ENEE 660: System Theory (Tu-Th 3:30-4:45 pm, fall 2010, CSI 3118)
Course website http://www.enee.umd.edu/courses/enee660.F2010/
Instructor: P. S. Krishnaprasad (krishna@isr.umd.edu; 301-405-6843); office in A.V. Williams Building - room 2233. Office hours: M 4:00-5:00 and 6:00-7:00; and Tu 5:00 -7:00.

Course Goals: This course is intended to provide a rigorous introduction to the structure and analysis of linear dynamical systems with inputs and outputs, and the synthesis and design of controllers for such systems. Fundamental concepts of solutions, internal (state-space) and external (input-output map or transfer function) descriptions, controllability and observability, stability of zero solution, canonical forms, realization of state space models from external data, and feedback and its effect on spectral properties, will form the core of the course. Concepts and results from linear algebra and linear differential equations will be a foundation for the course. Applications of these basic results to deterministic estimation of state (observer theory) and closed loop stabilization will be discussed. Generous use will be made of polynomial matrix theory in developing the time-invariant case. The fine structure of multivariable linear systems and associated invariant theory will also be discussed.

Course Prerequisite: *Prerequisite: ENEE460 or equivalent; MATH463 or equivalent; or permission of instructor.* A prior course in advanced calculus or a good course in differential equations would serve as adequate mathematics background.

Topic Prerequisite: It is desirable that the student be familiar with basic concepts and tools from linear algebra and signals and systems at an undergraduate level.

References:
(a) J. Hespanha *Linear Systems Theory*, Princeton University Press, 2009 (**this is the textbook**).
(b) G. F. Franklin, J. D. Powell and A. Emami-Naeini, *Feedback Control of Dynamic Systems*, 2nd edition, Addison-Wesley, Reading, 1991.
(c) T. Kailath, *Linear Systems*, Prentice Hall, Englewood Cliffs, 1980,
(d) W. J. Rugh, *Linear System Theory*, Prentice Hall, Englewood Cliffs, 1993.

Core Topics:
1. Matrix exponential, transition matrix, equations with periodic coefficients.
2. Stability, matrix Lyapunov equations.
3. Reachability, controllability, observability, gramians.
4. Canonical forms for time-invariant systems, eigenvalue assignment, minimality, state-space isomorphism theorem, impulse response.
5. Hankel matrices, Laurent series, McMillan degree, Cauchy index, minimal realization algorithm.
6. Feedback and structural invariants.
7. Observer-controller design, Bezout equations, time- and frequency-domain approaches to control system design.
8. A look at Riccati equations.

Additional Topics:

Spectral factorization; linear passive systems; applications to system identification; input-output equivalence in other system-theoretic settings.

Grading: Weekly homework sets (10%), Mid-term Examination I on Thursday, October 7 (25%), Mid-term Examination II on Thursday, November 4 (25%), and Final Examination (40%) Saturday, December 18, 10:30 a.m. – 12:30 p.m. All exams will be of the **closed-book** variety.

Policy on Collaboration and Classroom Environment:

(a) Students are encouraged to discuss problems in groups. **But all written submitted work should be individual in nature**.

(b) It is of utmost importance to maintain a classroom environment conducive to focus on and attention to instruction. **Hence usage of electronic devices (music equipment, cell phones, text messaging devices and computers) is disallowed during regular class hours.**