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

CMPE-242:
APPLIED FEEDBACK CONTROL

HOMEWORK #4
DUE 21-OCT-2010

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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. Compare your results to the MATLAB nyquist command to prove to yourself that this command does not work very well.

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

   b. $GK(s) = \frac{K}{s^2+25}$

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

   d. $GK(s) = \frac{K(s+1)}{(s+10)(s+2)^2}$

2. *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). Note that each of these forms a particular shape on complex plane, are names, and were all discovered in the 17^{th} and 18^{th} century.

   a. $GK(s) = \frac{1}{(s+1)^3}$

   b. $GK(s) = \frac{1}{s(s+1)}$

   c. $GK(s) = \frac{1}{(s-1)(s+2)}$

   d. $GK(s) = \frac{1}{(s-1)(s+2)^2}$

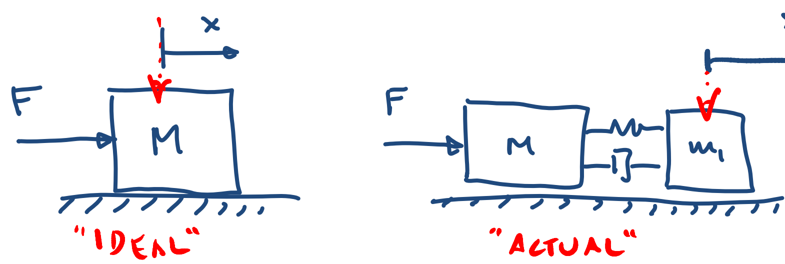
   e. $GK(s) = \frac{2(s+1)(s^2-4s+1)}{(s-1)^3}$

f. $GK(s) = \frac{(s+1)(s^2+3)}{4(s-1)^3}$

g. $GK(s) = \frac{(s^2+1)}{(s-1)^3}$

3. *Non-collocated 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.

$$G(s) = \frac{100(s+225)}{s^2(s^2+0.225s+225)}$$



a. Using root locus techniques and a Notch compensator, design a compensator with a closed loop natural frequency, ω_n, of 1 rad/s, and a damping ratio, ζ, 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.

b. Sketch the open and closed loop system response with this compensator.

4. *Bode Compensation*: Using the same plant as above:

$$G(s) = \frac{100(s+225)}{s^2(s^2+0.225s+225)}$$

a. Use Bode design techniques and lag compensation to hit the specifications of a crossover frequency, ω_{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.

b. Sketch the root locus of your plant and compensator, and note the poles at the design gain.

5. Assume that the natural frequency, ω_n, of the original lightly damped mode can be off by as much as ±20%. Comment on the relative merits of your two designs. Provide supporting plots, etc.