ECE 327: LABORATORY EXERCISE 4: ROOT LOCUS ANALYSIS AND DESIGN

EXERCISE 1. For the unity feedback system shown in Figure 1, where

$$G(s) = \frac{K(s^2 - 2s + 2)}{(s+2)(s+4)(s+5)(s+6)}$$

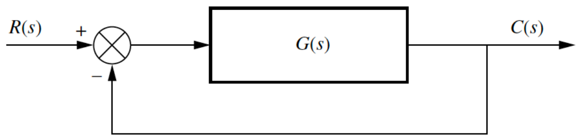

FIGURE 1

(a) Sketch the root locus.
(b) Find the range of gain, K, that makes the system stable.
(c) Find the breakaway points.
(d) Find the value of K that yields a closed-loop step response with $25\,\%$ overshoot.
(e) Find the location of higher-order closed-loop poles when the system is operating with $25\,\%$ overshoot.
(f) Using the "*feedback*" function, find the closed-loop transfer function. By plotting the step response of the feedback system discuss the validity of your second-order approximation.

EXERCISE 2. A unity negative feedback system has the open-loop transfer function

$$G(s) = \frac{(1+p)s - p}{s^2 + 4s + 10}.$$

Develop the root locus as p varies; $0 < p < \infty$. For what values of p is the closed-loop stable? (Hint. Write the characteristic equation so that the parameter of interest p appears as a multiplier, i.e., $1 + pH(s) = 0$).

EXERCISE 3. Sketch the root locus for the system as shown in Figure 2 and find the following:

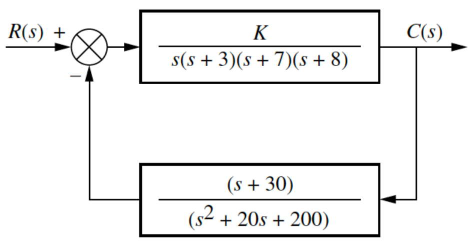

FIGURE 2

(a) The range of gain to yield stability.
(b) The value of gain that will yield a damping ratio of 0.707 for the system's dominant poles.
(c) The value of gain that will yield a settling time of 4 seconds.
(d) The value of gain that will yield 1 second rise time.

(**Useful Formulas.** (1) Rise time: $T_r \approx \frac{1.8}{\omega_n}$, (2) Damping ratio: $\zeta = \frac{-\ln(\text{P.O.})}{\sqrt{\pi^2 + \ln^2(\text{P.O.})}}$, where P.O. denotes the percent overshoot, and (3) Settling time: $T_s \approx \frac{4}{\zeta\omega_n}$, where $\zeta\omega_n$ is the real part of the closed-loop pole).