 401
Prerequisites:	BSME or consent of instructor

Course Description

ME-280 is a first graduate course in control engineering. In undergraduate system dynamics and control courses like ME-147 and ME-187 we studied modeling and control of linear systems using transfer function and frequency domain methods, sometimes referred to as classical control methods. In ME-280 we take a different path and study a *state-space approach* to analysis of linear dynamic systems and control design, "traditionally'' referred to as Modern Control Theory. State-space representation facilitates a convenient and systematic approach to analysis and control design for complex linear systems with multiple inputs and outputs. We start by an introduction to state-space representation and then cover key topics in *linear algebra* and *vector spaces*. This background will lay the foundation to important concepts such as *controllability*, *observablility* and the relation between state-space and transfer function representations (*realizations*). The *Lyapunov* approach to stability analysis will be introduced which is key in both linear and nonlinear systems analysis. The last part of the course focuses on linear controller and observer design, first based on *pole placement* approach and then based on *Linear Quadratic Regulator* from *optimal control theory*.

Course Learning Outcomes

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

1. *Develop state-space and transfer function models for linear dynamic systems.*
2. *Simulate the models of dynamic systems in the computer environment*
3. *Determine the solution of linear time invariant (LTI) state-space equations under free initial conditions and forced excitation inputs.*
4. *Determine the controllability and observability of LTI state-space systems.*
5. *Determine stability of LTI state-space systems*

6. *Design and simulate state feedback controllers, observers, and combined controllers and observers for LTI systems.*

Required Texts/Readings/Materials

Recommended Textbooks

- K. Ogata, *Modern Control Engineering*, 5th Edition, Prentice Hall, 2009.
- William L. Brogan, *Modern Control Theory*, 3rd Edition, Prentice Hall, 1990.
- John E. Bay, *Fundamentals of Linear State-Space Systems*, McGraw-Hill, 1998.
- Thomas Kailath, *Linear Systems*, Prentice Hall, 1980.
- Chi-Tsong Chen, *Linear System Theory and Design*, 4th Edition, Oxford University Press, 2012.
- N. S. Nise, *Control Systems Engineering*, 7th Edition, John Wiley & Sons, 2015.
- K. Åström and R. Murray, *Feedback Systems: An Introduction for Scientists and Engineers*, Princeton University Press, 2012. Available for free at: http://www.cds.caltech.edu/~murray/books/AM08/pdf/am08-complete_28Sep12.pdf

Required Software

MATLAB and Simulink Student Suite to be purchased 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 exams, and the final examination. 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:

- HW: 15%
- Midterm #1: 25%
- Midterm #2: 25%
- Final Exam: 35%

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

A 100 – 93% | A- 92 – 90% | B+ 89 – 87% | B 86 – 83% | B- 82 – 80% | C+ 79 – 77% |
C 76 – 73% | C- 72 – 70% | D+ 69 – 67% | D 66 – 63% | D- 62 – 60% | F < 59%.

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 each exam.

Classroom Protocol

I expect everyone to make their best effort to attend *all* class sessions and laboratory periods. Please arrive to the classroom or laboratory *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. Moreover, using computers and tablets during lecture time is highly discouraged unless for taking notes in tablet mode or working on in-class activities.

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-190 / Mechatronics System Design, Fall 2016

Tentative Course Schedule

Week	Date	Topics
1	8/25	Introduction to dynamic systems and feedback control
2	8/30	State-space representation of dynamic systems
2	9/1	State-space representation of dynamic systems
3	9/6	Review of matrix algebra
3	9/8	Review of matrix algebra
4	9/13	Fundamentals of linear vector algebra
4	9/15	Fundamentals of linear vector algebra
5	9/20	Solutions of linear state equations
5	9/22	Solutions of linear state equations
6	9/27	Stability of dynamic systems
6	9/29	Stability of dynamic systems
7	10/4	Review of classical control systems
7	10/6	Review of classical control systems
8	10/11	Midterm #1 Review
8	10/13	**10/13: Midterm Exam #1**
9	10/18	Controllability and stabilizability
9	10/20	Controllability and stabilizability
10	10/25	Observability and reachability
10	10/27	Observability and reachability

Week	Date	Topics
11	11/1	State feedback controller design
11	11/3	State feedback controller design
12	11/8	Design of state observers
12	11/10	Design of state observers
13	11/15	Midterm #2 Review
13	11/17	**11/17: Midterm Exam #2**
14	11/23	Controller and observer integration
14	11/25	Thanksgiving Break
15	11/30	Optimal control and Linear Quadratic Regulator
15	12/1	Integral control
16	12/6	Advanced topics in control design
16	12/8	Course review
Final Exam	**12/15/16**	**Thursday, 17:15 – 19:30, ENG 401**