ELEE 4700/5700: Control Systems II

Professor Hill

University of Detroit Mercy, Fall 2012

Homework #5

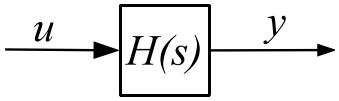
Assigned: October 16, 2012

Due: October 25, 2012

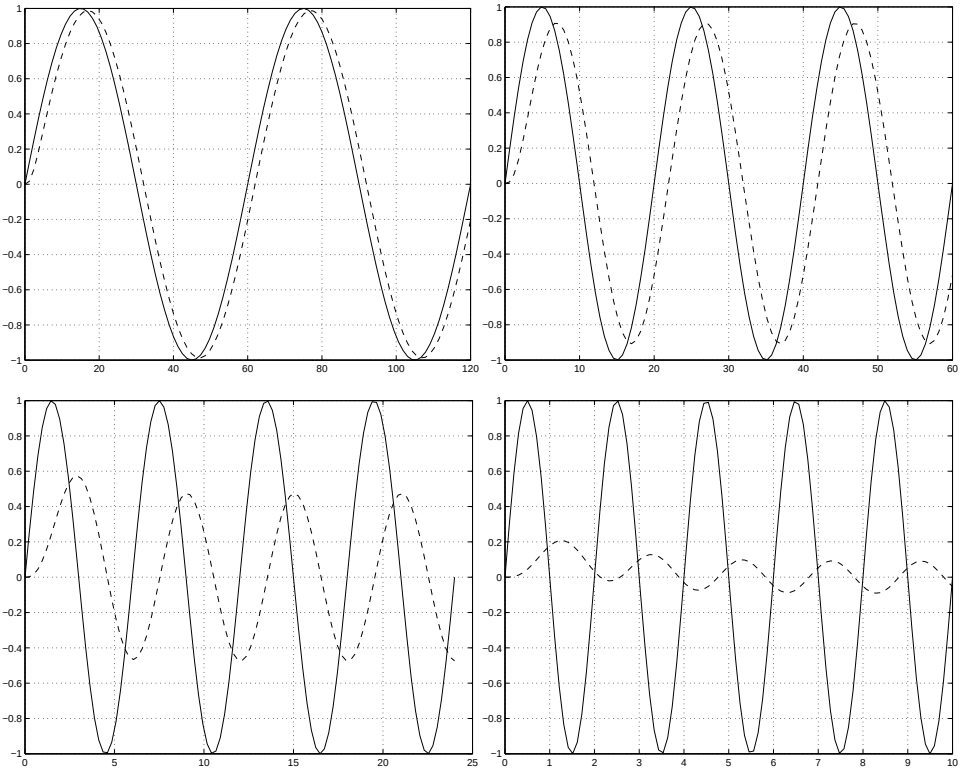
Read section 7-1 and 7-2 of the book.

Recommended example problems: ex. A-7-1, A-7-16.

1. (20 points) You are given a system and are attempting to identify a model experimentally.



You have at your disposal a sine wave generator and oscilloscope. You apply several sinusoidal inputs to the system, and measure the system response. Shown below are several input-output pairs for the system. The input $u(t)$ is the solid line and the output $y(t)$ is the dotted line.



(a) From each plot, estimate the frequency ω, magnitude, and phase shift of the output (with respect to the input).

(b) Sketch the frequency response of the system $H(s)$.

2. (30 points) Sketch the straight line approximations of the Bode diagrams of the following three transfer functions by hand. Check your results with the `MATLAB` command **bode**.

$$G_a(s) = \frac{1}{s(s+2)(s+4)} \quad G_b(s) = \frac{(s+5)}{(s+2)(s+4)} \quad G_c(s) = \frac{(s+3)(s+5)}{s(s+2)(s+4)}$$

3. (15 points) Recall the following two transfer functions from Problem 1 of Homework 3.

$$G_1 = \frac{25}{(s+1)(s^2+10s+125)}, \qquad G_2 = \frac{25}{(s+5)(s^2+2s+5)}$$

(a) Using the `MATLAB` command **bode**, plot the Bode plot of $G_1(s)$ and the Bode plot of the reduced-order transfer function found in Homework 3. Based on the Bode plots, comment on the how well the reduced-order model approximates the original transfer function.

(b) Repeat part (a), but for the transfer function $G_2(s)$.

4. (20 points) For a unity feedback system with a plant:

$$G(s) = \frac{5}{s(s+1)(0.2s+1)}$$

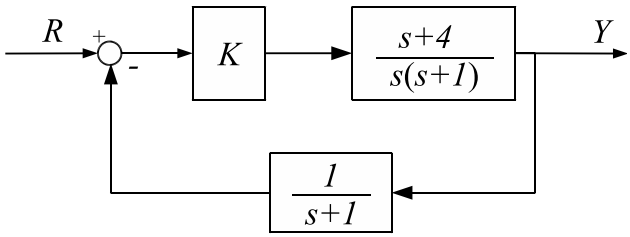
consider a lead compensator of the form:

$$K(s) = \frac{s/z+1}{s/10+1}$$

(a) A lead compensator adds phase lead to a system. Use `MATLAB` to plot the Bode plot of the lead compensator for $z = \{0.01, 0.1, 0.3, 1, 5\}$ on the same graph. What appears to be the maximum phase that can be added by a lead compensator?

(b) Using MATLAB, find the gain margin and phase margin for the entire system when $z = 1$.

5. (15 points) Reconsider the closed-loop system from Problem 1 of Homework 4.



(a) Plot the Bode plot of the open-loop transfer function and estimate the gain and phase margin for the system.

(b) Do your answers from part (a) agree with the root locus and range of K values you found in Problem 1 of Homework 4? Explain.