Due W 10/22

1. Show the region where a dominant pole-pair should be placed to meet the step response criteria \( t_r \leq \frac{1}{3} \text{sec} \), \( t_s \leq 1 \text{sec} \), \( P.O. \leq 15\% \), and \( e_{ss} \leq 1\% \).

2. Design a state-space controller for the pendulum that will meet the step response criteria provided above at the two equilibria \((0,0,0), (\frac{\pi}{2}, 0, mgl)\). Assume our motor can provide a peak input torque of 2Nm. Test your controller (both continuous-time and discrete-time versions through simulation) on the nonlinear system remembering that the linearization process changes the variables to \( \Delta u = u - u_o \), \( \Delta y = y - y_o \) and \( \Delta \vec{x} = \vec{x} - \vec{x}_o \), so you’ll have to include the operating point in your controller. Try a reference signal of \( \Delta r = r - r_o = 0.2 \text{rad} \). Is your system controllable? Do your controllers meet all the specifications? Include supporting information, figures, pole locations, responses, control algorithm, etc.

3. Design a state-space controller for the magnetic-ball-suspension system that will meet the criteria provided above at the equilibria \((0.5m, 0m/s, -2.215A, -2.215V)\). Assume our voltage supply can provide a peak input voltage of 24V. Test your controller (both continuous-time and discrete-time versions through simulation) on the nonlinear system remembering that the linearization process changes the variables to \( \Delta u = u - u_o \), \( \Delta y = y - y_o \) and \( \Delta \vec{x} = \vec{x} - \vec{x}_o \), so you’ll have to include the operating point in your controller. Try a reference signal of \( \Delta r = r - r_o = -0.02 \text{m} \). Is your system controllable? Does your controller meet all the specifications? Include supporting information, figures, pole locations, responses, control algorithm, etc.

4. Find a reference (paper, web site or book) that describes a levitating ball apparatus used in a control experiment. Turn in a copy of it and identify the key components (controller, actuator and sensor) and mathematical model if presented.

5. Do you have any ideas of how to build a levitating ball apparatus? What would you use for the controller, actuator and sensor?