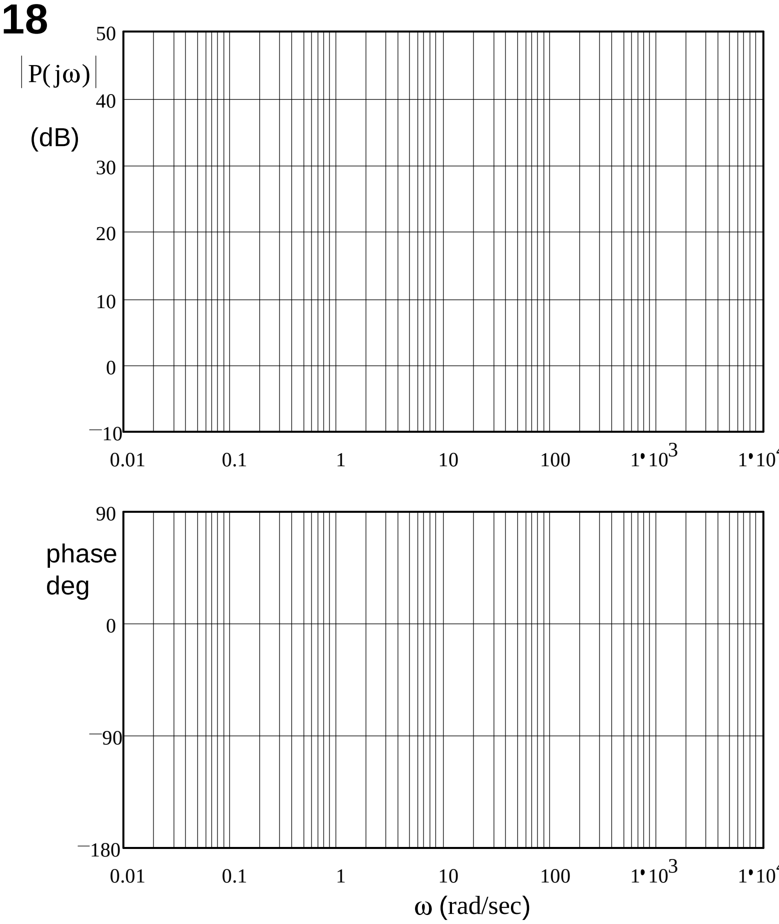
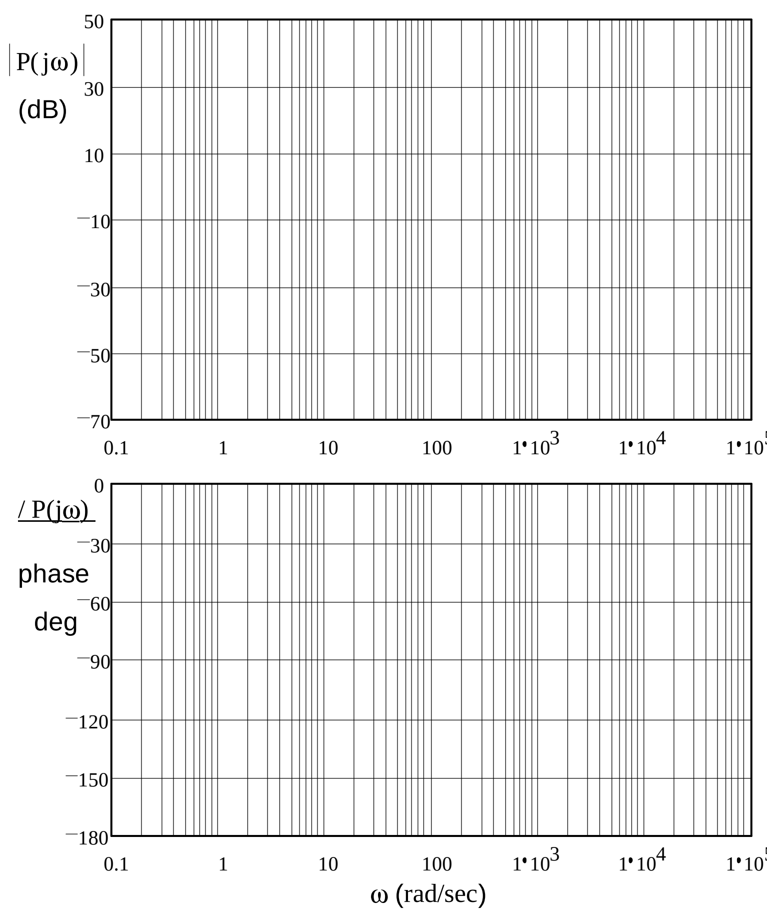
ECE 3510 Final given: Spring 18

