EECS 221A: Linear Systems Theory

S. S. Sastry

Fall 2005

Class : Tu Th 9:30 - 11:00 am., 293 Cory Hall
Section : F 2:00 - 4:00 pm., 293 Cory Hall
Instructors:

1. Prof. S. S. Sastry, 514 Cory Hall, sastry@eecs.berkeley.edu, 642-1857. Office Hours: M 2-3 pm. and W 3-4 pm. in 514 Cory or by appointment

2. **Teaching Assistant:** Onureena Banerjee, 262 M Cory Hall, 642-7153 onureena@eecs.berkeley.edu, Office Hours Tu 8:30-9:30 am., F 10-12 am. in 297 Cory Hall or by appointment,

Recommended Reading:

1. F. M. Callier and C. A. Desoer, "Linear System Theory", Springer Verlag, 1991. There is some concern that the format of this book is a little too "terse", but we will try to augment it with examples, supplementary reading and references. Parts of an earlier textbook by C. A. Desoer entitled "Notes for a Second Course on Linear Systems" van Nostrand Reinhold, 1972 (now out of print) will be made available as a reader with Copy Central on Euclid Avenue, under special permission from the author and Springer Verlag, Inc.

2. C. T. Chen, Linear Systems Theory and Design, 3rd Edition, Oxford University Press, 1998.

3. W. J. Rugh, Linear System Theory, Prentice Hall, 1993.

4. T. Kailath, Linear Systems, Prentice Hall, 1980.

5. D. F. Delchamps, State Space and Input-Output Linear Systems, Springer Verlag, 1988.

6. J. Lygeros, C. Tomlin, and S. Sastry, "Hybrid Systems", textbook in preparation, parts of this book will be made available for the last part of the course.

Grades: This class will have roughly 8-10 problem sets for 30 % of the grade, one midterm (8th week of the semester) for 20 % of the grade and a final for 50 % of the grade.

OUTLINE

1. **Review of Linear Algebra:** Rings, fields, vector spaces, matrices, bases, dimensions of vector spaces, properties of linear maps. Norms, induced norms.

2. **Differential Equations:** Linear, finite dimensional, time varying systems: $\dot{x} = A(t)x(t) + B(t)u(t)$. State transition matrix, properties of the state transition matrix; the adjoint equation and the variational equation. The linear time invariant case.

3. **Matrices and their eigenspaces:** Left and right eigenvectors, eigenvalues, invariant subspaces, direct sum of subspaces, minimal polynomials, generalized eigenvectors and the Jordan decomposition theorem. Functions of a matrix and the spectral mapping theorem.

4. **Numerical Considerations:** Hermitian matrices, adjoints, the singular value decomposition, condition number of a matrix.

5. **Controllability, Observability:** Characterization, effects of feedback, output injection, duality. Minimality and the Kalman decomposition, realization, Hankel and Toeplitz matrices. Stabilizability, detectability, internal and I/O stability.

6. **State Feedback and State Estimation:** Eigenvalue assignment by state feedback, full order and reduced order observers. The separation principle for output based pole placement. Applications.

7. **Linear Quadratic Optimal Control:** Least squares control and estimation, Riccati equations and properties of the Linear Quadratic regulator.

8. **Automata, Finite State Systems and Hybrid Systems** Controllability and strong connectedness, Diagnosability, State equivalence and minimality, regular languages and finite recognition systems.