ESE 406/505 & MEAM 513 - SPRING 2011
HOMEWORK #10
DUE Tuesday 26-Apr-2011 @ 3:00PM (Friday 29-Apr-2011 @3PM with Late Pass)

1. Work problem 5.12 in the textbook. You should try to "sketch" the locus by hand, but you may use Matlab to confirm your hand sketch and find the gain to achieve the desired pole locations. Using the gain your find for the desired pole locations, make a bode plot and identify the gain and phase margins. How much time delay will make the system neutrally stable? If the delay is half that much, what is the new gain margin?

   Answer: K ~ 15 for damping ratio 0.5. With K=15, PM=45 degrees @ 2.95 rps and GM is infinite. Time delay of 0.266 seconds causes neutral stability. With 0.133 seconds of delay, the gain margin is 6.1 dB at 4.7 rps.

2. Work problem 5.14 in the textbook. Do the block-diagram algebra by hand so that you can express the closed-loop denominator in the form a(s)+Kb(s). Then use a root locus to find the value of K that gives the required damping ratio.

   Answer: a(s)=s^2+s+10, b(s)=10s, K=0.22.

3. Work problem 5.31 but instead of the given compensator, use $H(s) = K\dfrac{s+1}{s+4}$. (The 2-to-1 lead ratio in the given compensator is very weak and doesn't provide much stabilization, so we will try a 4-1 lead compensator.) Using the gain you find in part (c), what are the gain and phase margins? Explain how the gain margin could be found on the root locus.

   Answer: (a) the root locus shows the roots are in the left-half plane for all K>0.

   (b) K ~ 8 for damping ratio ~ 0.32. PM=26 degrees @ 2 rps, GM ~ 13dB @ 5.1 rps. On the root locus, neutral stability is reached for K~36, which is an increase over the *nominal gain* of 13dB.

4. Work problem 6.59 in the textbook. Before completing part (a), create a root locus for the system, showing the closed-loop pole locations with the nominal plant gain (K=1). Please take your time with part (d), including a good technical summary of the options you evaluated. Your answer for this part will be evaluated for technical writing quality.

5. In this problem, we will do "system identification" on an unknown system using Simulink. The unknown system has been implemented in Simulink for you (HW10.mdl). We think that the transfer function of the system might be a simple first-order system plus some time delay: $G(s) = \dfrac{Ae^{-Ts}}{s+p}$. We want to do "experiments" in Simulink to find the best values of A, T, and p. Note that the data is noisy, which makes the time domain approach (part a) more difficult.

a. Use a step input (set the chirp gain to 0) and try to figure out the parameter values from the measured response. Submit a graph showing measured and theoretical time response using your best guess at the parameters.

b. Use a chirp input (set the step gain to 0) and try to figure out the parameter values from the measured response. The Matlab code below should help you with this. Submit a graph showing the measured and theoretical frequency response using your best guess at the parameters.

```
%
% parse the input and output values from the scope data
%
u = ScopeData.signals(1).values;
y = ScopeData.signals(2).values;
%
% run TFESTIMATE (magic hat)
% convert experimental frequency to rad/sec
%
[Gdata, f] = TFESTIMATE(u, y, [], [], [], 100.0);
omg = 2*pi*f;
%
% ENTER YOUR ESTIMATES OF A, T, p here
%
A =
T =
p =
%
% generate the theoretical bode at the same frequencies as data
%
G=tf(A,[1 p]);
set(G,'InputDelay',T);
[mag,pha]=bode(G,omg);
mag=squeeze(mag); pha=squeeze(pha);
%
% plot the results
%
subplot(211);
semilogx(omg, 20*log10(abs(Gdata)), omg, 20*log10(mag)); grid on;
axis([1 10 0 20]);
subplot(212);
semilogx(omg, (180/pi)*unwrap(angle(Gdata)), omg, pha); grid on;
axis([1 10 -200 0]);
legend('Data','Theory');
```