ECE 3510 Final given: Spring 12

This part of the exam is Closed book, Closed notes, No Calculator.

1. a) If a **signal** has a pole at origin, what does that mean?

   b) If a **system** has a pole at origin, what does that mean?

   c) If a **system** has a **zero** at origin, what does that mean?

2. Answer the following with the lettered answers given. More than one may apply, but list only the most restrictive (meaning if you said answered "no poles in bottom-half plane" don't also list "no double poles in the bottom-half plane".

   a) If a signal is bounded, its poles MAY NOT BE:

   b) If a signal converges to zero, its poles MAY NOT BE:

   c) If a signal converges to a non-zero value, its poles MAY NOT BE:

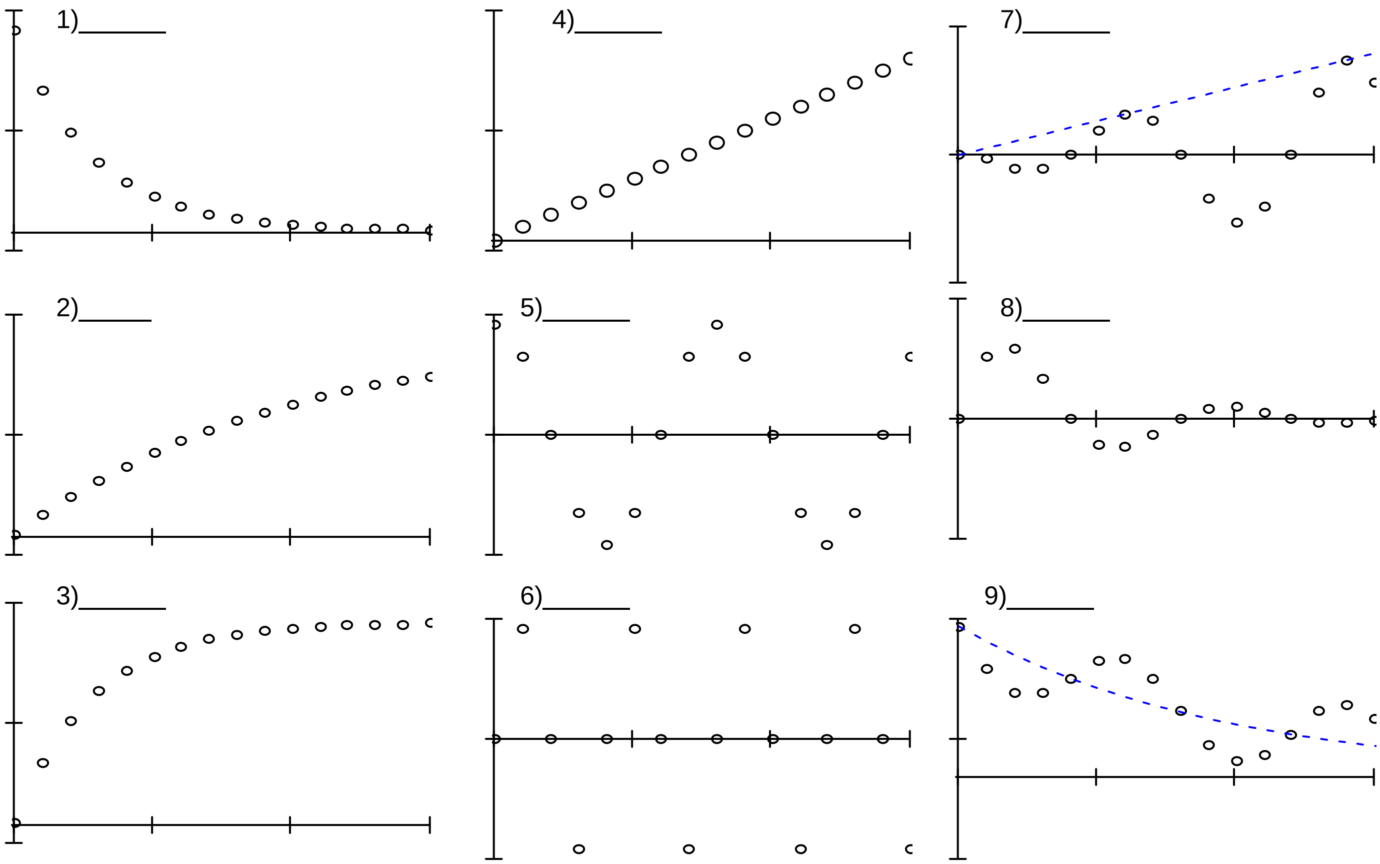
   d) If a signal has absolutely no ringing, its poles MAY NOT BE:

