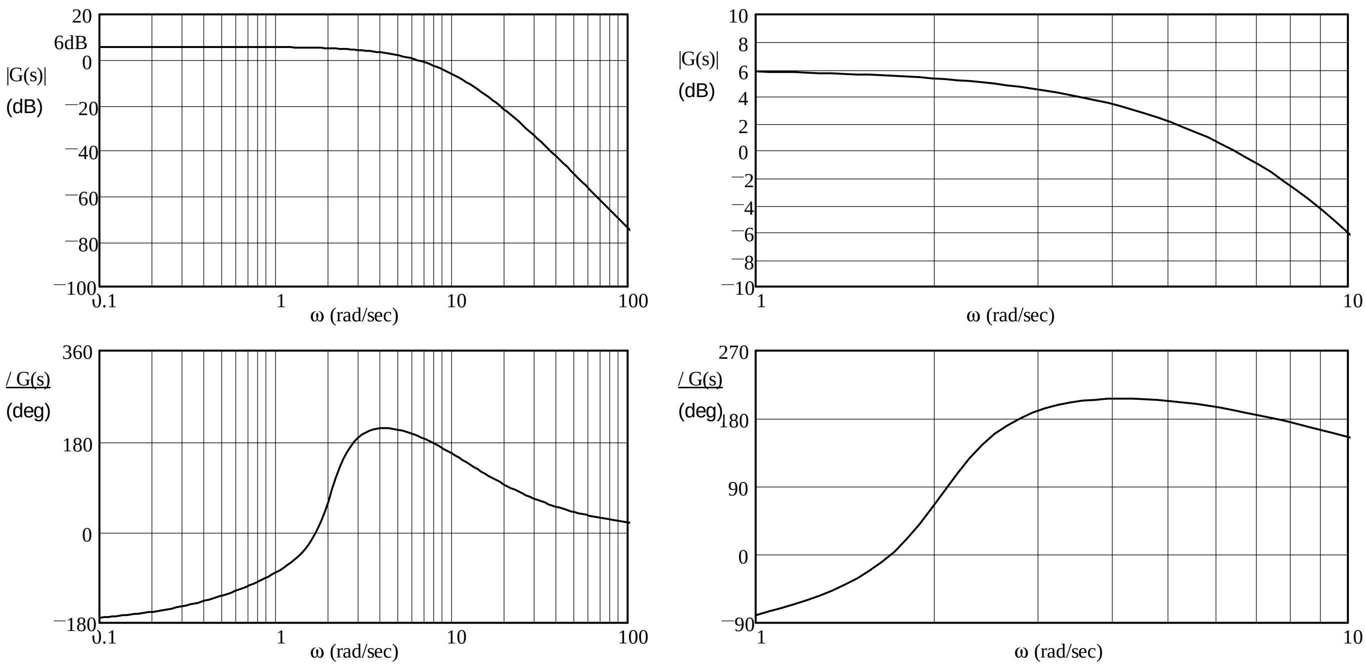
Name: ____________________ Homework # Bd4 a

Plan to attend ME Design Day, next Thur in the Union Ballroom

1. Problem 5.13 b & new c & d (p.149) in the text.

b) Bode plots of the open-loop transfer function of a feedback system are shown below, with the detail from 1 to 10 rad/sec shown on the left. For this system:

- How much can the open-loop gain be changed (increased and/or decreased) before the closed-loop system becomes unstable ?
- What is a rough estimate of the phase margin of the feedback system? Show on the graph how the results are obtained. The numerical results do not have to be precise.
- How much time delay can there be in feedback system before the phase margin disappears.

