ECE 3510 Exam 3 given: Spring 22 (Some of the space between problems has been removed.)

This part of the exam is Closed book, Closed notes, No Calculator.
Your answers should specific, clear, concise, and legible, or I'll assume you don't know.

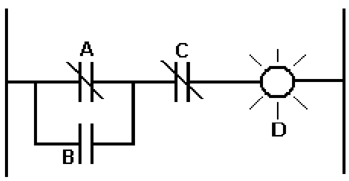
1. An instrumentation amplifier is a good way to implement what function(s) or block(s) in a typical feedback loop?

2. Some compensators use differentiators, but real differentiators have some serious issues. What is the most important issue (the reason given in lab 5b for moving the differentiator into the feedback part of the loop).

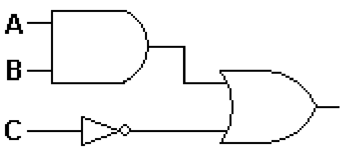
   Extra credit for naming the second most important issue.

3. a) Ladder logic was originally developed to help design logic circuits based on what type(s) of part(s)?

   b) Show the Boolean expression or the equivalent logic gates for the ladder-logic shown below.
   Inputs A, B and C control a light, D.



   c) Show the ladder-logic equivalent of the Boolean expression and the logic gates shown below.
   Let the output, D, be a light.



D $= A \cdot B + \overline{C}$

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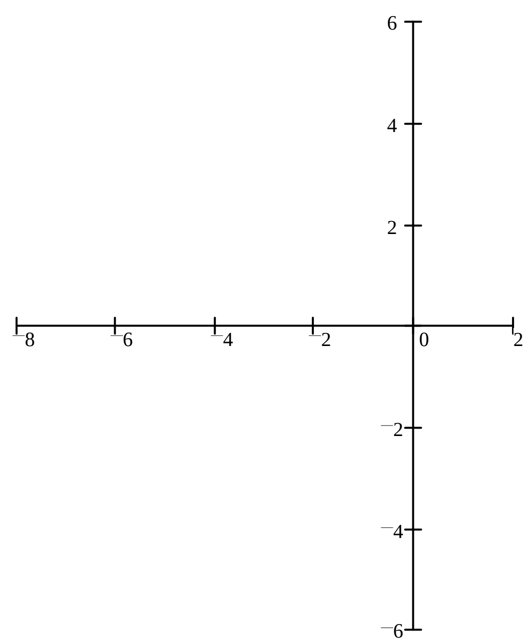
Open-notesheets problems

1. (18 pts) Sketch the unconventional root-locus plot for the open-loop transfer function below.
   The root-locus should be plotted for an increasing x.

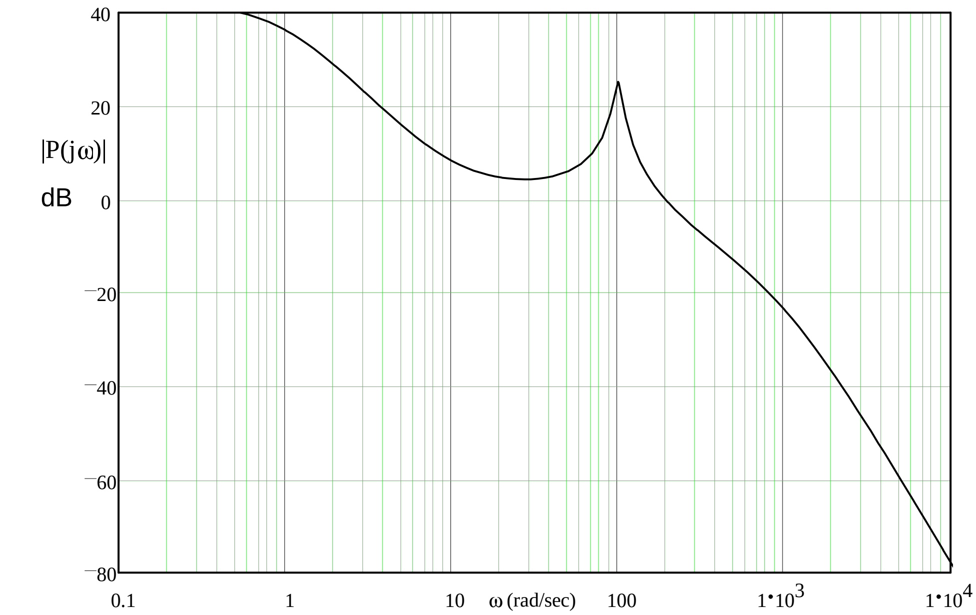
$$G(s) = \frac{k \cdot (5 \cdot (s + 2 \cdot x) - 6)}{s \cdot (x \cdot s + 2 \cdot (s + 2 \cdot x))} \qquad k = 2 \text{ and is fixed}$$

