UNIVERSITY OF CALIFORNIA, DAVIS
Department of Electrical and Computer Engineering

EEC250 Linear Systems and Signals Fall 2009

Course Information

Course Content: Review of linear algebra. Mathematical description of systems. Solution of the state equations and analysis of reachability and observability. Transfer functions, poles, zeros, and realizations. State feedback, pole placement and stability. Observers and state estimation.

Prerequisite: EEC150A

Lectures: MW 2:00–4:00pm, 1134 Bainer

Instructor: Bernard Levy
3183 Kemper
752-8025
Email: levy@ece.ucdavis.edu

Office Hours: Tu 4:00-5:30pm

Course notes and textbook: The lectures will be based on course notes which will be posted by the instructor on the course website. To complement these notes, the following book is recommended, but not required:

Panos J. Antsaklis and Anthony N. Michel, *A Linear Systems Primer*, Birkhauser, Boston 2007.

In addition to the notes and recommended text, several books and Internet resources contain useful complementary material:

a) Gilbert Strang, *Introduction to Linear Algebra*, Fourth Edition, Wellseley-Cambridge, Wellseley, MA, 2009. This book presents an introduction to linear algebra for engineers. Although this material will be reviewed during the first two weeks of the course, students are supposed to be already familiar with it.

b) Alan J. Laub, *Matrix Analysis for Scientists and Engineers*, Soc. for Indust. Applied Math, Philadelphia, 2009. A concise overview of key results of matrix analysis for engineers.

c) Thomas Kailath, *Linear Systems*, Prentice-Hall, Englewood Cliffs, NJ, 1980. This book discusses systems theory in depth, but is addressed at advanced students.

d) Stephen Boyd, lecture notes for Stanford course EE263, *Introduction to Linear Dynamical Systems*, and for course EE363, *Linear Dynamical Systems*, available on Prof.

Boyd's web site: http://www.stanford.edu/~boyd The videos of course EE263 lectures are also available on YouTube at http://www.youtube.com/edu. Linear systems theory presented with a strong optimization flavor.

e) Munther Dahleh, Mohammed Dahleh, and George C. Verghese, notes for MIT course 6.241, *Dynamic Systems and Control*, available through the MIT Open Course Ware Initiative at:
http://ocw.mit.edu/OcwWeb/Electrical-Engineering-and-Computer-Science/6-241Fall2003/CourseHome/index.htm

These notes are addressed at advanced students.

Web Site Information: Most of the information for this course will be provided on the course web page at http://www.ece.ucdavis.edu/~levy/eec250.html. This course information appears on the course web page. Also on the web page will be problem set assignments, problem set solutions, and exam solutions. The web page will be updated frequently during the quarter.

Enrollment: Enrollment in this course is handled on the Web at http://sisweb.ucdavis.edu. If you decide to drop the course, you must place your drop request before Wednesday, October 21, 2009. The last date to add the course is Friday, October 9, 2009.

Problem Sets: Each Wednesday, you will be assigned a problem set, which will be due in class the following Wednesday. Problem set solutions will be posted on the course web site. The problem sets will be graded very coarsely on a scale of 0 to 5.

Examinations: There will be two mid-term exams. The first will take place during the normally scheduled lecture on Wednesday, Oct. 28. The second will be a take-home exam. It will be assigned on Monday November 16, and will be due on the following Monday, November 23 (three days before Thanksgiving). Since this midterm will be relatively time-consuming, it is recommended that you should set aside some time during this week. In addition, there will be a final exam during the examination period scheduled by the Registrar on Friday, December 11 from 8:00-10:00am. The first midterm and final exam will be closed-book, but for these two exams, you will have the right to use respectively one and three $8\,1/2 \times 11$ pages of notes written on both sides. Calculators will be allowed, but you will be informed in advance if you really need them. For the take-home midterm, you are allowed to consult any book or document, except the exam of one of your fellow students. In fact, you are not allowed to discuss the exam with anyone, except the instructor. During the week of the take-home exam, the instructor's office hours will be expanded in order to give you enough time to ask questions concerning the mid-term. Detailed information on exam content will be given in class prior to each examination.

Giving a make-up examination is difficult, as the examination requires a considerable amount of time to prepare, and it is difficult to make this examination equivalent to the regularly scheduled examination. Therefore, requests for make-up examinations will only be approved in cases where strong written justification can be provided. Acceptable justification includes illness (confirmed in writing by a physician) and personal problems (confirmed

by personnel at the Counseling Center). You must contact the instructor before the regularly scheduled examination to request approval of a make-up examination.

Regrading: If you think you deserve more points on a problem set or examination question, write a short note indicating what should be reconsidered, attach it to the problem set or examination, and return it to the instructor. The instructor will review the grading, reassign points if justified, and return the paper in class. If you are still not satisfied with your score, please make an appointment to meet with the instructor.

Grading: Course grades are based on a weighted sum of problem set scores, midterms, and final examination scores, with the following weights.

Problem sets	10%
Midterm 1	20%
Take-home Midterm	40%
Final exam	30%

The grading method lies somewhere in between an absolute scale and a curve. The instructor usually gives approximately 50% As, 40% Bs, and 10% Cs for introductory graduate courses. However, theses percentages are adjusted to take into account yearly fluctuations in the level of student performance.

Course Outline

recommended book that cover topics presented during each lecture are listed in the column with heading Reading.

Date		Lect	Topic	Reading
Sep.	28	1	Vector spaces, matrices	App A.1-A.3
	30	2	Solution of linear equations	App. A.3
			row, column spaces, matrix rank	
Oct.	5	3	Four fundamental spaces of a matrix	
			Linear map, change of basis, similarity	App. A.4
	7	4	Matrix determinant, char. polynomial	App. A.5-A.6
			Eigenvalues/eigenvectors, Jordan form	
	12	5	Linear state-space models	Chap 2
			diff. equation realization	
	14	6	Canonical realizations of diff. equations	Chap. 3
			Solution of state equations	
	19	7	Matrix exponential	Chap. 3
			eigenvalue/eigenvector expression	
	21	8	Natural modes	
			Poles, zeros	
	26	9	Reachability, tests, decomposition	5.2-5.3, 6.2-6.3
	28		*Midterm #1*	
Nov.	2	10	Reachability of CT systems, Gramian	5.3
			Symmetric, positive definite matrices	
	4	11	Observability, tests, decomposition	5.4, 6.2-6.3
	9	12	Kalman decomposition of a linear system	6.2
			Minimal realizations	8.3
	11		*Veterans Day*	
	16	13	Stability, Lyapunov equation	Chap 4
	28	14	Linear state feedback, pole assignment	9.2
	23	15	Observers	9.3
	25	16	Joint controllers and observers	9.4
			Separation principle	
	30	17	Realization of MIMO systems	8.4
Dec.	2	18	Review	
	11		*Final examination* (F, 8:00 – 10:00am)	