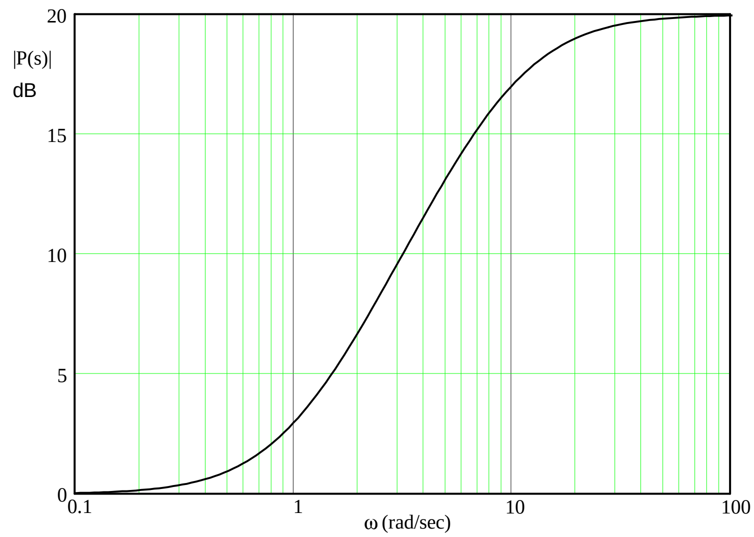
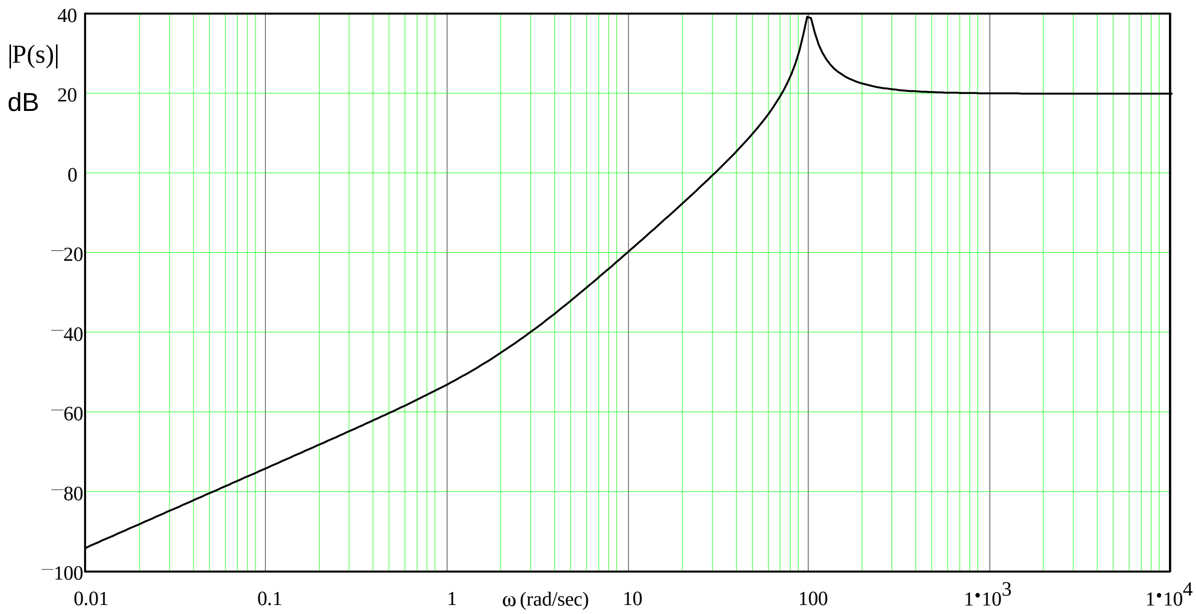
Name: ____________________ Homework # BP2 Due: c

You must show the work needed to get the answers below. Add your own paper if necessary.

1. (a & c are from Problem 5.2 in Bodson text.)
   a) The magnitude Bode plot of a system is shown below. What are the possible transfer functions of stable systems having this Bode plot?



   b) A Bode plot is shown below, estimate of the transfer function of the system. Assume no negative signs in the transfer function (all poles and zeros in LHP). Show your work (how you made your estimate).



