AME 541:Linear Control Systems II

Time:	Th 6:30-9:10
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Homework: Will be assigned every Thursday and **must be submitted** the following Thursday

Grading: The final grade will be assigned according to the following weightings :

Homework:	20%
Midterm (October 2o):	30%
Final (December 8, 7pm):	50%

Textbook
J.P. Hespanha, *Linear Systems Theory*, Princeton Press, 2009.

Reference books

1. C.T. Chen, *Linear Systems Theory and Design, 3rd Edition*, Oxford University Press, 1999.
2. F. Szidarowski and A. T. Bahill, *Linear Systems Theory,* CRC Press, 1992.
3. W. J. Rugh, *Linear Systems Theory*, Prentice-Hall, 1993.
4. T. Kailath, *Linear Systems,* Prentice-Hall, 1980.
5. K. Ogata, *State Space Analysis of Control Systems*, Prentice-Hall, 1967.

Outline

1. **Mathematical Representation of Systems** (Notes)

(a) Modeling of dynamical systems

2. **Linear Systems Modeling** (Chapters 2-4)

   (a) State representation
   (b) Linearization
   (c) Realizations of transfer functions

3. **Mathematical Background** (Notes)

   (a) Linear spaces, norms, basis
   (b) Properties of matrices
   (c) Lyapunov equation
   (d) Singular value decomposition

4. **Solution of State Equations** (Chapter 5-7)

   (a) Properties of transition matrix
   (b) Computation of transition matrix for time-invariant systems
   (c) Equivalent Systems
      i. Time-invariant systems
      ii. Time-varying systems
   (d) Realizations
      i. Time-invariant systems
      ii. Time-varying systems
   (e) Discretization and solution od discrete-time equations

5. **Stability Analysis** (Chapters 8-9)

   (a) Input-output stability of LTI systems
   (b) Internal stability
   (c) Lyapunov theorem
   (d) Bounded-input, bounded output stability
   (e) Conditions for input-output stability

6. **Controllability** (Chapter 11-13)

   (a) Controllability and reachability: definitions and conditions
   (b) Controllable decomposition
   (c) Discrete systems

7. **Observability** (Chapter 15-16)

(a) Observability and constructability: definitions and conditions
(b) Observable decomposition
(c) Kalman decomposition

8. **Minimal Realizations** (Chapter 17)

(a) Implications of of coprimness
(b) Minimal realization of SISO systems
(c) Balanced realization of SISO systems

9. **Poles and Zeros of MIMO Systems** (chapters 18-19)

(a) Polynomial matrices: Smith form
(b) Rational matrices: Smith-McMillan form
(c) McMillan degree, poles and zeros
(d) Transmission zeros and invariant zeros
(e) Minimal realization of MIMO systems

10. **State Feedback and State Observers** (Chapter 14,16)

(a) Stabilizability
(b) Pole placement
(c) Observers
(d) Reduced-order observers.
(e) Separation principle and output feedback

11. **Linear Optimal Control** (Chapter 20)

(a) Quadratic performance indices
(b) Riccatti equation
(c) Robustness characteristics

12. **Frequency Domain Analysis** (Notes)