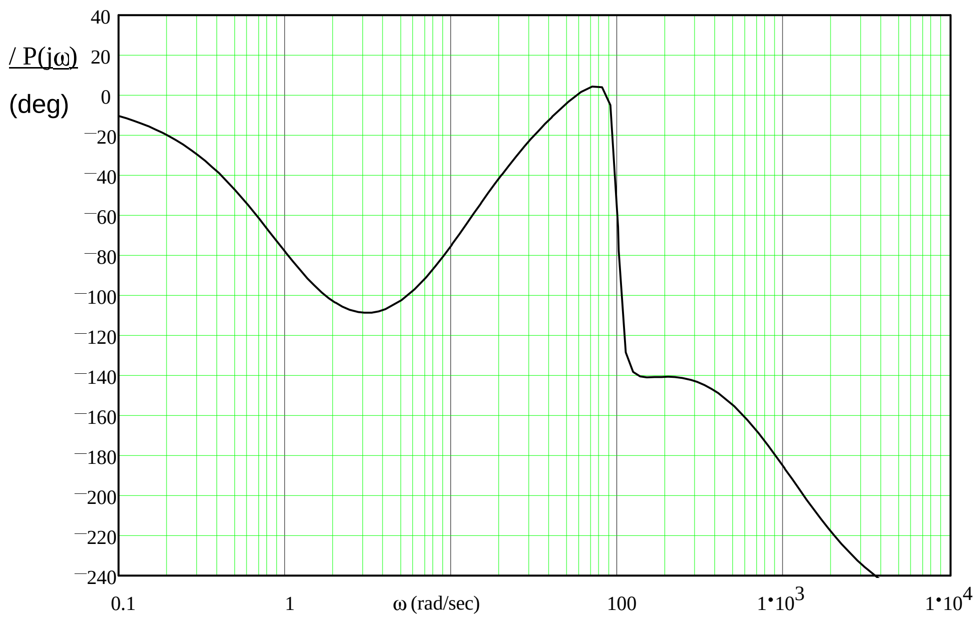


   b) Can you place a closed-loop pole on the real axis at -4?
   If yes, find the value of x needed to place the pole at this location. If no, indicate what you think the best point on the real axis is and find the value of x needed to place the pole at that location.

2. (18 pts) The open-loop Bode plots of a system are given at right.

   a) Find the gain margin and phase margin of the closed-loop system. Show your work on the drawings.