   e) If a **system** is BIBO stable, its poles MAY NOT BE:

   A. In the right-half plane
   B. In the bottom-half plane
   C. On the jω axis
   D. On the real axis
   E. On jω axis, except for one at the origin
   F. Double poles on jω axis
   G. Double poles on real axis
   H. Double poles in the left-half plane
   J. Double poles in the right-half plane
   K. At the origin
   L. Double poles at the origin
   M. Anywhere but the real axis

3. (25 pts) a) Match each of the following discrete-time **signals** to one of the answers on the next page.

   Find the single best match for each. Your answers should make sense relative to one another.



b) Match each of the following transfer functions to one of the answers on the next page.

1) $H(z) = \dfrac{6 \cdot z}{(z-1)\cdot(z+0.7)}$ _______ 2) $H(z) = \dfrac{2 \cdot z}{z^2 - 1.414\cdot z + 1}$ _______

c) If the answers on the next page are considered poles of **transfer functions**, list all that are BIBO stable.

ECE 3510 Final, ANSWERS to closed-book question 3

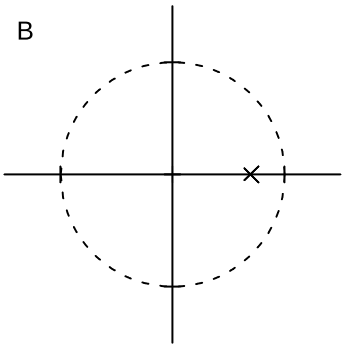
Each answer below is a z-plane showing the unit circle and usually some poles

Answers may be used more than once or not at all. dbl = double pole at that location.

ANSWERS

A None of these answers match.

B



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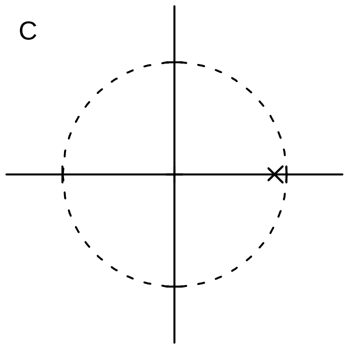

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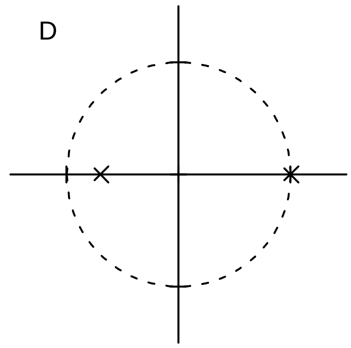

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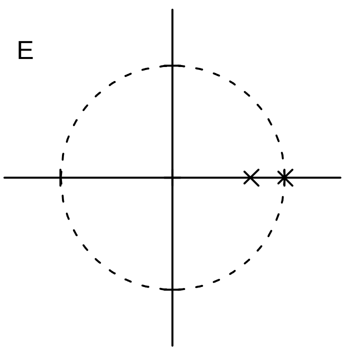

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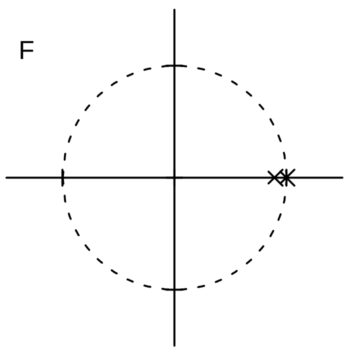