1. (32 pts) Sketch the Bode plot for the following transfer functions. Use the method I taught in class to find magnitudes, slopes and angles. Also draw the "smooth" lines.

   a) $P(s) = \dfrac{4 \cdot s \cdot (s+2) \cdot (s+1000)}{(s+0.1) \cdot (s+40)^2}$



   b) $P(s) = \dfrac{20 \cdot \left[(s+10)^2 + 9900\right]}{\left(s^2 + s + 4\right) \cdot (s+2000)}$

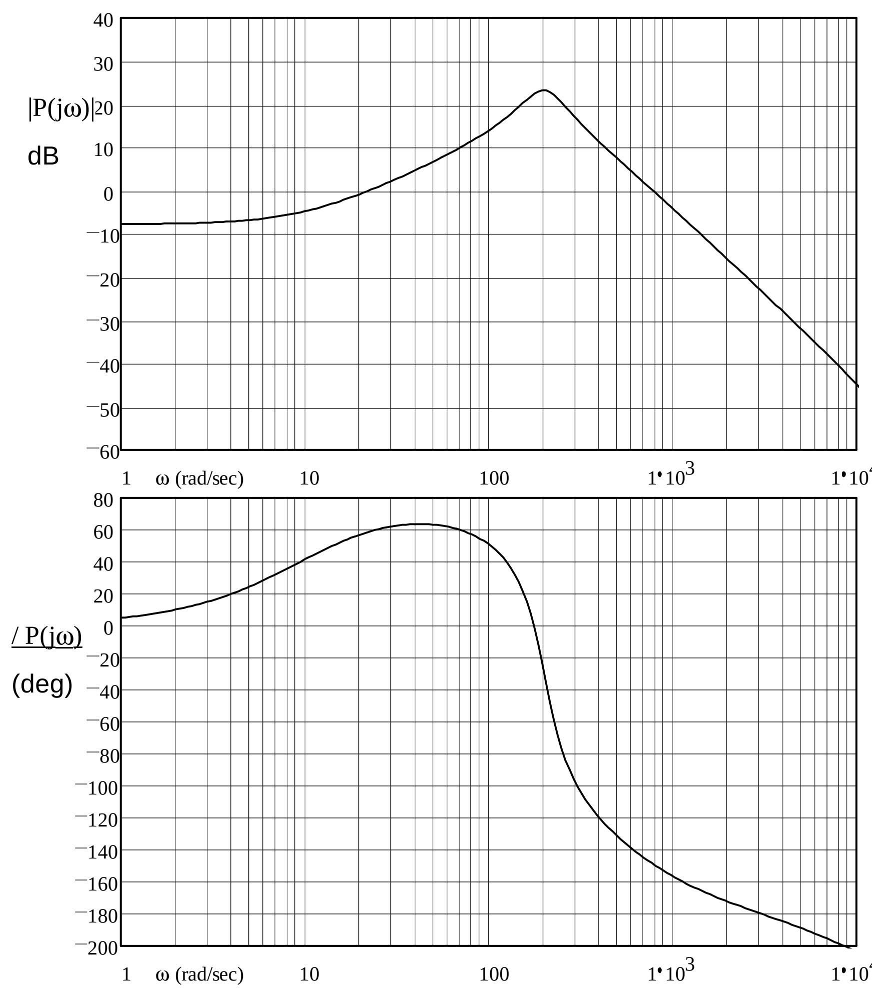


2. (18 pts) Given the magnitude Bode plot of a system, estimate the transfer function of the system. Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane). Use a straight edge and show your work (how you made your estimate).

