Instructor: Zak M. Kassas
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Course Webpage: Available through iLearn
Office Hours: Tue., 6:30 pm – 8:00 pm, and by appointment
Teaching Assistant: Mengfu Di, `mdi002@ucr.edu`
TA Office Hours: Fri. 1:00 pm – 2:00 pm, WCH 223
Lectures: Tue. & Thu., 05:10 pm – 06:30 pm, WCH 143
Discussions: Thu., 6:40 pm – 7:30 pm, WCH 143

Text: John S. Bay, *Fundamentals of Linear State Space Systems*, McGraw-Hill, 1999

Suggested References:

- T. Kailath, *Linear Systems*, Prentice Hall, 1980
- W.J. Rugh, *Linear System Theory*, Second Edition, Prentice Hall, 1995
- J.P. Hespanha, *Linear Systems Theory*, Princeton University Press, 2009
- C.T. Chen, *Linear System Theory and Design*, Fourth Edition, Oxford University Press, 2012

Prerequisites: EE132: Automatic Control

Course Objective: This course develops an understanding of the mathematical tools and fundamental concepts of linear systems. The topics covered include: advanced linear algebra, solutions of state equations, system stability, controllability and observability, system realization, state feedback and observers, and an introduction to optimal control and estimation.

Homework Assignments: Homework assignments will be assigned on a regular basis and will be due at the beginning of the lecture. Late submissions will **not be accepted** (unless it is the result of an officially excused absence). You may discuss homework problems with other students, but you are **not** allowed to copy from others. If you decide to discuss your solutions with other student(s), you must provide the name(s) of the student(s) with whom you have worked. University disciplinary procedure will be invoked if **any** form of cheating is detected. The lowest homework assignment grade will be dropped.

Exams: There will be unannounced, aperiodic quizzes during the discussion sessions. There will also be one midterm exam and a final. Missed exams may **not** be made up (unless it is the result of an officially excused absence).

Project: There will be a final project, which integrates many of the topics introduced in the course. The project will require the use of computer-aided control system design tools (e.g., Matlab and LabVIEW).

Attendance and Course Policy: Attendance is expected. You are responsible for material covered in class and in the reading assignments.

Grading:

Homework Assignments	10%
Project	10%
Quizzes	10%
Midterm Exam	30%
Final Exam	40%

Final Grade Assignment:

A+: $\geq$ 97%, A: $\geq$ 93%, A–: $\geq$ 90%, B+: $\geq$ 87%, B: $\geq$ 83%, B–: $\geq$ 80%, C+: $\geq$ 77%, C: $\geq$ 73%, C–: $\geq$ 70%, D+: $\geq$ 67%, D: $\geq$ 63%, D–: $\geq$ 60%, F: < 60%

Tentative Topical Coverage:

Week	Date	Topics	Chapters
1	09/27	**Models of Linear Systems:** State space, transfer functions, linearization	1
2	10/02, 10/04	**Vectors and Vector Spaces:** Definitions, linear independence, basis, rank, inner products, norms, orthonormalization, projection theorem	2
3	10/9, 10/11	**Linear Operators on Vector Spaces:** Definitions, range and null spaces, simultaneous linear equations	3
4	10/16, 10/18	**Eigenvalues and Eigenvectors:** Definitions, Jordan canonical forms, singular value decomposition	4
5	10/23, 10/25	**Functions of Vectors and Matrices:** Linear functionals, quadratic forms, functions of matrices, Cayley-Hamilton theorem **Solutions to State Equations:** Time-invariant systems, homogeneous systems, phase portraits	5 6
6	10/30, 11/01	**Solutions to State Equations:** Time-varying systems, discrete-time systems **Midterm**	6
7	11/06, 11/08	**System Stability:** Lyapunov stability, equilibrium point, Lyapunov's direct method, time-invariant systems, external stability, relationship between stability types	7
8	11/13, 11/15	**Controllability and Observability:** Definitions, controllability & observability of time-invariant systems, Kalman decomposition, controllability & observability of time-varying systems, controllability & observability of discrete-time systems	8
9	11/20	**System Realization:** Minimal realizations, canonical realizations, balanced realizations	9
10	11/27, 11/29	**State Feedback and Observers:** State feedback for SISO systems, observers, separation principle, Reduced-order observers, discrete-time observers	10
11	12/04, 12/06	**Introduction to Optimal Control and Estimation:** Linear quadratic regulator, Kalman filter	11
12	12/08	**Final Exam**	