EE 141 – Final
Fall 2013

03/20/2013
Duration: 2 hours and 50 minutes

The final is closed book and closed lecture notes. No calculators.
You can use a single page of handwritten notes.
Please carefully justify all your answers.

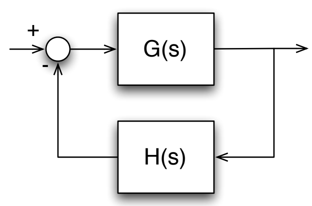

Figure 1: Feedback interconnection for Problem 1.

Problem 1: Consider the following linear differential equation:

$$\frac{d}{dt}x_1 = -x_1 + 2x_2 \quad (1)$$

$$\frac{d}{dt}x_2 = x_2 + u. \quad (2)$$

1. Assuming that $x_1(0) = 0$ and $x_2(0) = 0$, what is the evolution of x_1, in the time domain, when a step is applied as input at $t = 0$?

2. Assume that we place a controller with transfer function $H(s) = K_D s + K_P$ in a feedback loop with the system G defined by the differential equations (1) and (2), as depicted in Figure 1. Design K_D and K_P so that the rise time of the closed-loop system is 0.9 seconds and the damping ratio is 1.

3. For your design, compute the overshoot and the settling time.

4. Sketch the step response.
5. Would the closed-loop system be able to track a ramp?

Problem 2: Consider the system described by the transfer function:

$$G(s) = \frac{s+1}{s^2(s+10)^2}$$

1. Sketch the root locus for G.
2. Where would you place the closed-loop poles in order to reduce the overshoot in a step response?
3. How would the range of values of K for which the closed-loop system is stable change if you eliminate one of the poles located at -10?
4. Sketch the bode plot for G.
5. What is the phase margin for this system?
6. What would the phase margin be if you eliminate one of the poles located at -10? Relate the answer to this question with the answer you gave to question 3.
7. What is the maximum phase margin you can achieve by controlling G with a proportional controller while maintaining the closed-loop system stable? Carefully justify your answer.