EE 141 – Midterm

02/12/15
Duration: 1 hour and 40 minutes

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

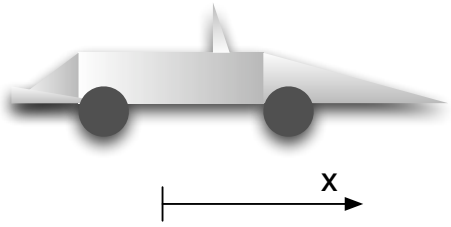

Figure 1: Car for Problem 1.

Problem 1: Consider a car moving horizontally as represented in Figure 1.

1. Write the differential equation governing the position of the car knowing that there are only two forces applied to the car: f, the force generated by the engine, and the aerodynamic drag which is proportional to the velocity with proportionality constant b.

2. Assume now that the transfer function from the gas pedal position p to the force generated by the engine is:
$$\frac{F(s)}{P(s)} = \frac{2}{s+k}$$
where $k \in \mathbb{R}$ is a parameter to be designed. What is the transfer function from $P(s)$ to the velocity of the car $V(s)$ assuming zero initial conditions?

3. Using the inverse Laplace transform and $m = b = 10$ compute the value of k for which $\lim_{t\to\infty} v(t) = 1$ when a step is applied as input.

4. For your choice of k, what is the settling time and the overshoot?

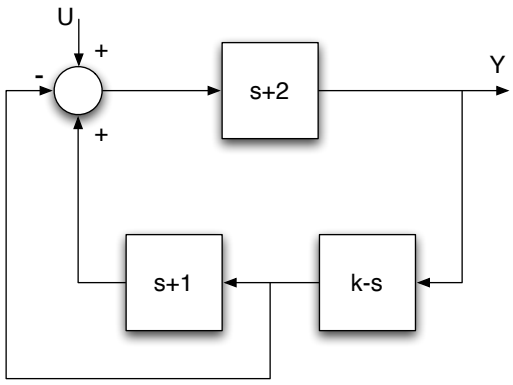

Figure 2: Block diagram for Problem 2.

Problem 2: Consider the system represented in Figure 2 with input U and output Y.

1. For which values of k is this system stable? It may be helpful to know that $\sqrt{6} \approx 2.45$.
2. Pick a value of k making the system stable and design a controller so that the resulting closed-loop system is able to track step inputs with zero steady-state error.