Chapter 10 HW Assignment & Hints

Review Questions. 2, 5, 6, 19, 20.

Problems. 1a, 2a, 4a, 25, 44.

Problem 1(a). Substitute $s = j\omega$ into the given $G(s)$, and evaluate the magnitude and angle of the resulting complex expression. Multiply out the denominator as appropriate, then find the magnitude and angle.

I got an intermediate result of

$$G(j\omega) = \frac{1}{\omega\left[-6\omega + j(8 - \omega^2)\right]} \tag{1}$$

It's not too hard to find expressions for the magnitude and angle of (1).

Express your magnitude and angle expressions as

$$M(j\omega) = ???$$
$$\phi(j\omega) = ???$$

Be sure and use the `atan2` function for computing arctangent (not really necessary unless you're going to compute it, but...)

Problem 2(a). Plot the Bode plots of 1(a) using MATLAB. You can either use MATLAB to evaluate the results you got in Problem 1(a), or use the MATLAB`bode(G)` built-in function (much easier).

If you just invoke `bode(G)`, MATLAB will select the frequency range of ω and draw plots "automatically." You can specify various parameters to `bode()` and have left-hand results returned to let you have more control over the plots. Probably nobody wants to do this, but you can...

Problem 4(a). Now **SKETCH** the Bode plots for 1(a) using the asymptotic approximations. Compare the sketch with the plots of Problem 2. In fact, you could make a second copy of the MATLAB plots for Problem 2 and sketch the asymptotic approximations "on top" of the MATLAB plots. Just a suggestion...

Problem 25. You are given Bode plots of the forward path $G(s)$ in a unity-feedback control system. Note that these are (supposed to be) experimentally-obtained plots; we're never given the $G(s)$ transfer function.

  a. The gain margin, phase margin, zero dB frequency, and 180° frequency can all be found directly from the given Bode plots. The closed-loop bandwidth (frequency at which the closed-loop amplitude ratio is -3 dB) can be approximated by applying the reasoning from the middle paragraph of text p. 591:

> ...the closed-loop bandwidth ω_{BW} equals the frequency at which the open-loop magnitude response is between -6 and -7.5 dB if the open-loop phase response is between $-135°$ and $-225°$ (true for this problem)...

  So the open-loop tandwidth is generally a little lower than the closed-loop bandwidth (a general principle). Nevertheless, if you want to achieve a given closed-loop bandwidth, the bandwidth of the open-loop should be about that high. Then you're safe.

  b. The damping ratio is related to phase margin by Fig. 10.48; we have already studied the relationship between damping ratio and % overshoot. The closed-loop bandwidth, settling time, and peak time are related by referring to Figure 10.41.

Problem 44. I would like to use this problem to show the effect of a PD controller. Please do the problem as follows:

   a. For the system shown, use MATLAB to draw the Bode plots of the open-loop transfer function. Find the phase margin (deg).

   b. Find the unit step response of the system as given. Does this step response look desirable?

   c. Add a **PD Controller** between the "Transducer" block and the "Fin actuator" block. The transfer function of an idealized PD controller is:

$$G_{PD}(s) = K_P + K_D s.$$

     Let parameters $K_P = 1$ and $K_D = 1$.

     Use MATLAB to draw the open-loop Bode plots of the system with PD controller added, and find the new phase margin (deg). Is the system more stable now?

   d. Plot the step response of the closed-loop system with PD controller. Is the response improved?

   e. With $K_P = 1$, draw the **root locus** of the characteristic equation of the PD-controlled system vs parameter K_D. Does increasing K_D seem to stabilize the system?