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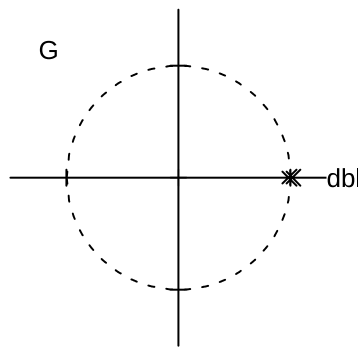

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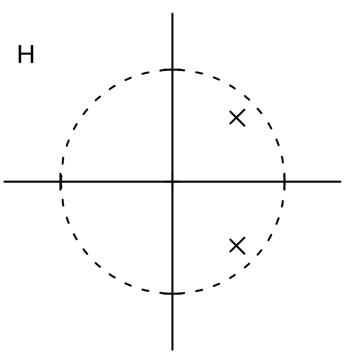

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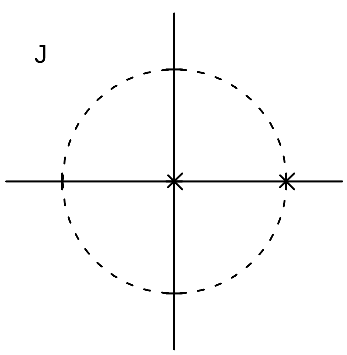

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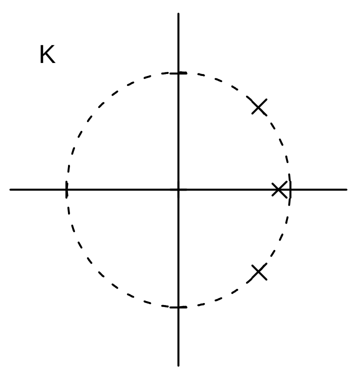

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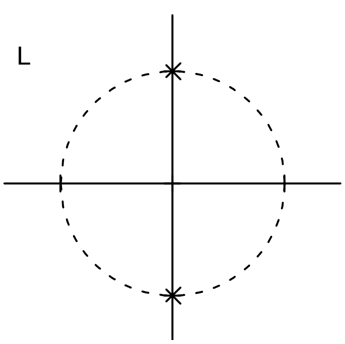

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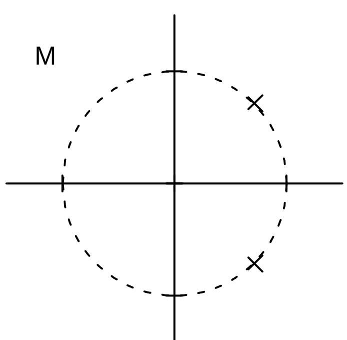

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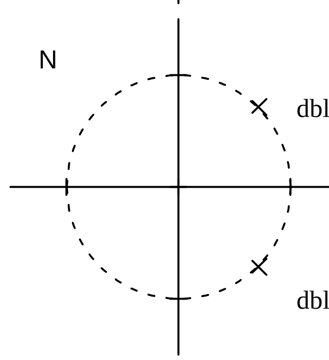
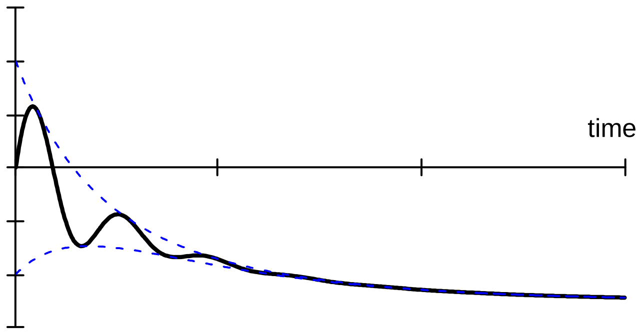
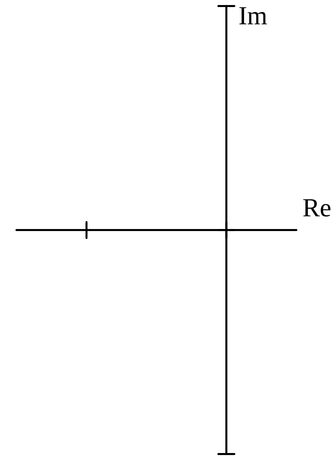