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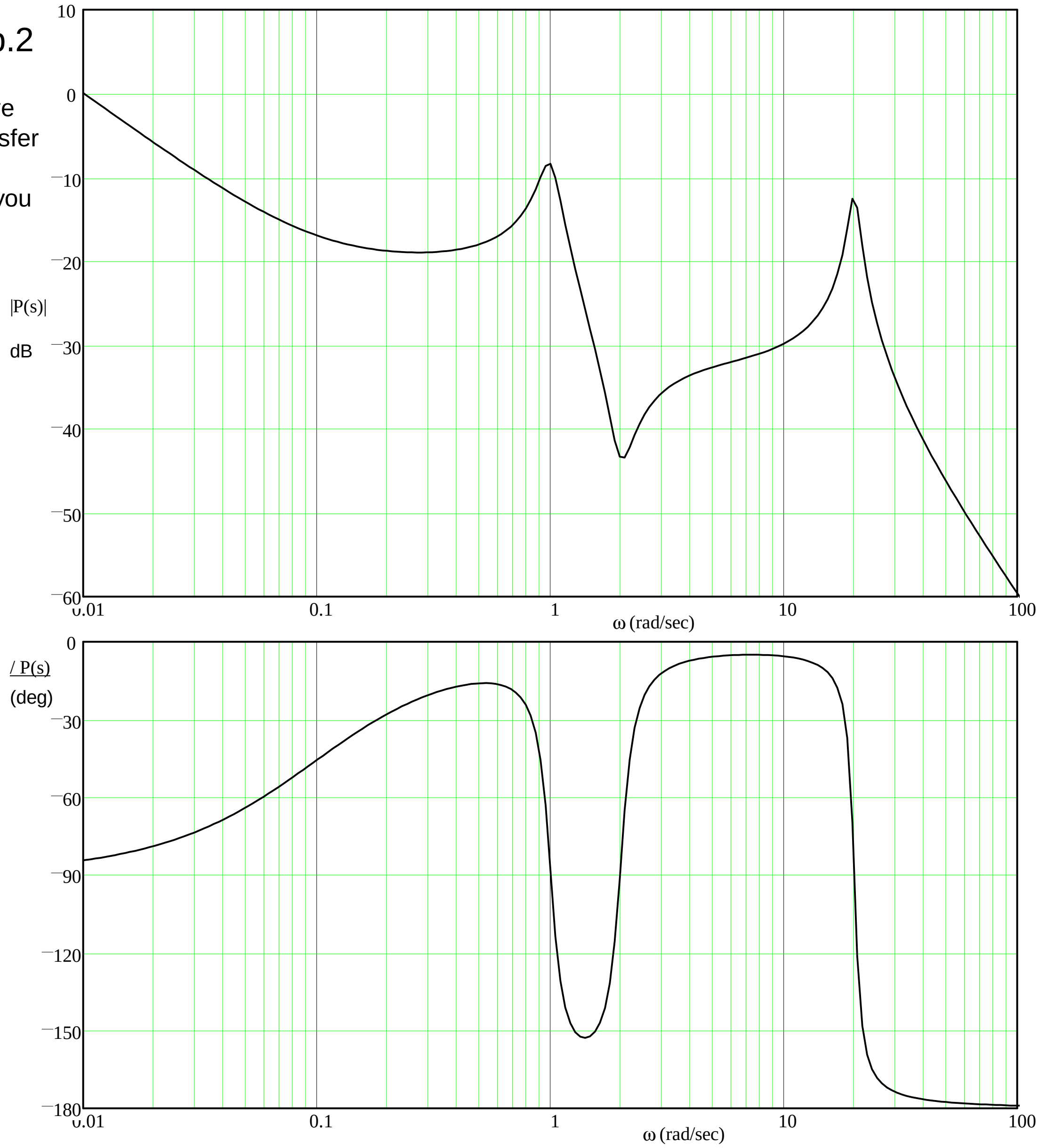
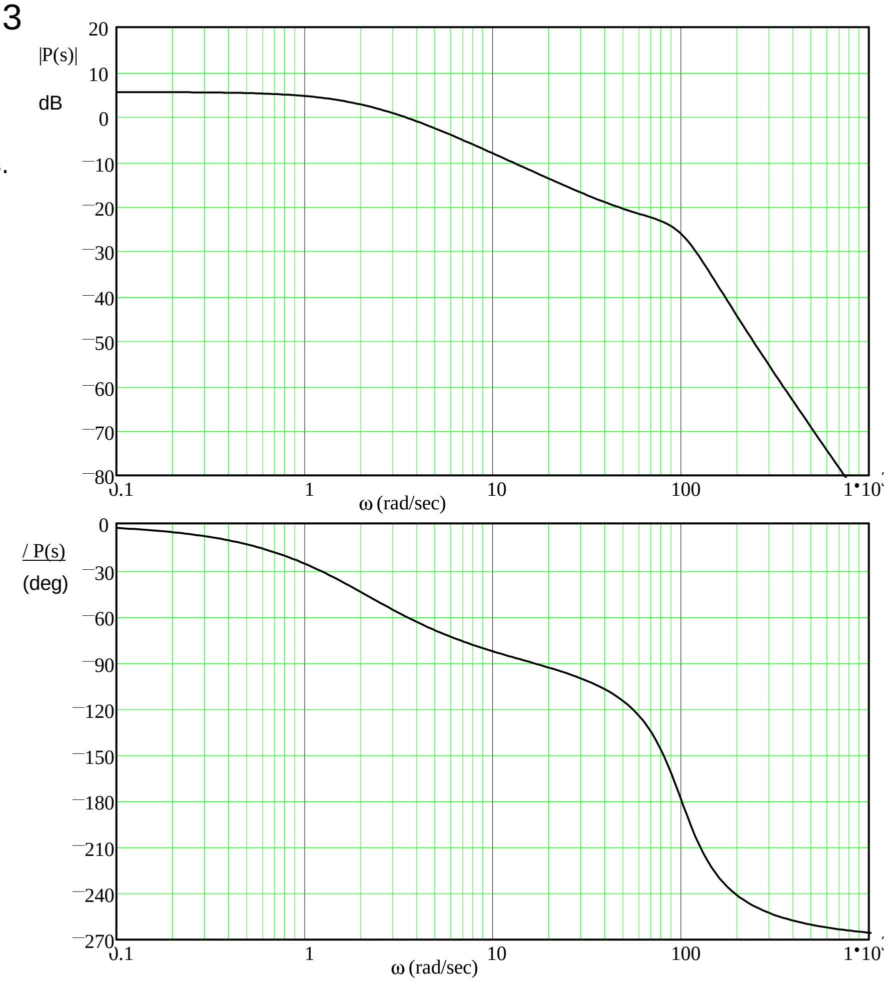
c) The Bode plots of a system are shown. Give an estimate of the transfer function of the system. Show your work (how you made your estimate).