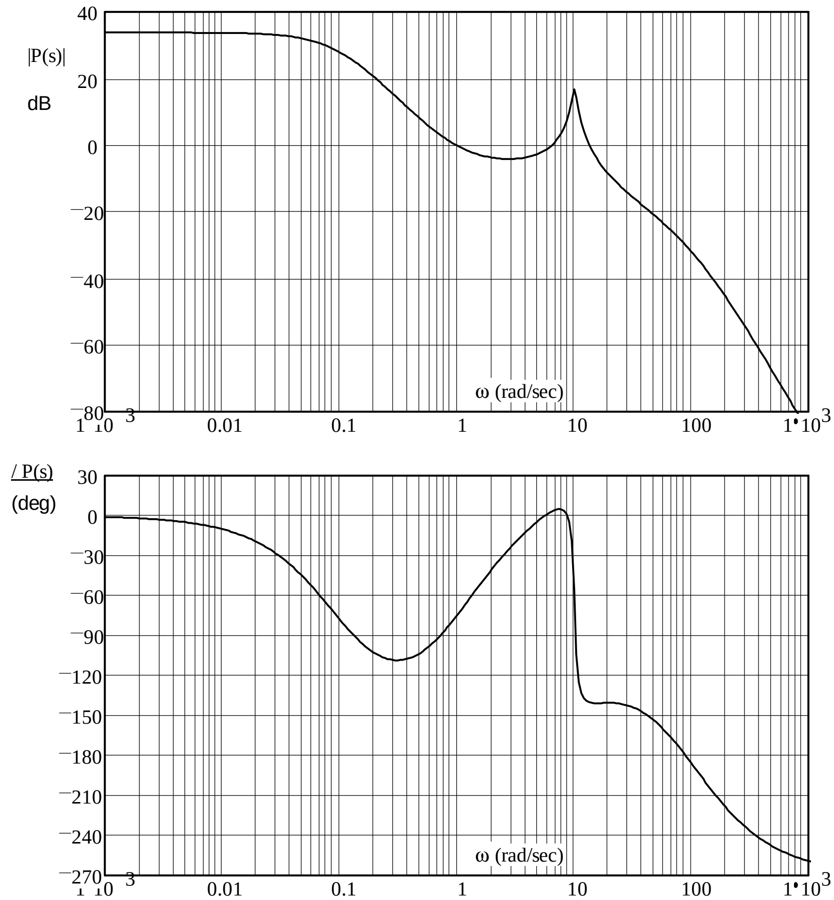


c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 4\cos(10t)$. express the answer in the time-domain.

d) Give the steady-state response of the closed-loop system for the same input. Hint: closed loop output is: $\text{input} \cdot \frac{G(10 \cdot j)}{1 + G(10 \cdot j)}$

2. Like problem 5.9a (p.147) in the Bodson text.

   a) Give the gain margin, the phase margin and the delay margin of the system whose Bode plots are shown at right (the plots are for the open-loop transfer function and the closed-loop transfer function is assumed to be stable).



Add another sheet of paper the following:

3. A system has a delay of $D := 0.01 \cdot sec$ How many degrees of phase does this represent at:

   a) $f := 1 \cdot Hz$ $\quad f := 10 \cdot Hz$ $\quad f := 100 \cdot Hz$ $\quad f := 1 \cdot kHz$

   b) $\omega := 1 \cdot \frac{rad}{sec}$ $\quad \omega := 10 \cdot \frac{rad}{sec}$ $\quad \omega := 100 \cdot \frac{rad}{sec}$ $\quad \omega := 1000 \cdot \frac{rad}{sec}$

4. a) If the phase response of a pure time delay were plotted on linear phase vs. linear frequency plot, what would be the shape of the curve?

   b) If the phase response of a pure time delay were plotted on linear phase vs. logarithmic frequency plot, what would be the shape of the curve?

Plan to attend ME Design Day, next Thur in the Union Ballroom

Answers

1. b) Gain may be increased by ~ 2dB and reduced by ~ 4.4dB. $\quad PM \sim 13 \cdot deg$ $\quad DM \sim 36 \cdot ms$

   c) $2 \cdot \cos(10 \cdot t + 158 \cdot deg)$ $\quad$ d) $3.5 \cdot \cos(10 \cdot t + 140 \cdot deg)$

2. a) $GM \sim 30 \cdot dB$ $\quad PM \sim 40 \cdot deg$ $\quad DM \sim 50 \cdot ms$

3. a) $3.6 \cdot deg$ $\quad 36 \cdot deg$ $\quad 360 \cdot deg$ $\quad 3600 \cdot deg$ $\quad$ b) $0.573 \cdot deg$ $\quad 5.73 \cdot deg$ $\quad 57.3 \cdot deg$ $\quad 573 \cdot deg$

4. a) A straight line of negative slope, ωD, where D is the time delay.

   b) A negative sloping line with a slope of ωD. Since the frequency increases by a factor of 10 each decade, so would the downward slope of the line.