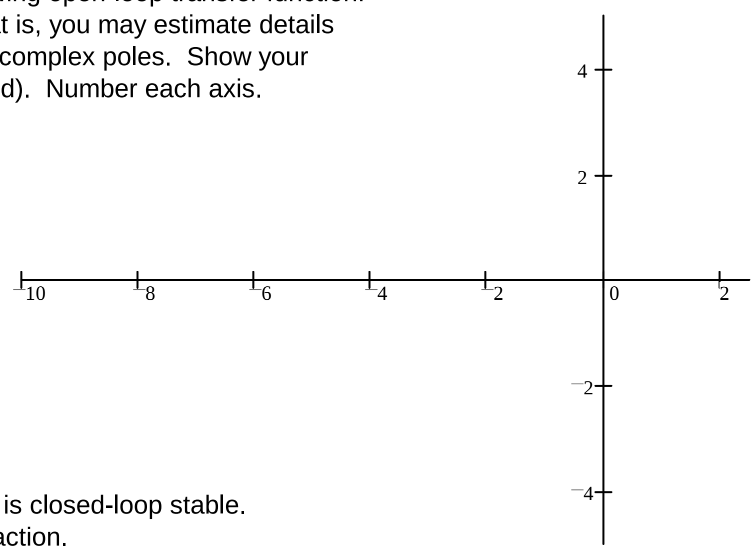
4. (8 pts) For the time-domain signal shown, draw the poles of the signal's Laplace transform on the axes provided. The real and imaginary axes have the same scaling. Clearly indicate double poles if there are any.





5. (12 pts) a) Sketch the root-locus plot for the following open-loop transfer function: Use only the rules you were told to memorize, that is, you may estimate details like breakaway points and departure angles from complex poles. Show your work where needed (like calculation of the centroid). Number each axis.

$$\mathbf{G}(s) = \frac{s^2 + 2\cdot s + 5}{(s-1)\cdot(s+6)\cdot\left(s^2 + 10\cdot s + 29\right)}$$



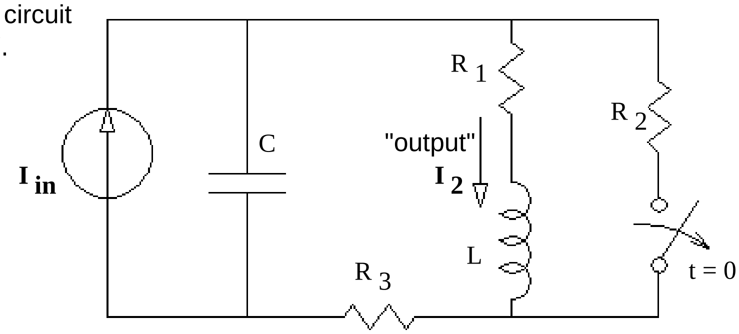
b) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$. The answer may be left as a fraction.

Open-book Part

1. (16 pts) a) Find the s-type transfer function of the circuit shown after time $t = 0$. Consider $\mathbf{I_2}$ as the "output".

You MUST show work to get credit. Simplify your expression for $H(s)$ so that the denominator is a simple polynomial with no coefficient before the highest-order s term in the denominator.

$$\mathbf{H}(s) = \frac{\mathbf{I_2}(s)}{\mathbf{I_{in}}(s)} = ?$$



b) How many zeroes does this transfer function have?

If it has 1 or more, express them (probably in terms of R_1, R_2, R_3, L and C).

c) How many poles does this transfer function have?

If it has 1 or more, express them (probably in terms of R_1, R_2, R_3, L and C).