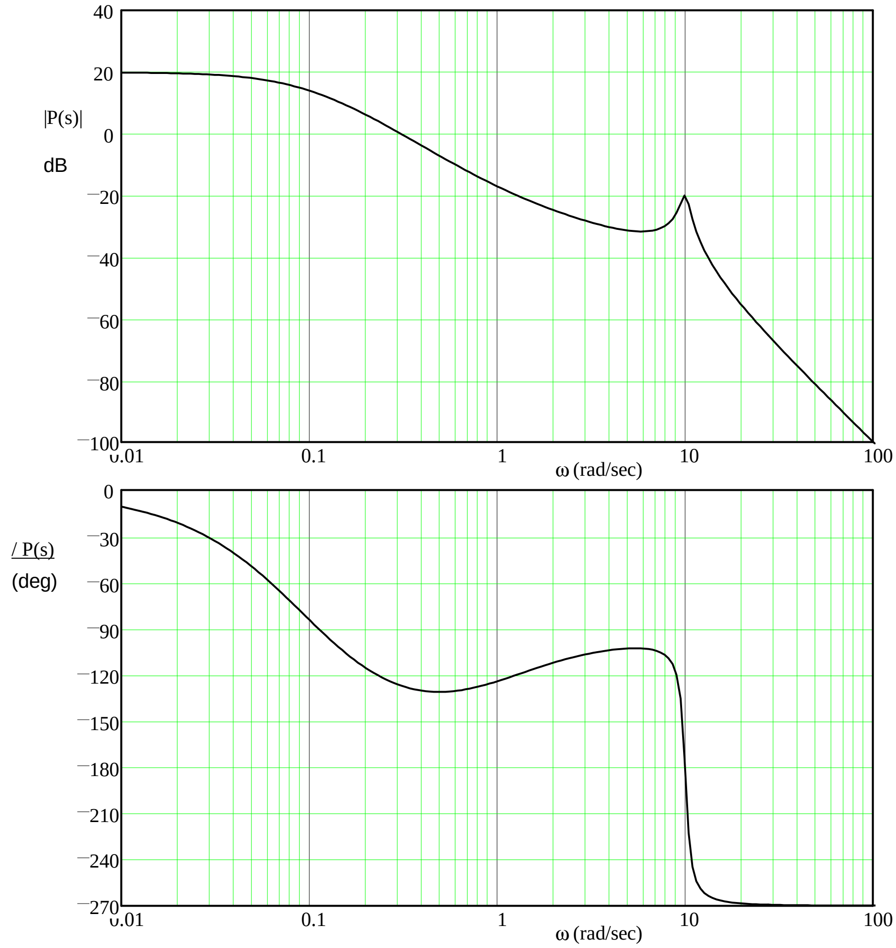


2. The system whose Bode plots are given at right is stable in closed-loop. Find its gain margin, phase margin, and delay margin. Show your work on the drawings.



3. Problem 5.3 in the text.

   a) The system whose Bode plots are given at left is stable in closed-loop. Find its gain, phase, and delay margins. Show your work on the drawings.



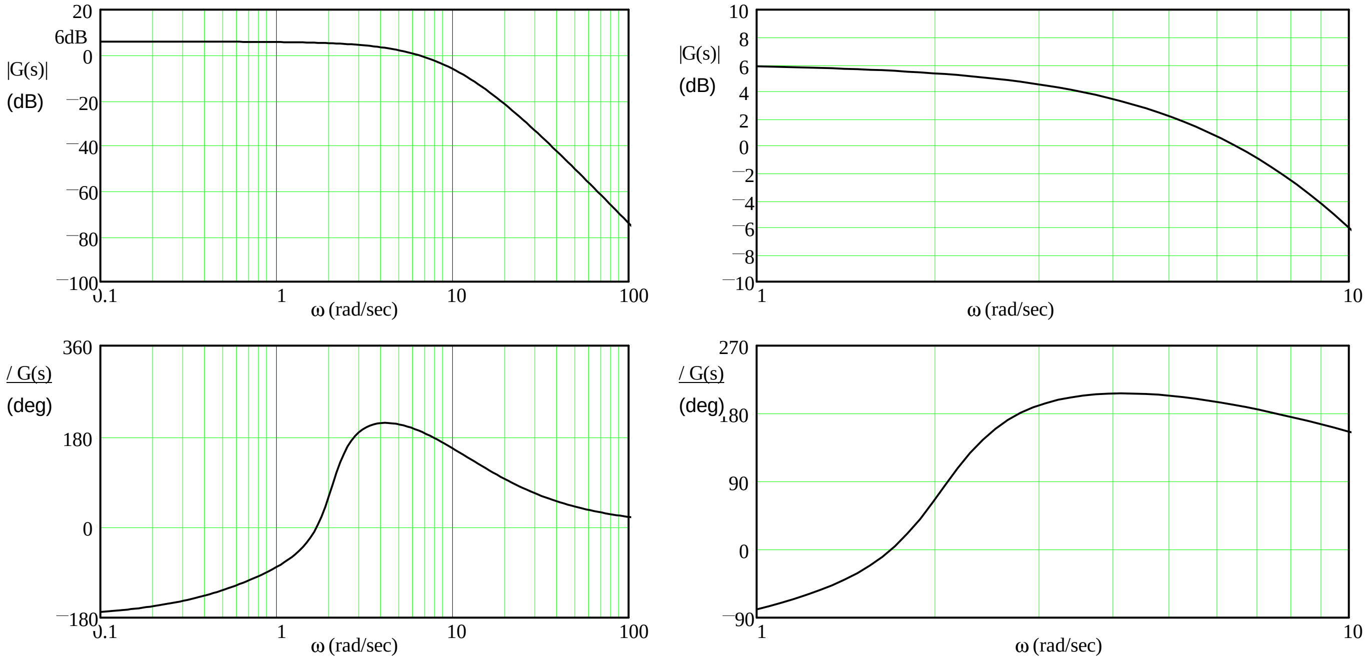
b) Describe the behavior of the closed-loop system of part (a) if the open-loop gain is increased to a value close to the maximum value given by the gain margin. In particular, what can you say about the locations of the poles of the closed-loop system?

c) Consider an open-loop stable system which is such that the magnitude of its frequency response, including the gain factor k, is less than 1 for all ω ($|kG(s)| < 1$). Can you determine whether the closed-loop system is stable with only that information? If yes, show how.

