Reading Assignments:

Shinners: Chapter 6 (Sections 6.7 and 6.12).

Doyle, Francis, and Tannenbaum: Chapter 5.

Please enter your answers using the D2L Quiz for Homework #8.

1. Given

$$G[s] = \frac{300(s+100)}{s(s+10)(s+40)}$$

(a) Sketch the Bode plot (magnitude plot and phase plot), by hand.
(b) From your sketch, show that the phase crossover frequency, i.e., the frequency where the phase curve equals -180°, is 28.3 radians/second.
(c) Find the magnitude of the transfer function, in dB, at the phase-crossover frequency.

2. Problem P8.6 (Dorf and Bishop). See the Problem Statements in the file immediately below this homework assignment on the course website.

3. Exercise E10.4 (Dorf and Bishop). You should be able to sketch a straight-line approximation Bode plot of $G_c[s]G[s]$ with K = 100. For this problem, however, you may generate the true Bode plot using MATLAB. Identify on the MATLAB Bode plot, by hand, the gain crossover frequency, ω_G, the phase crossover frequency, ω_P, the phase margin, PM, and the gain margin, GM.

4. Problem P10.1 (Modified part (a)). You may use $K_1 = 1.0$, $K_2 = 1.0$, and J = 1.0. For this problem, show that a phase-lead controller $G_c[s] = \frac{K(s+z)}{(s+p)}$ with K = 81.25, z = 3, and p = 15.7 does a reasonable job at meeting the design specifications. Show this controller works, by executing the following MATLAB commands.
   a. Plot the Bode plot of the uncompensated system. You should be able to use the MATLAB command 'bode' to generate the Bode plot. For example, the following two commands should work: g = tf(1,[1,0,0]); bode(g)
   b. Plot the Bode plot of the compensated system and have MATLAB calculate the stability margins. You can use the command: margin(lgain), assuming that 'lgain' is the name

used to label the series combination of your plant and controller. A MATLAB command like lgain = g * gc; will produce the series combination of two transfer functions. See the definition of gc in part (c).

c. Plot the Bode plot of the compensator. For example, gc = tf([81.25*[1,3],[1,15.7]), bode(gc). What is the maximum amount of phase your compensator adds to the system? At what frequency does your compensator add in the maximum amount of phase?
d. Plot the Bode plot of the closed-loop system. What is the bandwidth (-3dB) of your system? The closed-loop system may be obtained using the 'feedback' command in MATLAB. For example, cltf = feedback(lgain,1); bode(cltf) will generate a Bode plot of the closed-loop system. MATLAB assumes negative, output feedback in 'feedback'. In the feedback command shown, I have let H[s] = 1 (the feedback transfer function has been set equal to one).
e. Plot the step response of the system. Does your percent overshoot correspond to the overshoot of a pure, two-pole system with a $\zeta = 0.6$? Explain why your overshoot does or does not agree with Figure 5.7 (or Figure 4.5 in Shinners' Text, see below). (A step response of the closed-loop system can be generated using the 'step' command in MATLAB. For example, step(cltf) should produce the needed time domain step response for a closed-loop system stored in 'cltf'.)

The Dorf and Bishop problems are from "Modern Control Systems," Thirteenth Edition, Richard C. Dorf and Robert H. Bishop, 2017.

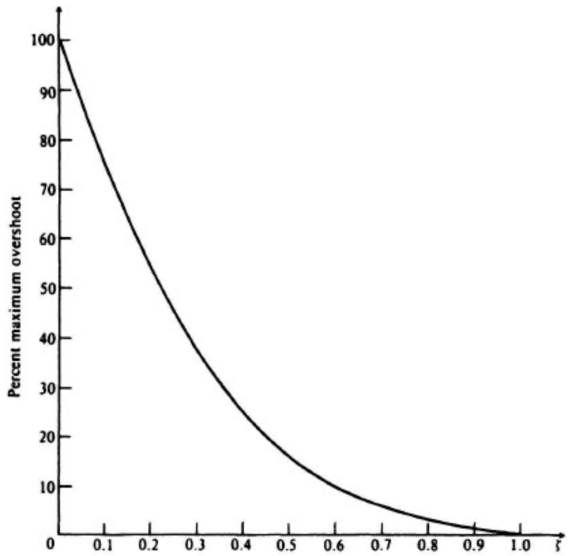

Figure 4.5 Percent maximum overshoot versus damping ratio for a second-order system.

Figure 4.5 from "Modern Control System Theory and Design," Second Edition, Stanley M. Shinners, John Wiley & Sons, Inc., 1998, pg. 249.