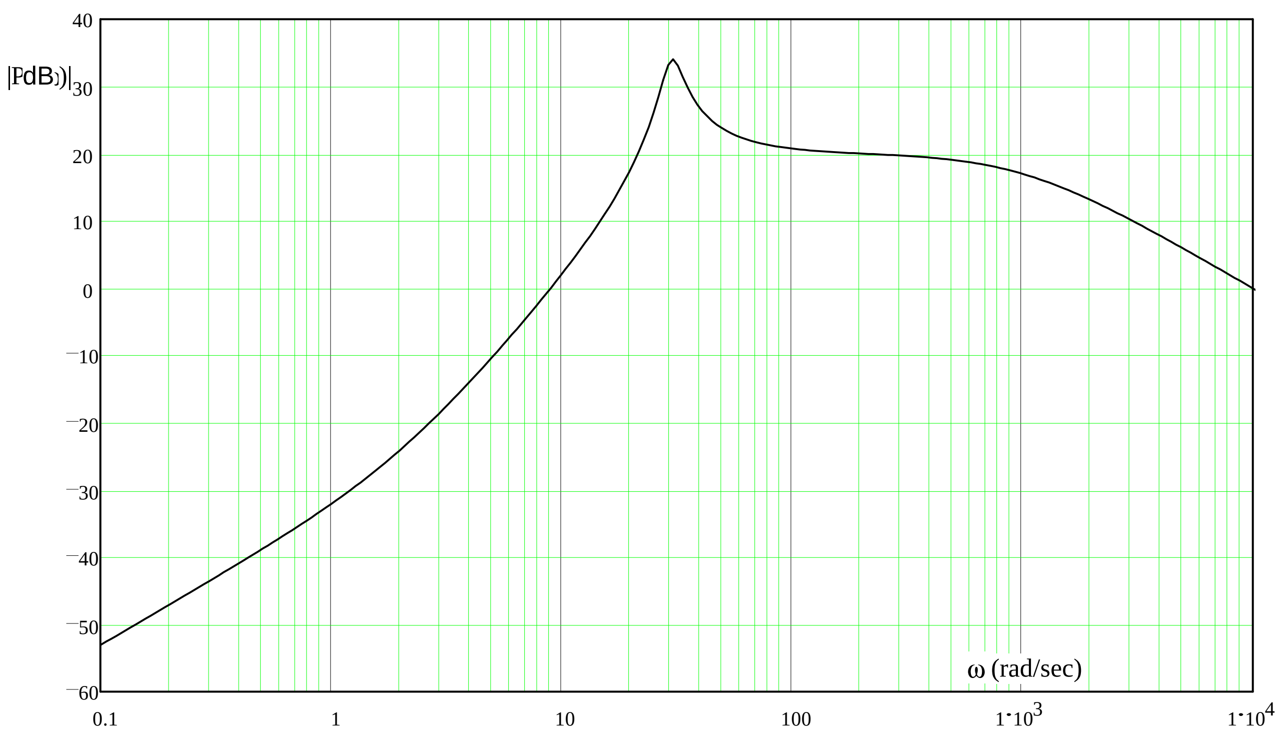
2. (22 pts) Consider this transfer function. $G(s) := \dfrac{s+8}{s\cdot(s+5)\cdot(s+20)}$

a) You wish to add a compensator to get closed-loop ζ of 0.7071 if the ringing is 15 rad/sec. (using the second-order approximation). Find the required $C(s)$.

b) With the compensator in place and a closed-loop pole at the location desired in part b) What is the gain?

