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To: ME 5554 / AOE 5754 / ECE 5754 Students

From: Dr. Steve Southward

Subject: Phase II Development Program (i.e. your Final Project)

Now that you have gained pole-placement experience developing a full-state feedback control system, your next task is to develop a full-state estimator and demonstrate its closed-loop performance through a series of simulation studies. This part of the design project will ONLY focus on the y-direction dynamics, states, and control signals.

Problem 1. [5 pts.] Determine the observability of the open-loop plant.

Problem 2. [5 pts.] Starting from a valid set of closed-loop pole locations for full-state feedback (you can use the design that was presented in class), design the state feedback controller gains. The closed-loop performance must meet the requirements as defined below:

- $|y| \le 0.2m$ after 10 seconds
- $|u_1| \le 10000, \quad |u_4| \le 1000$
- $y_1(0) = 0.2, \quad p_4(0) = -0.5,$ all other states are zero

Simulate the closed-loop response of the system for 16 seconds, and plot the output response as well as the control signal responses.

Problem 3. [5 pts.] Design a set of closed-loop observer pole locations for a state estimator. The closed-loop performance must also meet the same requirements as defined above. Plot the open-loop poles, the closed-loop controller poles, and the observer poles on a pole-zero map.

Problem 4. [20 pts.] Demonstrate your output feedback control system by simulating the closed-loop performance of your complete output feedback controller (i.e. full-state feedback + state estimator). Your simulation should produce plots for the output and the inputs using a format like what was used in the Midterm Project. Choose the exact same initial conditions for the plant that were used in problem 2 above; however, you MUST choose all zero initial conditions for the observer state vector. Your simulation should plot the responses out to 16 seconds; however, the controller cannot be turned on until after 4 seconds. The first 4 seconds should be an open loop response of the plant to allow the observer to converge. You must also modify your plotting code to plot the observer outputs $\hat{y}$ directly on the corresponding subplots.