3. (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.

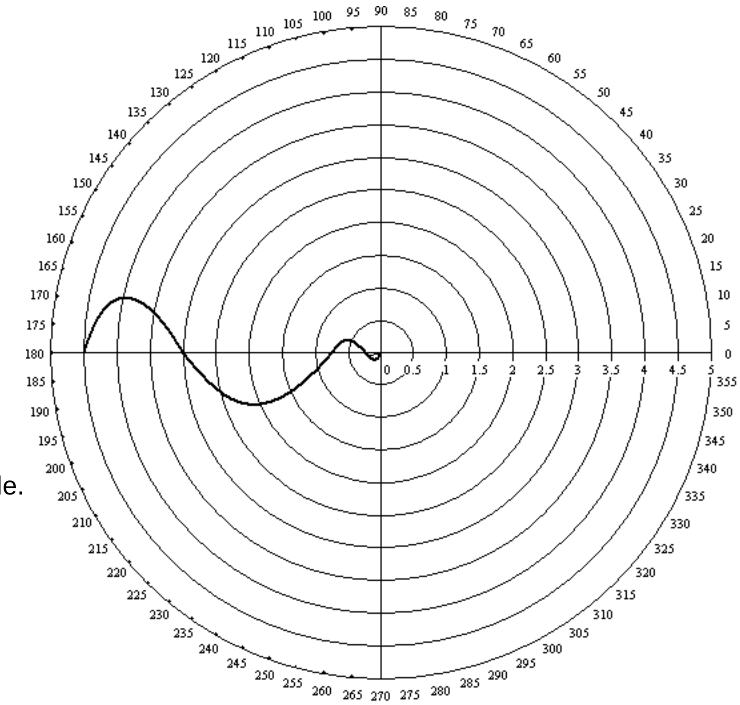


   c) For the system of part (a), give the steady-state response of the open-loop system an input $x(t) = 4\sin(9t)$. express the answer in the time-domain. $y_{ss}(t)$ = ?

4. (17 pts) For the given Nyquist plot, find the following for the **open-loop** system:
   a) the DC gain

   b) (number of poles - number of zeros)
   $n - m$

   c) Number of poles in RHP, given the closed-loop system is stable at the current gain and is not stable at a gain of 0.1.



Find the following for the **closed-loop** system:
   d) Gain margin. Show your work on the drawing. Be sure to indicate ALL the regions that would be stable.

   e) Phase margin. Show your work on the drawing.

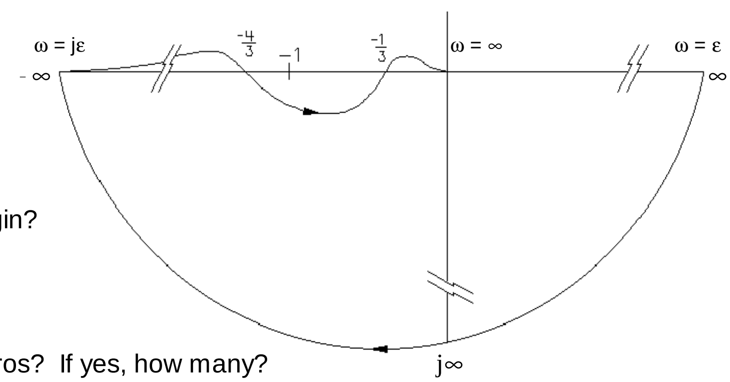
   f) What gain would result in the best GM an PM?

5. (12 pts) Refer to the Nyquist curve at right (only the portion for $\omega > 0$ is plotted).
   a) The closed-loop system is stable. How many unstable poles can the open-loop system have? Show why.

   b) Does the open-loop system have any poles at the origin?

