Midterm #1

ELEE 4700/5700, Controls II

Professor Hill

University of Detroit Mercy, Fall 2010

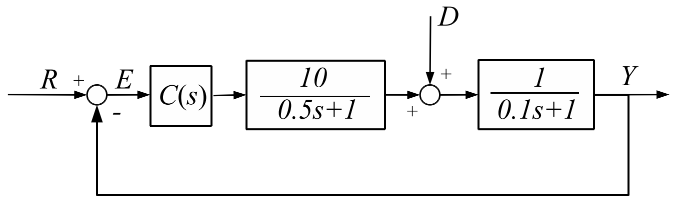
Name: ______________________________

Date: ______________________________

Scores:	Problem 1	________	25 points
	Problem 2	________	45 points
	Problem 3	________	30 points
	total	________	100 points

Please write your answers in the spaces provided on the exam. If you use the backs of the pages or extra sheets, provide a note and/or arrows to point out the location of your solution.

1. (25 points) Consider a system for the speed control of a magnetic tape-drive system shown in the figure below. The speed sensor is fast enough that its dynamics can be neglected and the diagram shows the equivalent unity feedback system.



(a) (6 points) Sketch the region in the complex plane where the closed-loop poles must be located to satisfy the requirement that the settling time be less than 0.1 seconds and the overshoot be less than 5% assuming a step input and a canonical second order system.

(b) (15 points) Find values of K_P and K_D for a PD controller that will place the closed-loop poles in the region identified in Part (a).

(c) (4 points) After implementing the controller you designed in Part (b) the resulting system response still has too much overshoot and the settling time is too large. How could you change your gains to meet the necessary requirements? Justify your answer.

2. (45 points) Consider the system from Problem 1 again. There are some disadvantages associated with PD control that you might like to avoid by employing a lead controller of the form given below.

$$C(s) = \frac{s+z}{s+p}$$

(a) (12 points) Design $C(s)$ to place the closed-loop poles at $s = -50 \pm 40j$. You may assume that the pole of the compensator is $p = -250$. Therefore, you only need to determine the location of the zero z.

(b) (4 points) Identify two reasons why a lead compensator may be preferred to a PD compensator.

(c) (10 points) Sketch the closed-loop step response of a canonical second order system with poles located at $s = -50 \pm 40j$.

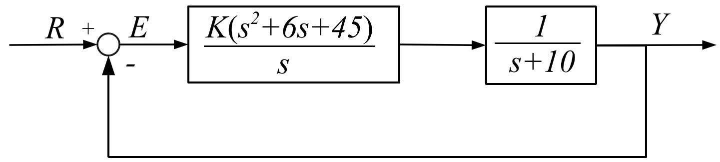
(d) (3 points) Would the actual closed-loop step response for this system match the sketch drawn in Part (c)? Explain why or why not.

(e) (7 points) Determine the steady error experienced by the resulting closed-loop system subject to a unit step reference.

(f) (3 points) How could the pole and zero of your lead compensator be modified to further reduce the steady state error you found in Part (e)? Justify your answer.

(g) (6 points) Identify two other ways your compensator could be redesigned to reduce the steady state error of the closed-loop system. What are the tradeoffs between these two alternative approaches?

3. (30 points) Consider the following closed-loop system employing a PID controller.



(a) (15 points) Sketch the root locus for this system.

(b) (5 points) Based on your answer to Part (a), can you achieve closed-loop poles with a damping ratio of $\zeta = 0.707$ only modifying the value of K? Explain.

(c) (10 points) Find the value of K and the closed-loop pole locations that will achieve the fastest response possible (smallest t_s) with the minimum amount of overshoot.