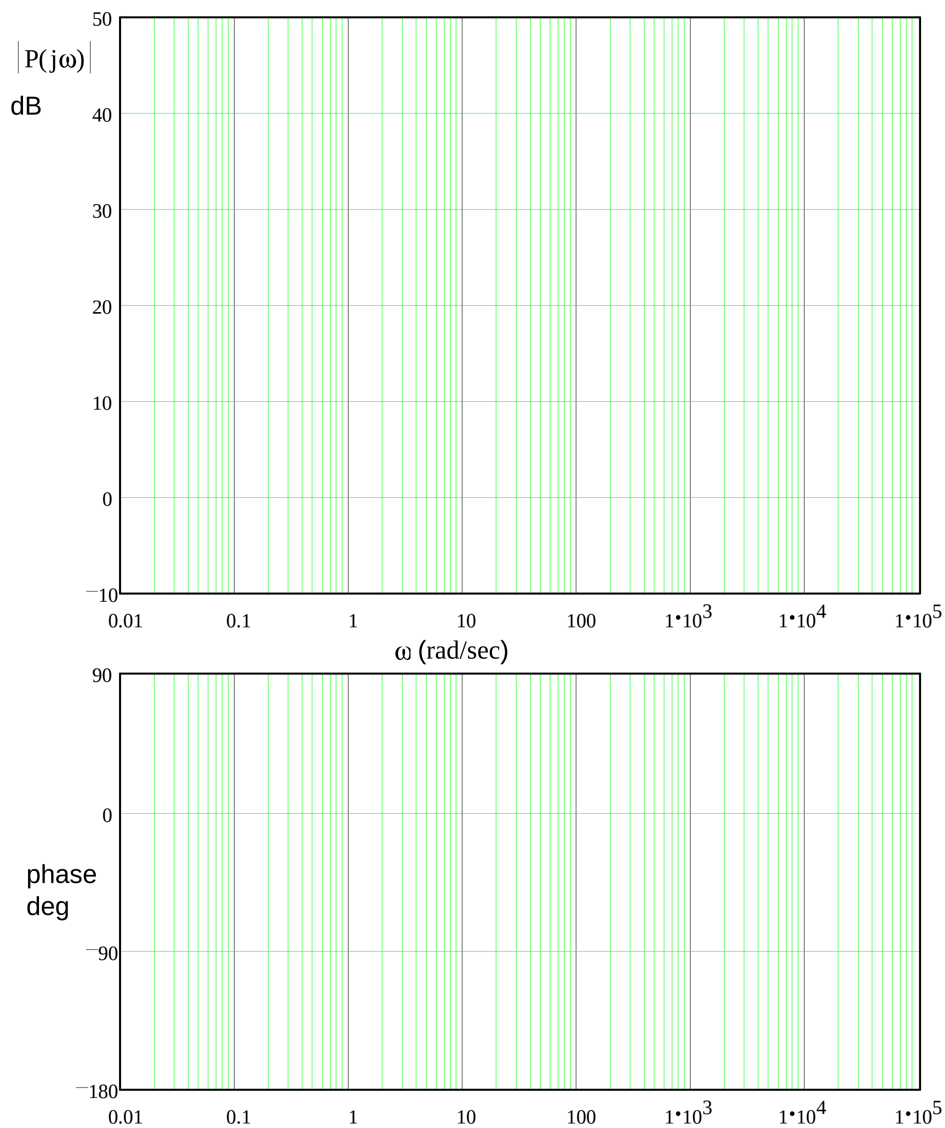


   b) Find the delay margin.

