EE221A Linear System Theory

`http://inst.eecs.berkeley.edu/∼ee221a/`

Course Outline

Professor C. Tomlin
Department of Electrical Engineering and Computer Sciences
University of California at Berkeley
Fall 2017

Lecture Information

Lectures: TuTh 2-3:30, Cory 521
Section: F 2-4, Cory 521

Contacts

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Graduate Student Instructor:
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Prerequisites

Linear Algebra (Math 110 or equivalent)

Evaluation

There will be 10 problem sets, a midterm test, and a final exam. Course grades: Problem sets (40%); Midterm (20%); Final (40%).

Section

Discussion sections will be run by the GSI and will supplement the lecture by

- reinforcing concepts already seen in lecture
- discussing practice problems
- introducing applications for the theory seen in lecture.

Discussion handouts will be made available on the class website in advance of discussion, and we will assume that students have familiarized themselves with the material of the section. It would be helpful to start working on the problems before going to section.

If you cannot make the section, go through the handout and try working on the problems yourself. If you get stuck, check with your peers or with the GSI during OH. We will not post solutions to the discussion problems.

Policies

It is encouraged that you work in groups, however each person must hand in her/her own problem sets. Problem sets are due by 4.30pm in Tomlin's mailbox in 253 Cory.

Course references

The course is based on a set of lecture notes which will be made available throughout the term.

Systems:

- F. Callier & C. A. Desoer, *Linear Systems*, Springer-Verlag, 1991.
- C.T. Chen, *Linear Systems Theory and Design*, Holt, Rinehart & Winston, 1999.
- T. Kailath, *Linear Systems Theory*, Prentice-Hall.
- R. Brockett, *Finite-dimensional Linear Systems*, Wiley.
- W. J. Rugh, *Linear System Theory*, Prentice-Hall, 1996.

Algebra:

- G. Golub and C. Van Loan, *Matrix Computations*, Johns Hopkins Press.
- M. Gantmacher, *Theory of Matrices, Vol 1 & 2*, Chelsea.
- G. Strang, *Linear Algebra and its Applications*, 3$^{\text{rd}}$ edition, 1988.

Analysis:

- J. Hale, *Ordinary Differential Equations*, Wiley.
- W. Rudin, *Principles of Mathematical Analysis*, Mcgraw-Hill.
- W. Rudin, *Real and Complex Analysis*, Mcgraw-Hill.

Course Outline

Linear Algebra: Fields, vector spaces, subspace, bases, dimension, range and null spaces, linear operators, norms, inner-products, adjoints.

Matrix Theory: Eigenspaces, the Jordan form, Hermitian forms, positive-definiteness, singular value decomposition, functions of matrices, spectral mapping theorem, computational aspects.

Optimization: Linear equations, least-squares approximation, linear programming.

Differential Equations: Linear time-varying systems $\dot{x} = A(t)x(t) + B(t)u(t)$ and the linear time-invariant case. Existence and uniqueness of solutions, Lipschitz continuity, linear ordinary differential equations, the notion of state, the state transition matrix.

Stability: Internal stability, input-output stability, the method of Lyapunov.

Linear Systems – Open-loop aspects: Controllability, observability, duality, canonical forms, the Kalman decomposition, realization theory, minimal realizations.

Linear Systems – Feedback aspects: Pole placement, stabilizability and detectability, observers, state estimation, the separation principle.

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

Advanced topics as time permits: Robust control, hybrid systems.