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:

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
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<tr>
<td>Midterm (October 20)</td>
<td>30%</td>
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<tr>
<td>Final (December 8, 7pm)</td>
<td>50%</td>
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Textbook

Reference books

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 of 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)