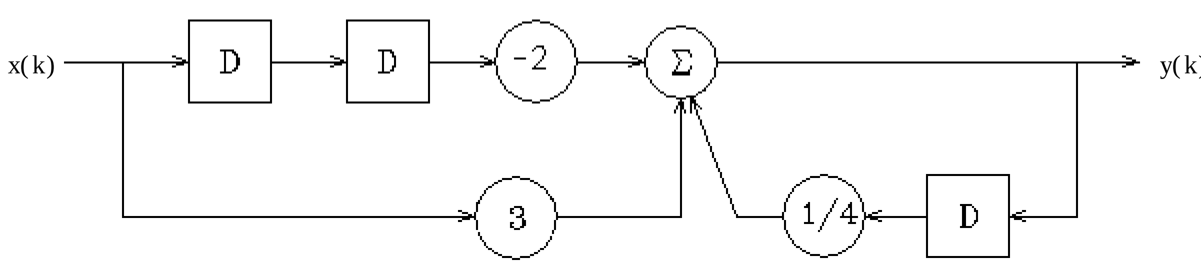
   c) What is (are) the gain margin(s)?

   d) Does the open-loop system have more poles than zeros? If yes, how many?



6. a) (12 pts) Use partial fraction expansions to find the $x(k)$ whose z-transform is: $X(z) = \dfrac{6 \cdot z}{(z-1)\cdot(z+2)}$

7. (6 pts) Find the difference equation corresponding to block diagram below.



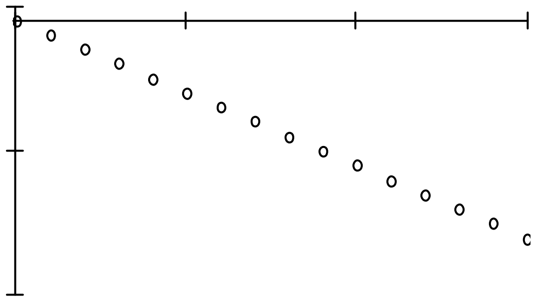
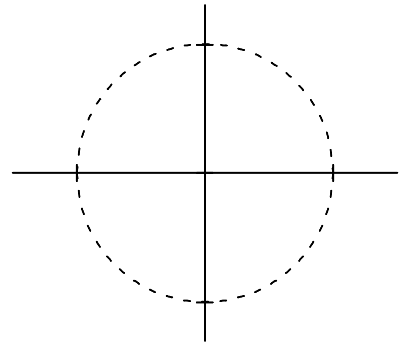
8. (13 pts) a) Find the transfer function $H(z) = Y(z)/X(z)$ corresponding to the difference equation below.

$$y(k) \quad = \quad 4 \cdot x(k) + 3 \cdot x(k-3) - \frac{1}{2} \cdot y(k-2)$$

   b) List the poles of $H(z)$. Indicate multiple poles if there are any.

   c) Is this system BIBO stable? Give a reason for your answer.

9. (20 pts) For each of the following discrete-time **signals**, draw the poles on the z-plane shown.
A unit circle is shown on each z-plane as a dotted line.

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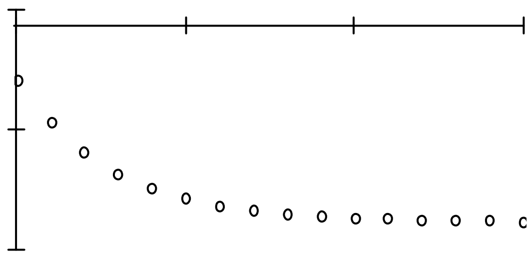
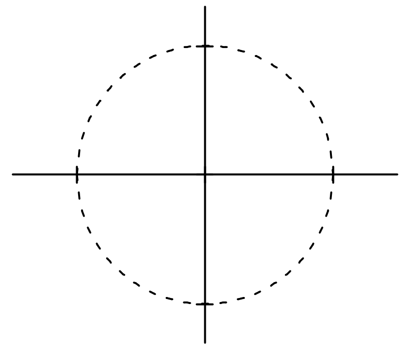

