

UNIVERSITY OF CALIFORNIA, SANTA CRUZ  
 BOARD OF STUDIES IN COMPUTER ENGINEERING



CMPE-242:  
 APPLIED FEEDBACK CONTROL

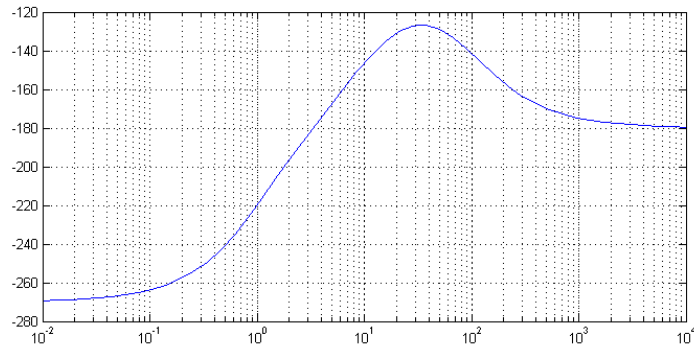
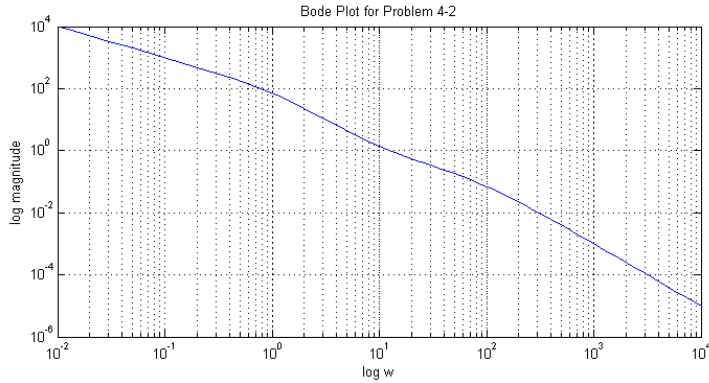
HOMWORK #4  
 DUE 05-FEB-2014

1. *Nyquist Plots*: Sketch the Nyquist plots based on the Bode plots for each of the following systems. That is, sketch the Bode plot (to level of asymptotes) and then sketch the Nyquist plot. Determine the limits of stability, and how they go unstable (both +/- gain).

a.  $GK(s) = \frac{K(s+2)}{(s+10)}$

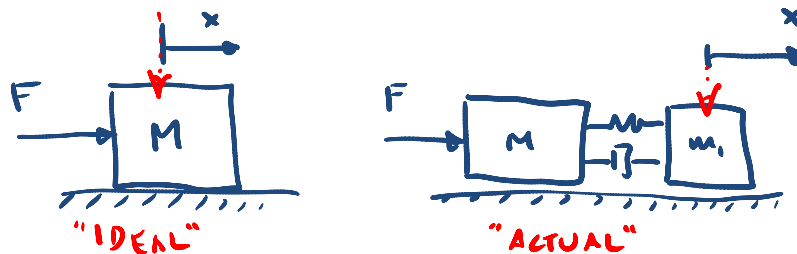
b.  $GK(s) = \frac{K}{(s+10)(s+2)^2}$

2. *Bode Plot*: The Bode plot for the system is shown below:  $G(s) = \frac{100\left[\left(\frac{s}{10}\right)+1\right]}{s\left[\left(\frac{s}{1}\right)-1\right]\left[\left(\frac{s}{100}\right)+1\right]}$



- Why does the phase start at -270 degrees at the low frequency?
  - Sketch the Nyquist plot for  $G(s)$ .
  - Is the closed loop system pictured in the Bode plot stable?
  - Will the system be stable if the gain is reduced by a factor of 100?
  - Make a rough sketch (by hand) of the Root Locus of the system, and qualitatively confirm your answer.
3. *Non-allocated Control*: Given the plant below, which describes the input output of a two-mass system, where the displacement of the forward mass is measured. If the spring connecting them was completely rigid, then this would be a  $1/s^2$  plant. Since there is, in fact, a spring constant and damping, we wind up with a resonant mode we did not originally know about, which is described in the actual transfer function.

$$G(s) = \frac{200(s + 100)}{s^2(s^2 + 0.15s + 100)}$$



- Using root locus techniques and a Notch compensator, design a compensator with a closed loop natural frequency,  $\omega_n$ , of 1 rad/s, and a damping ratio,  $\zeta$ , of 0.5. Be aggressive with the notch, and cancel the poles exactly. Turn in a step response plot, along with the root locus plot.
  - Sketch the open and closed loop system Bode response with this compensator.
4. *Bode Compensation*: Using the same plant as above:

$$G(s) = \frac{200(s + 100)}{s^2(s^2 + 0.15s + 100)}$$

- Use Bode design techniques and lag compensation to hit the specifications of a crossover frequency,  $\omega_{co}$ , of 1 rad/sec and a PM of 40 degrees. Sketch your bode plot of the open and closed loop system, and a step response of your plant.
  - Sketch the root locus of your plant and compensator, and note the poles at the design gain.
5. Assume that the natural frequency,  $\omega_n$ , of the original lightly damped mode can be off by as much as  $\pm 20\%$ . Comment on the relative merits of your two designs. Provide supporting plots, etc.