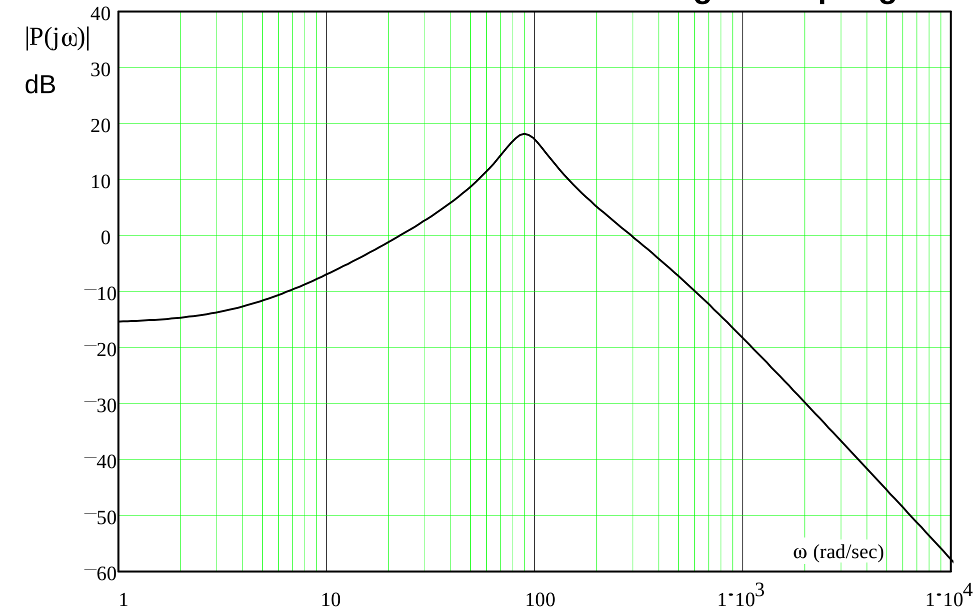
c) With this compensator in place, is there possibility for improvement (better speed and/or lower ringing)? If yes, what would be the simplest thing to do? Justify your answer.

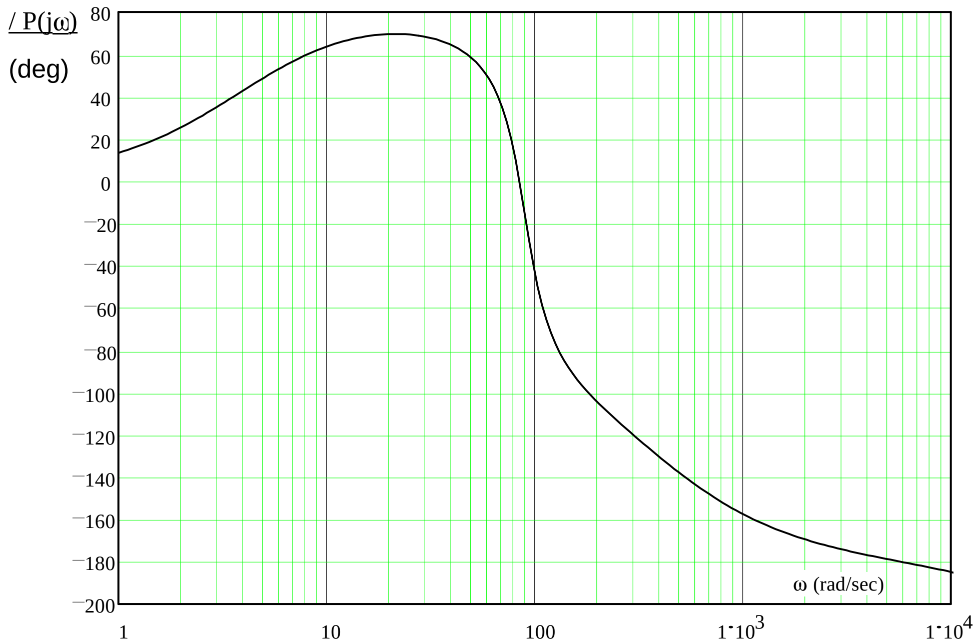
3. (17 pts) Given the magnitude Bode plot of a system, estimate the transfer function of the system. Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane). Use a straight edge and show your work (how you made your estimate).



4. (12 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.