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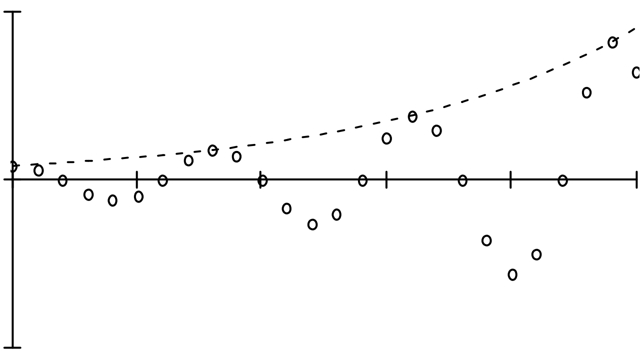
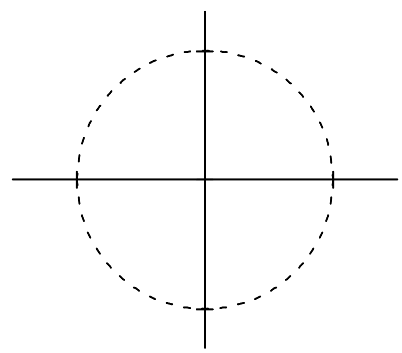

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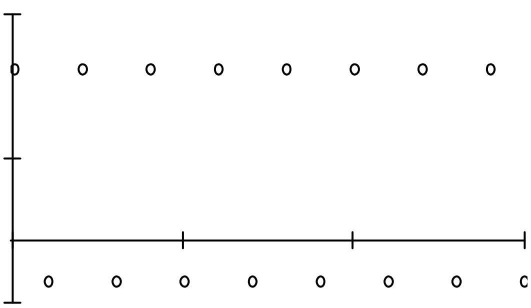
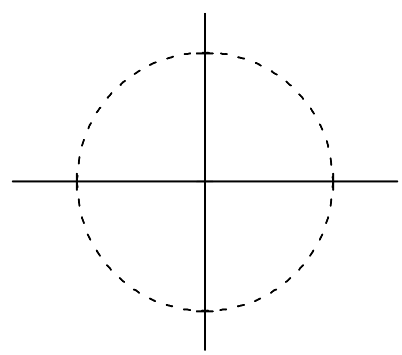

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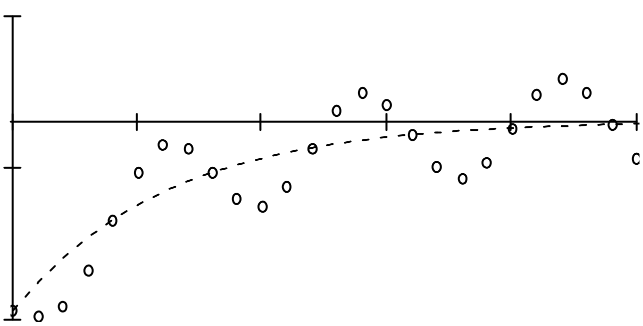
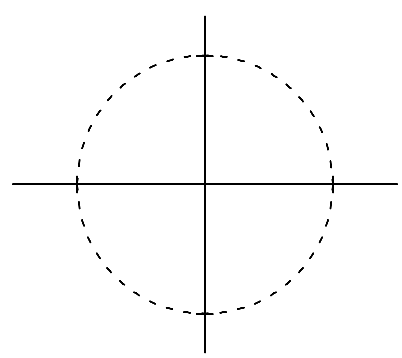
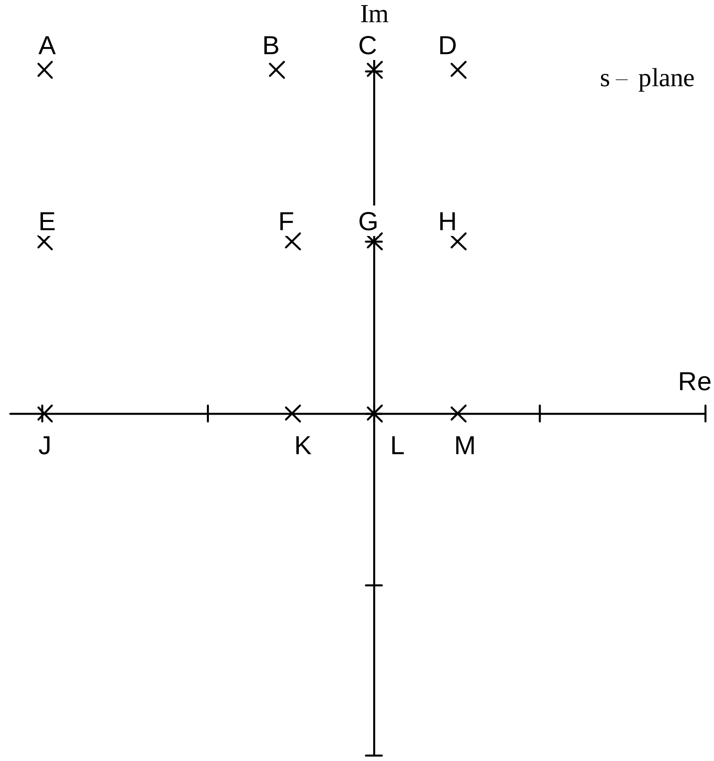