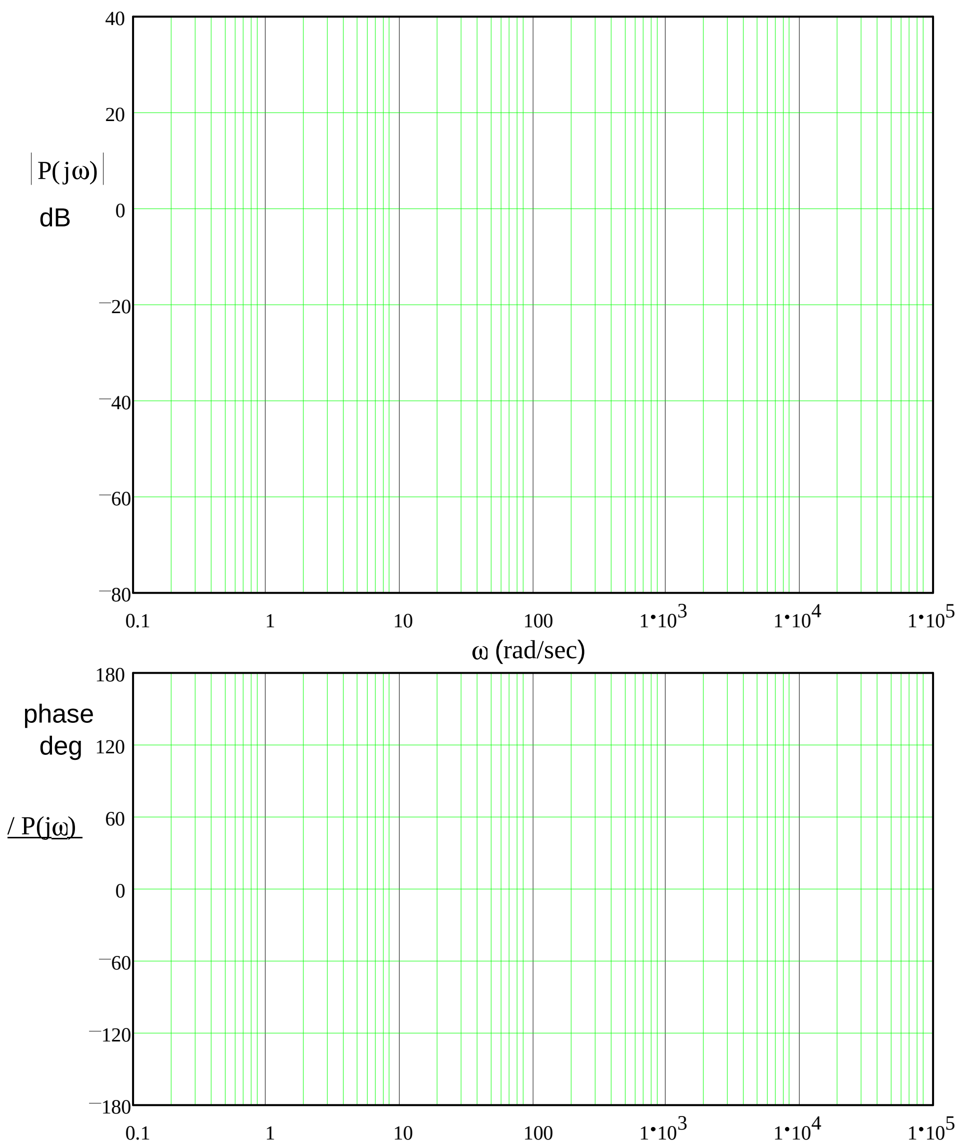
   c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 7\cos(4t+30^{o})$. express the answer in the time-domain. $y_{ss}(t)$ = ?

3. (30 pts) Sketch the Bode plot for the following transfer functions. Use the method I taught in class to find magnitudes, slopes and angles and to check yourself. Also accurately draw the "smooth" lines.

a) $$P(s) = \frac{20000\cdot(s+0.1)\cdot(s+80)}{(s+2)^2\cdot(s+5000)}$$



b) $P(s) = \dfrac{18000 \cdot \left(s^2 + 0.3 \cdot s + 9\right)}{\left[(s+20)^2 + 9600\right] \cdot (s + 5000)}$