5. (18 pts) For the given Nyquist plot, find the following for the open-loop system:

   a) the DC gain

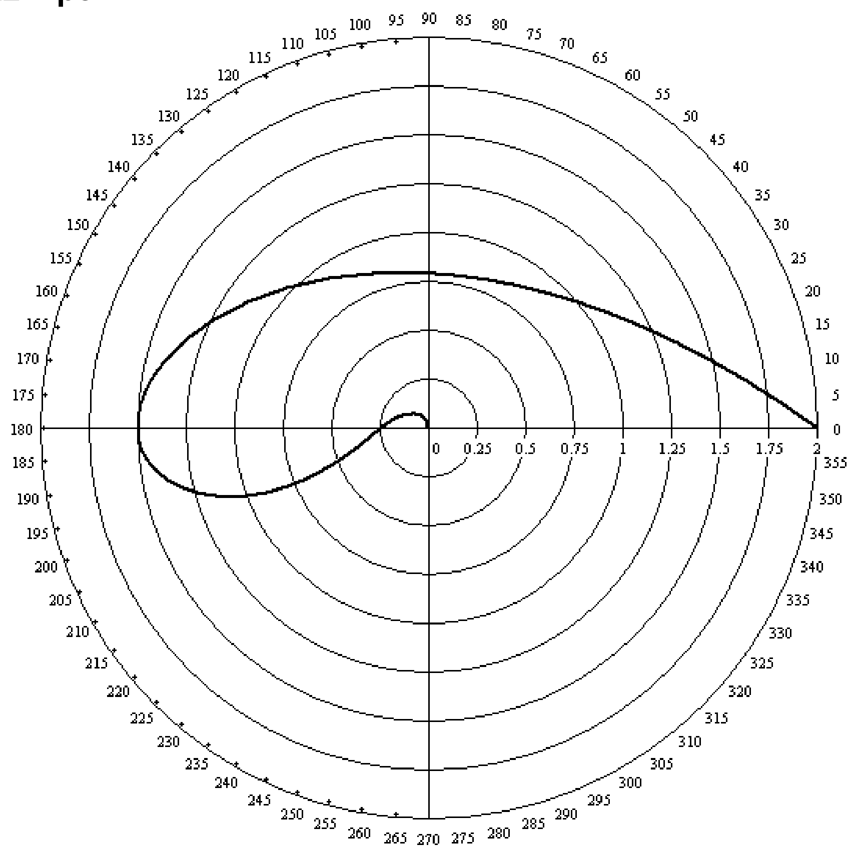
   b) $n - m$

   (number of poles - number of zeros)

   c) Number of poles at the origin

   How do you know?

   d) 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:

e) Gain margin. Show your work on the drawing. Be sure to indicate ALL the regions that would be stable.

f) Phase margin. Show your work on the drawing. You may report two numbers

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

6. (20 pts) a) Draw the block diagram of a simple direct implementation of the difference equation.

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

   b) Find the $H(z)$ corresponding to the difference equation above. Show your work.

   c) List the poles of $H(z)$. Indicate multiple poles if there are any.
   If you can't find the actual poles, show the equation you would have to solve in order to find them.

   d) Is this system BIBO stable? Justify your answer. If you don't have the information you need, say how you would determine this.

7. (12 pts) Find the $x(k)$ whose z-transform is given. Use partial fraction expansion. Answers should not have complex numbers

$$X(z) = \frac{3\cdot z}{(z-0.5)\cdot(z+0.8)\cdot(z+1)}$$

8. Do you want your grade and scores posted on the Internet? 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. It will show the homework, lab, and exam scores of everyone who answers here.

Answers

1. a) The signal has a DC component

   b) The system <u>integrates</u> the input signal OR

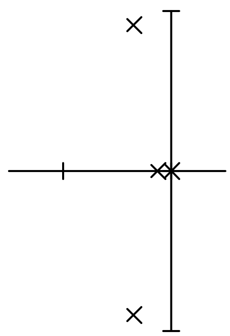
   The output signal will ramp to an unbounded value if the input has DC (pole at origin)

   c) The system <u>differentiates</u> the input signal OR The system <u>does not pass any DC</u> to the output

2. a) A F b) A C c) A E d) M e) A C

3. 1) B 2) F 3) E 4) G 5) M 6) L 7) N 8) H 9) K b) 1) D 2) M c) B C H

4.