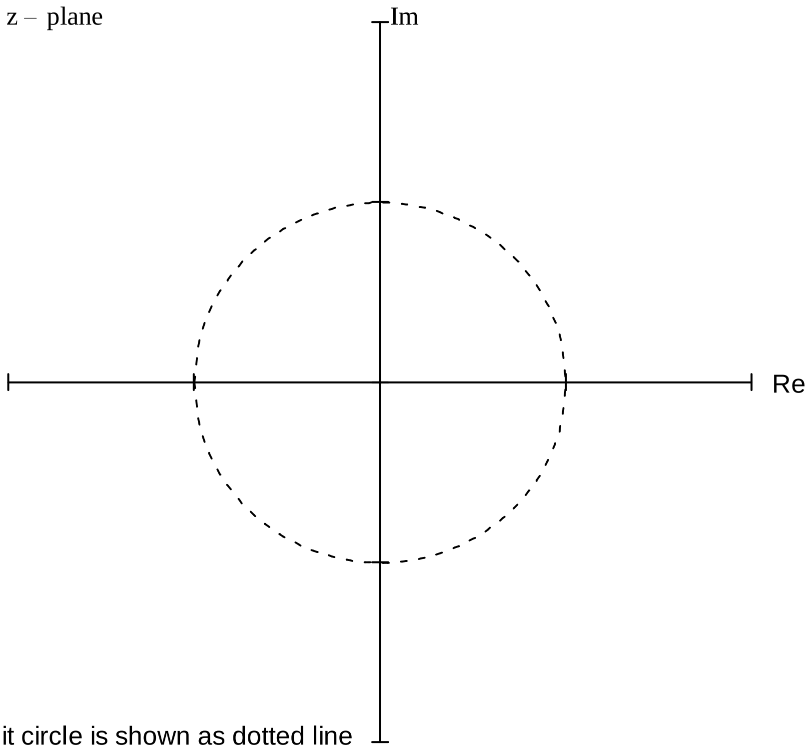
10. (20 pts) For each of the pole locations shown on the s-plane below, Draw and label a similar pole location on the z-plane.

    Assume that the highest frequencies shown on the s-plane are close to maximum allowable digital frequencies, and that no aliasing occurs. Your answers should make sense relative to one another.



Note: The poles on both planes do come in complex-conjugate pairs, but I have only shown those above the real axis.

You may do the same below.

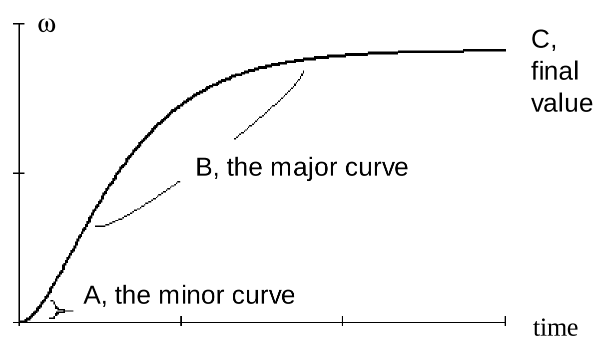


11. (7 pts) In Lab 4 you characterized a DC motor. The curve at right is a typical rotational speed vs time measurement for such a motor. Tell me what motor parameter or characteristic is most responsible for each of the labeled parts of the curve.

