1. ES305H Honors Linear Control Systems

2. 4 credit hours, 3 recitation hours, 2 laboratory hours

3. Course coordinator: Professor Rich O'Brien

4. Textbook: Control Systems Engineering: seventh edition, Norman S. Nise, 2015

5. Specific course information

   a. This course provides a foundation in classical control systems covering mathematical modeling, time and frequency response analysis, and design of PID compensators. The lecture material is supported by a series of laboratory projects on the modeling and analysis of physical systems and the design and implementation of control systems for these systems.

   b. Prerequisite: ES202 Principles of Mechatronics

      Co-requisite: ES301 System Modeling and Simulation

   c. Required

6. Specific goals for the course

   a. At the conclusion of the course, students will be able to:

      - Compute the magnitude and angle of a complex number
      - Apply Laplace transform techniques
      - Determine the transfer function from a differential equation using the Laplace transform
      - Compute the poles and zeros of a transfer function
      - Compute the inverse Laplace transform using partial fraction expansion techniques
      - Determine the stability of a transfer function from its poles
      - Apply the final value theorem to compute the steady-state response given a transfer function model and a step input with known magnitude
      - Analyze 1st order systems
      - Predict and sketch the response of a 1st order system given a transfer function model and a step input with known magnitude
      - Analyze 2nd order systems
      - Predict and sketch the response of a 2nd order system given a transfer function model and a step input with known magnitude. Annotate the sketch with settling time, time to peak, peak value, and steady-state value of the response.

- Apply Mason's gain formula to compute a closed-loop transfer (from any input to any output) from a given block diagram
- Compute steady-state error
- Compute the steady-state error for power-of-time inputs using the number of integrators (Type number) in the open-loop transfer function
- Sketch the root locus given an open-loop transfer function
- Draw a specification region given specifications on maximum closed-loop percent overshoot and settling time
- Compute the proportional control gain given an open-loop transfer function and a design point
- Explain the roles of the angle and magnitude criteria in proportional control design
- Compute a compensator given a system transfer function and specifications on maximum closed-loop percent overshoot, settling time, and steady-state error.
- Apply the design process, including selection of the simplest, appropriate compensator
- Interpret compensator design in terms of the (uncompensated) root locus
- Discuss the feasibility of a design point based on its location in the complex plane relative to the (uncompensated) root locus
- Predict the closed-loop step response characteristics based on extra (more than 2 closed-loop poles) and closed-loop zeros
- Iterate the design process until the closed-loop step response meets specifications

b. This course introduces the following Student Outcome:

- (e) an ability to identify, formulate, and solve engineering problems

7. Topics covered:

- System response
- System identification
- Block diagram reduction
- Root locus
- Steady-state error
- System type
- Proportional, Proportional-derivative, Lead, Proportional-integral, Proportional-integral-derivative, and Proportional-integral-lead control design
- System analysis