EE 141 – Final
Spring 2018

06/11/18
Duration: 2 hours and 50 minutes

The final is closed book and closed lecture notes. No calculators.
You can use a single sheet of handwritten notes.
Please carefully justify all your answers.
Make sure your answers (handwriting) are clear and legible.

Problem 1: Consider the vertical motion of a drone subject to the following forces: lift created by the propellers, gravity, and aerodynamic resistance modeled as a force proportional to velocity.

1. Write the equations of motion describing the vertical motion of the drone (there is no other type of movement except for vertical motion).
2. Compute the transfer function from lift (this is treated as an input) to the drone's vertical position.
3. Is the system described by this transfer function stable?
4. Design a controller so that the system described by the transfer function in item 2 can track step reference inputs. Provide the set of all the values that can be used for the constants appearing in your controller.
5. Compute the point reached by the drone when you use the controller designed in item 4 with a reference of L meters. Do not forget to account for the effect of gravity.
6. If the answer to your previous question was different from L meters, redesign your controller so that the answer becomes L meters. Provide the set of all the values that can be used for the constants appearing in your controller.

Problem 2: Consider the transfer function:

$$G(s) = \frac{7}{(s^2+1)(s+1)-7},$$

in closed-loop with a proportional and derivative controller $D(s) = K_p + K_d s$ placed on the feedback path.

1. Sketch the root locus with respect to the parameter K_d knowing that $K_p = 1$.
2. Which value of K_d would you pick to reduce the settling time?

Problem 3 Consider the transfer function:

$$G(s) = 10^8 \frac{s+1}{(s^2+5s+100)(s+1000)^2}.$$

1. Sketch the bode diagram for G.
2. Knowing that a proportional controller with gain 1000 in a unity feedback loop with G results in an unstable system, what are the phase and gain margins of G?
3. Design a proportional controller that achieves a gain margin of 40dB.
4. Design a compensator that results in a gain of 10dB at 0.01rad/s and a gain margin that is infinity.
5. What is the bandwidth for the closed-loop system?