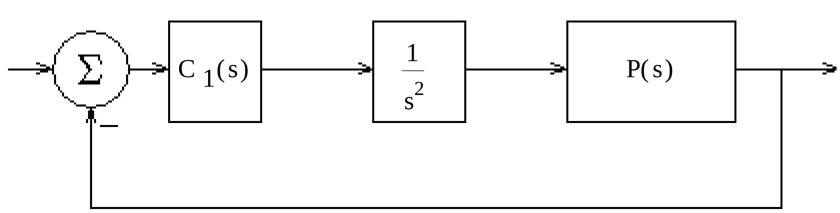
    A, the minor curve

    B, the major curve

    C, final value



12. (5 pts) Consider this block diagram. The double intergrator is a big problem and is making the entire system difficult to control. What, if anything, can be done to change the pole locations of the double integrator? You may want to redraw the block diagram to show your change(s).



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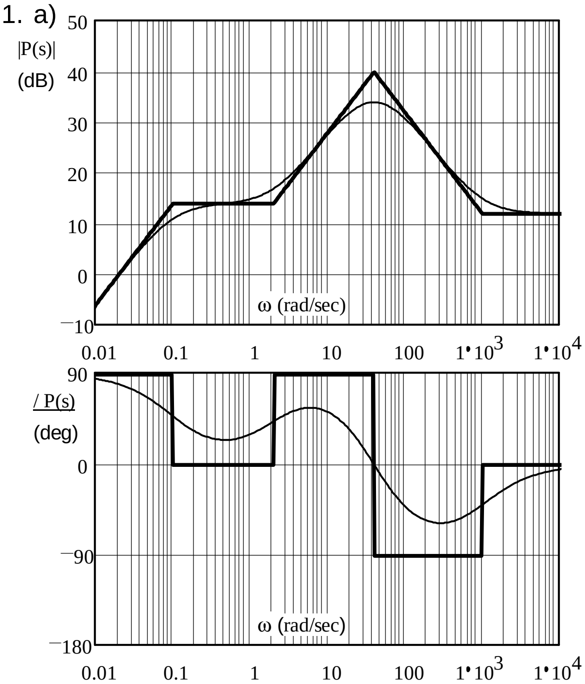
If your answer is yes, then provide some sort of alias: ______________________________
otherwise, leave blank

The grades will be posted on line in pdf form in alphabetical order under the alias that you provide here.
I **will not** post grades under your real name or an alias that looks like a real name or u-number.
The pdf spreadsheet will show the homework, lab, and exam scores of everyone who answers here.

Answers

1. a)



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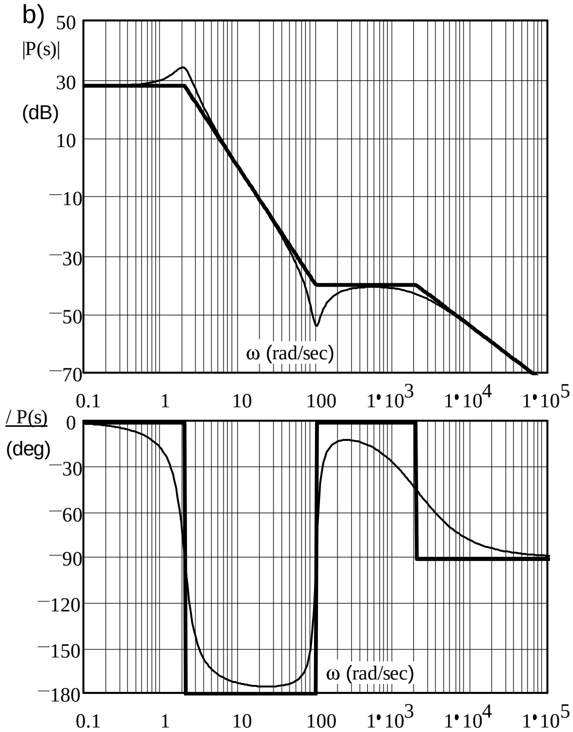


