1. The open-loop transfer function of a unity negative feedback system is:

$$G(s) = \frac{K}{s(s+2)}$$

A system response to a step input is specified as follows: Peak time $T_p = 1s$ and percent overshoot = 5%.

   (a) Determine whether both specifications can be met simultaneously by selection of K.

   (b) If the specifications cannot be met simultaneously, determine a compromise value for K so that the peak time and percent overshoot specifications are relaxed by the same percentage.

2. A position-control system has the overall transfer function (meter/meter) given by

$$\frac{y}{r} = \frac{b_0 s + b_1}{s^2 + a_1 s + a_2}$$

Suppose we are able to select all the parameters. Choose them so that

   (a) Rise time is $t_r \leq 0.1s$.

   (b) Percent overshoot $M_p \leq 20$.

   (c) Settling time $t_s \leq 0.5s$.

   (d) Steady-state error to a constant command is zero.

   (e) Steady-state error to a ramp of $0.1m/s$ is not more than 1 mm.

3. Prove that a combination of two poles p_1 and p_2 and one zero z_1 to the left of both of them on the real axis results in a root locus that is a circle centered at the zero with radius $\sqrt{|p_1 - z||p_2 - z|}$.

4. Sketch the root locus for the following systems. Be sure to give the asymptotes, arrival and departure angles, and imaginary crossings if any.

   (a) $KG(s) = \dfrac{K}{s(s^2 + 2s + 10)}$.

   (b) $KG(s) = \dfrac{K(s^2 + 2s + 8)}{s(s^2 + 2s + 10)}$.

   (c) $KG(s) = \dfrac{K(s^2 + 2s + 12)}{s(s^2 + 2s + 10)}$.

   (d) $KG(s) = \dfrac{K(s+3)}{s(s+1)(s^2 + 4s + 5)}$.

   (e) $KG(s) = \dfrac{K(s+2)}{s^4}$.

5. Draw Bode plots for the following systems.

   (a) $G(s) = \dfrac{1}{(s+1)^2(s^2+s+2)}$.

   (b) $G(s) = \dfrac{s}{(s+1)(s+5)(s^2+5s+2500)}$.

   (c) $G(s) = \dfrac{4s(s+10)}{(s+20)(4s^2+5s+4)}$.

   (d) $G(s) = \dfrac{10(s+4)}{s(s+2)(s^2+2s+5)}$.