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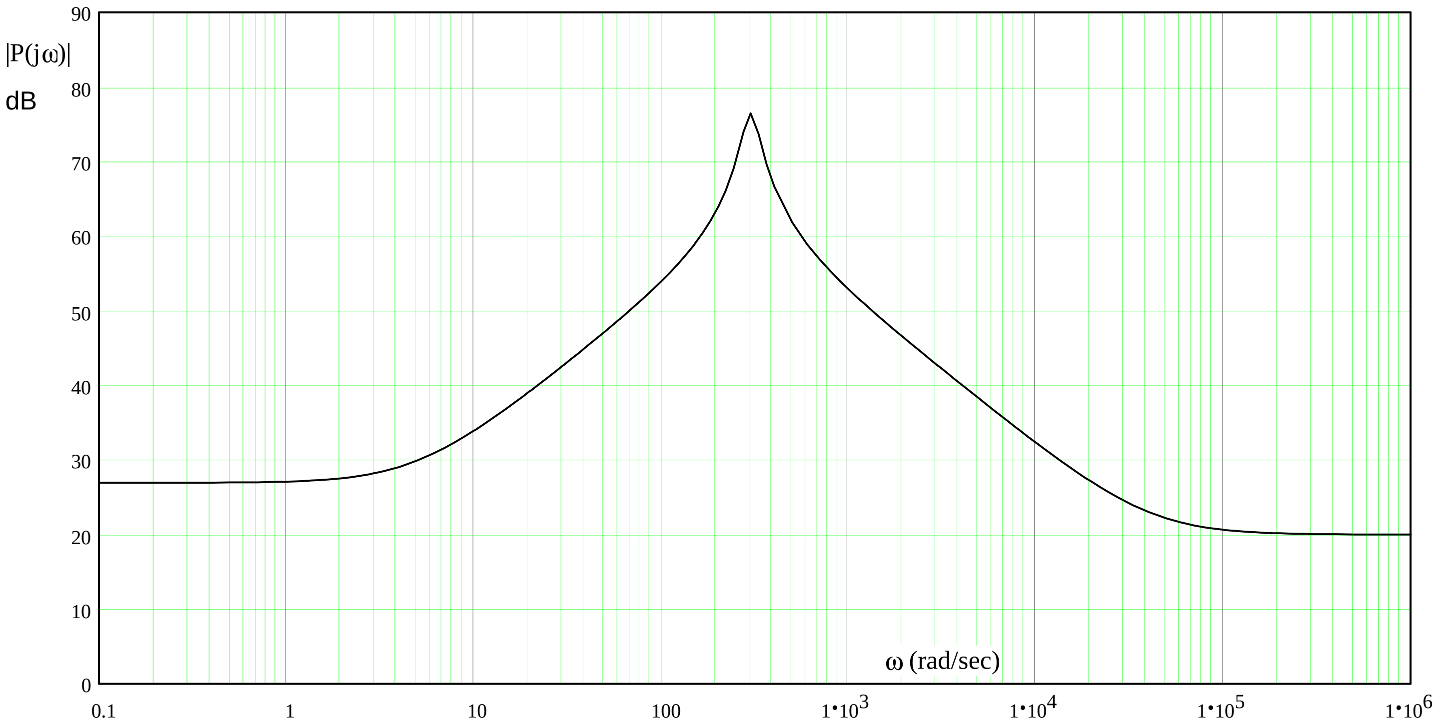
4. (20 pts) Given the magnitude frequency plot of a system, estimate the transfer function of the system. Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane). Use a straight edge and show your work (how you made your estimate).



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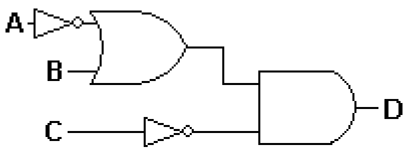
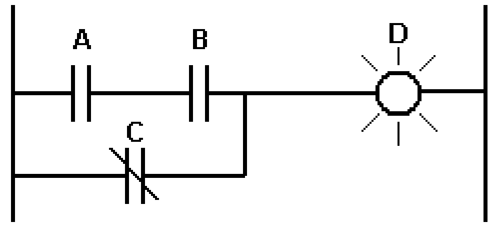
Answers

1. The summer with + and - , and the gain block
2. A true differentiator would produce an impulse when the input is a step. No real differentiator can do this. Differentiators are high-pass filters and accentuate the noise.
3. a) Electromechanical relays and simple switches

   b) $\left(\overline{A}+B\right)\cdot\overline{C}$ OR

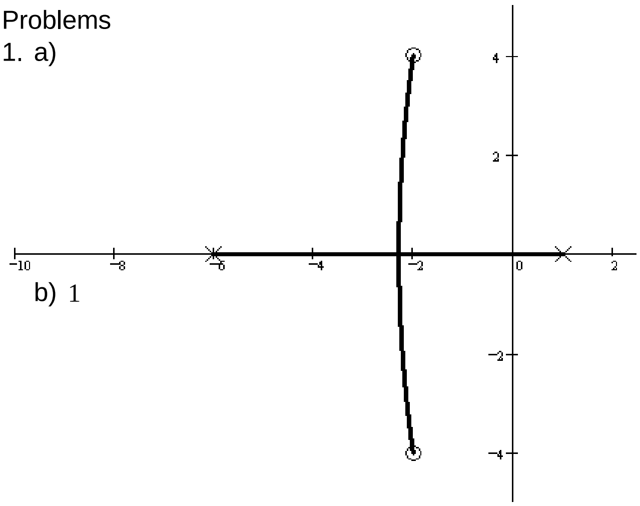


   c)



Problems

1. a)