2. $\frac{1000}{3}\cdot\frac{(s+3000)\cdot s}{(s+5)\cdot\left(s^2+40\cdot s+10000\right)}$

3. a) $24\cdot dB$ $30\cdot deg$ b) $0.65\cdot ms$

4. a) -4.5 b) 1 c) 1 d) 1/3 < k < 4/3 OR k > 4 e) $15\cdot deg$

f)about 0.6 A very large gain is even better, but may be unrealistic in practice

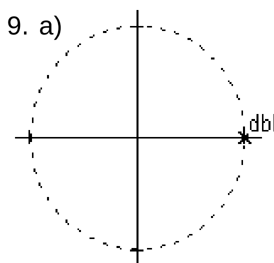
5. a) 0 b) yes 180° arc at ∞ 2 c) 3/4 < k < 3 d) 2

6. $\left[2-2\cdot(-2)^k\right]\cdot u(k)$

7. $y(k) = 3\cdot x(k) - 2\cdot x(k-2) + \frac{1}{4}\cdot y(k-1)$

8. $\frac{4\cdot z^3+3}{z\cdot\left(z^2+\frac{1}{2}\right)}$

9. a)



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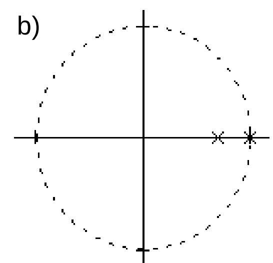

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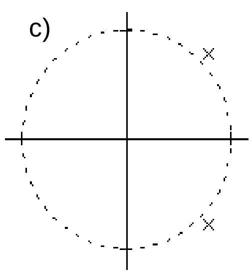

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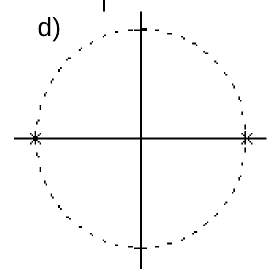

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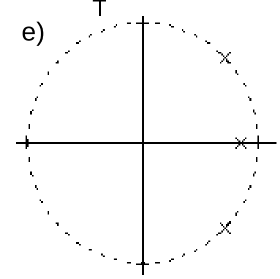
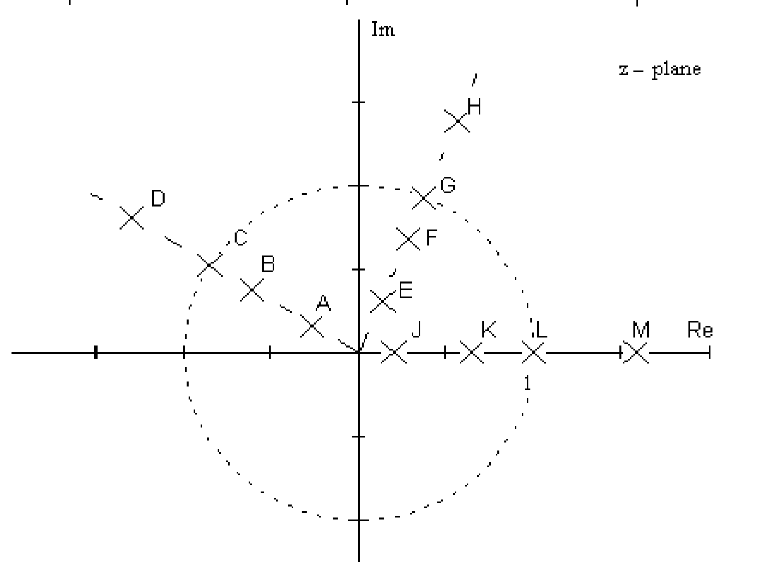


10.



11. L_a J_m K_V

12.