ESE 406/505 & MEAM 513 - SPRING 2012
HOMEWORK #10
DUE by Wednesday 4-April-2012 (Late Pass Monday 9-April-2012)

1. In homework #5, we solved problem 4.29 in the textbook. (Recall that the problem statement contains and extra "-" sign in the description of the feedback.) Revisit this problem from the frequency response perspective, starting with the gains you computed for part (b). Specifically:

    a. Make a frequency response magnitude plot of the sensitivity function, $S(j\omega)$. Is feedback making the response to disturbances worse at any frequency? Explain briefly.

    b. Make a loop Bode plot for the system and clearly identify the gain margin and phase margin. If you keep the ratio of $\frac{K_I}{K_P}$ fixed, what values of K_P would yield margins of 6dB and 45°, respectively? Hint: You can compute these values directly from the Bode plot.

2. Let's also revisit problem 4.33, from homework #6. This is the Ziegler-Nichols PID problem. Do the following:

    a. Make a bode plot of the plant and use it to find the values of P_u and K_u that are required for the "Ultimate Sensitivity Method" tuning rules. Verify your answers against the information given in part (b) of the problem.

    b. Make a bode plot of the loop transfer function with the PID controller from part (b) of the original problem. What are the gain and phase margins? How larger would the time delay (which is nominally 2 seconds) need to be to cause the closed-loop system to be unstable with the nominal PID controller?

    c. *OPTIONAL*: Can you find a stable open-loop system for which the Ultimate Sensitivity Method produces an unstable closed-loop?

3. Work problem 6.16(b). With what period would the system oscillate if the gain were set for neutral stability? *Answers*: K=242, T~1.36 seconds. Root locus up to you.

4. Work problem 6.31, parts (a), (b), and (d). *Answers*: K=1.1 yields PM=45° & GM=15dB. The root locus is shown at right.

5. Work problem 6.21 for positive K only. Answers: Nyquist plot is shown at far right. Stable for K<10.