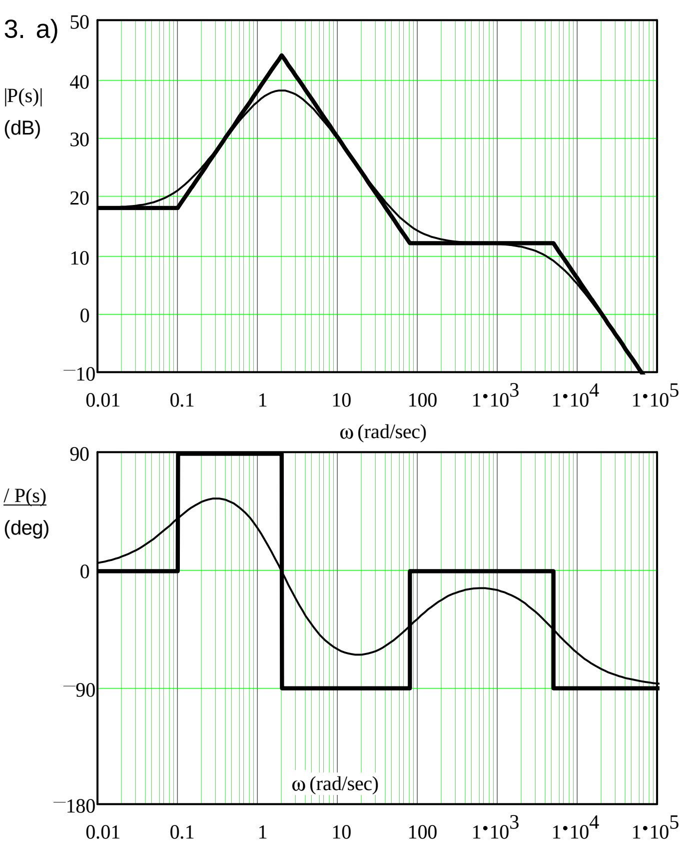
   b) 1

2. a) GM $\simeq$ 22·dB
   PM $\simeq$ 40·deg

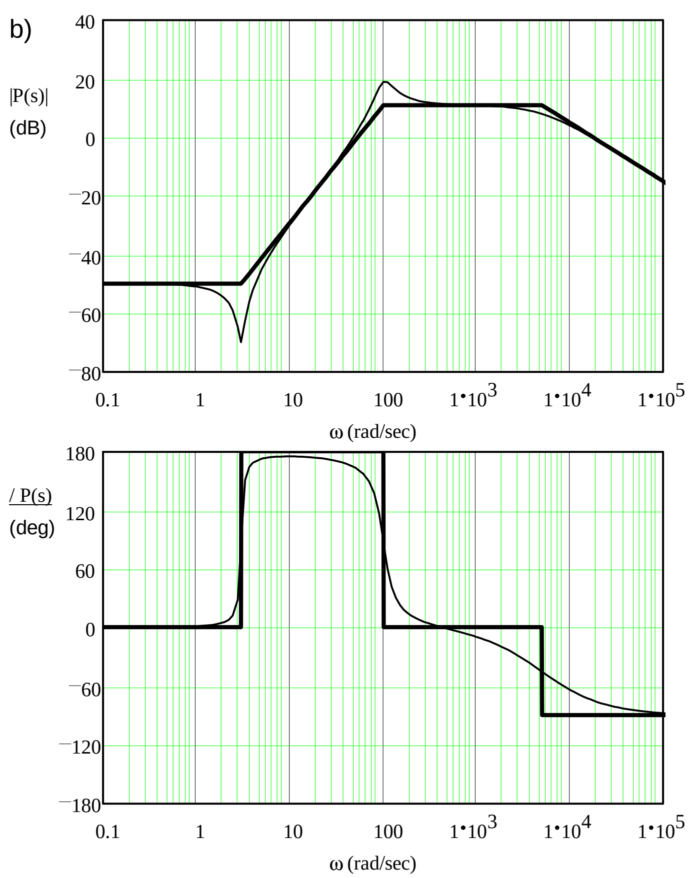
   b) DM $\simeq$ 3.5·ms

   c) $70\cdot\cos(4\cdot t+79\cdot deg)$

3. a)



   b)



4. $\mathbf{P}(s) = \dfrac{10\cdot(s+5)\cdot(s+40000)}{\left(s^2+60\cdot s+90000\right)}$