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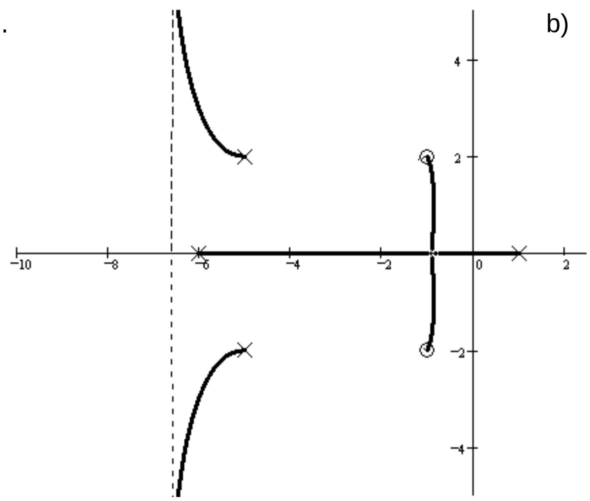


b) $k < 34.8$

1. a) $\mathbf{H}(s) = \dfrac{\frac{1}{LC}}{s^2 + \frac{R_1 + R_3}{L}\cdot s + \frac{1}{L\cdot C}}$ b) 0 c) 2 $\dfrac{-\frac{R_1+R_3}{L} \pm \sqrt{\left(\frac{R_1+R_3}{L}\right)^2 - \frac{4}{L\cdot C}}}{2}$

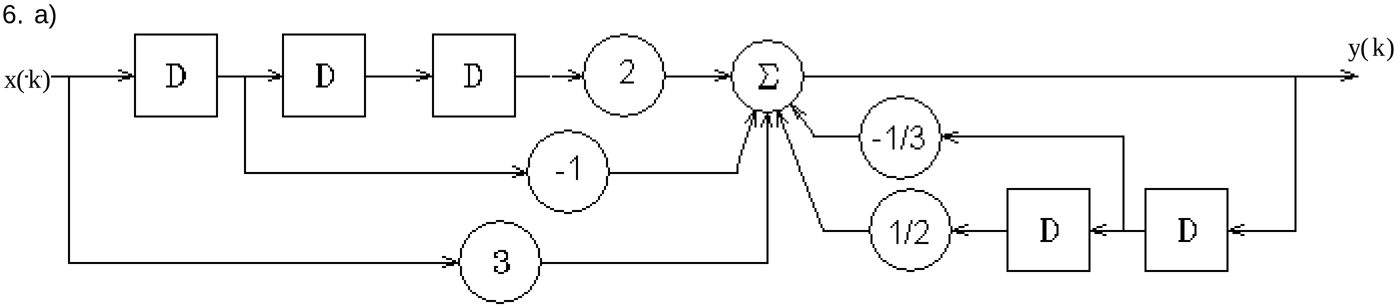
2. a) $C(s) := (s + 36.234)$ b) 14.05 c) A quick sketch of the new root-locus shows that simply increasing the gain would improve the system

3. $P(s) = 10000\cdot\dfrac{s\cdot(s+2)}{(s+1000)\cdot\left(s^2 + 6\cdot s + 900\right)}$

4. a) $GM := 49\cdot dB$ $PM := 60\cdot deg$ b) $DM := 3.5\cdot ms$

5. a) 2 b) 3 c) 0 No arc at ∞ d) 2 e) $\left[\frac{2}{3}, 4\right]$ f) 20 deg OR -47 deg g) about 1.6

6. a)



b) $H(z) = \dfrac{3\cdot z^3 - z^2 + 2}{z^3 + \frac{1}{3}\cdot z^2 - \frac{1}{2}\cdot z}$ c) 0 0.56 -0.893 d) Yes, all poles are inside the unit circle

7. a) $x(k) = 1.538\cdot(0.5)^k - 11.538\cdot(-0.8)^k + 10\cdot(-1)^k$