4. 4. 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.

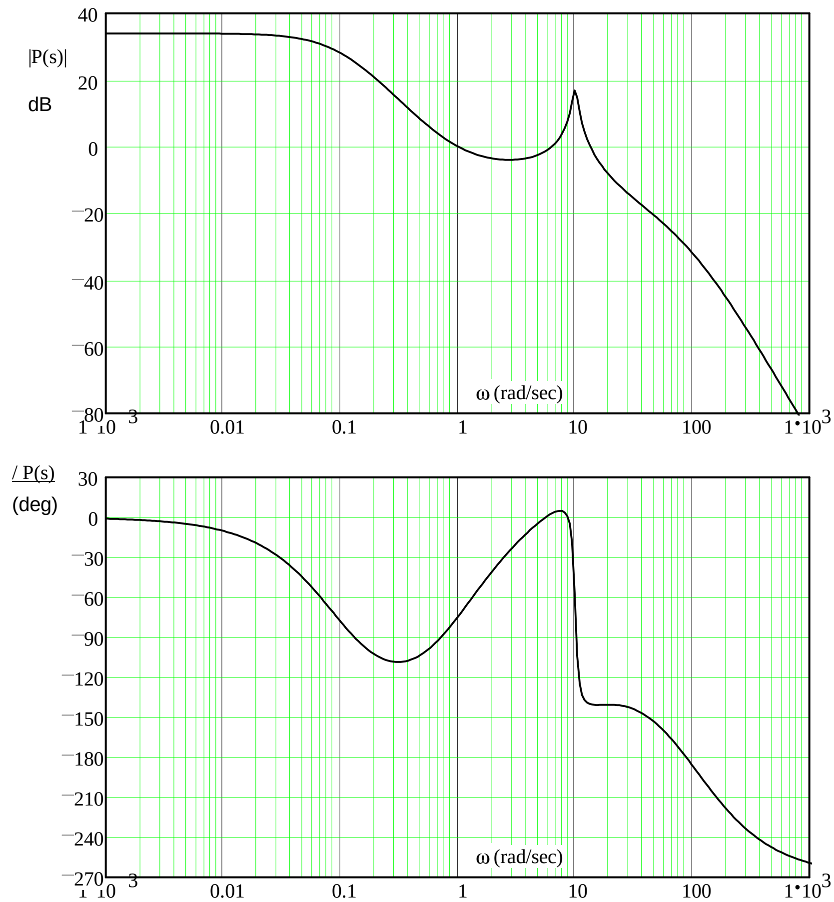


c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 4\cos(10t)$. express the answer in the time-domain.

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

5. 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).



Answers

1.a) $P(s) = 10\cdot\frac{s+1}{s+10}$ $\quad 10\cdot\frac{s-1}{s+10}$ $\quad -10\cdot\frac{s+1}{s+10}$ $\quad -10\cdot\frac{s-1}{s+10}$

The rest are NOT stable: $10\cdot\frac{s+1}{s-10}$ $\quad -10\cdot\frac{s-1}{s-10}$ $\quad -10\cdot\frac{s-1}{s-10}$ $\quad -10\cdot\frac{s+1}{s-10}$

b) $P(s) = \frac{10\cdot s\cdot(s+2)}{\left(s^2+10\cdot s+10000\right)}$

c) $P(s) = \frac{10\cdot(s+0.1)\cdot\left(s^2+0.4\cdot s+4\right)}{s\cdot\left(s^2+0.2\cdot s+1\right)\cdot\left(s^2+2\cdot s+400\right)}$

2. $GM \simeq 25\cdot dB$ $\quad PM \simeq 120\cdot deg$ $\quad DM := 600\cdot ms$

3. a) $GM \simeq 21\cdot dB$ $\quad PM \simeq 50\cdot deg$ $\quad DM := 2.6\cdot sec$

   b) The system will have a transient ring at about 10 rad/sec. Two poles of the closed loop system will be close to $\pm$ 10j.

   c) Yes, it must be stable. Prove by closed-loop transfer function, Bode gain margin or Nyquist: N=0, P=0, Z=0

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

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

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