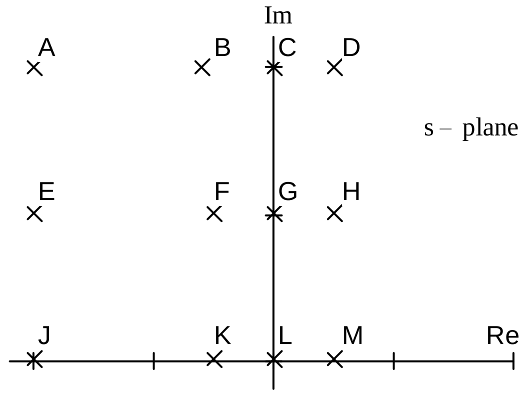
ECE 3510 Final given: Spring 10

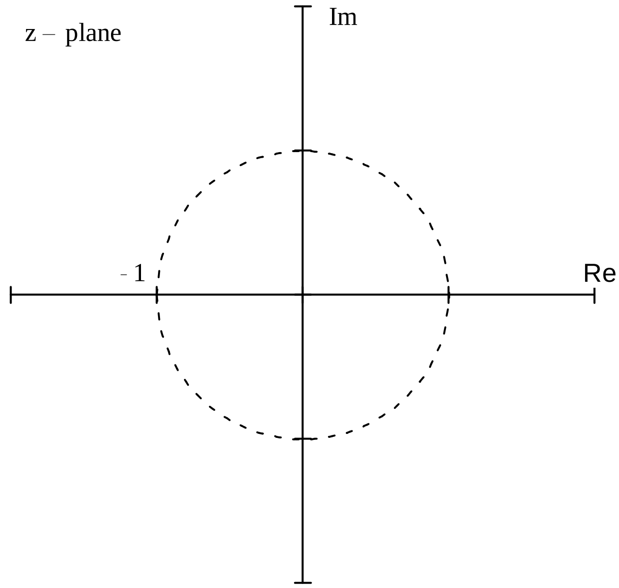
This part of the exam is Closed book, Closed notes, No Calculator.

1. (20 pts) For each of the pole locations shown on the s-plane, 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.

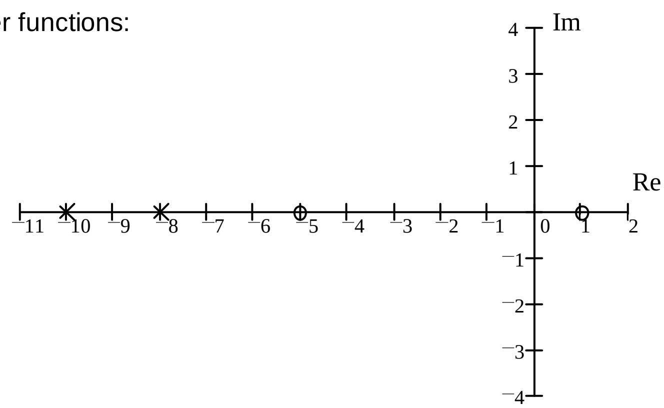




Sketch the root-locus plots for the following open-loop transfer functions:

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).

Draw things like the asymptote angles carefully.

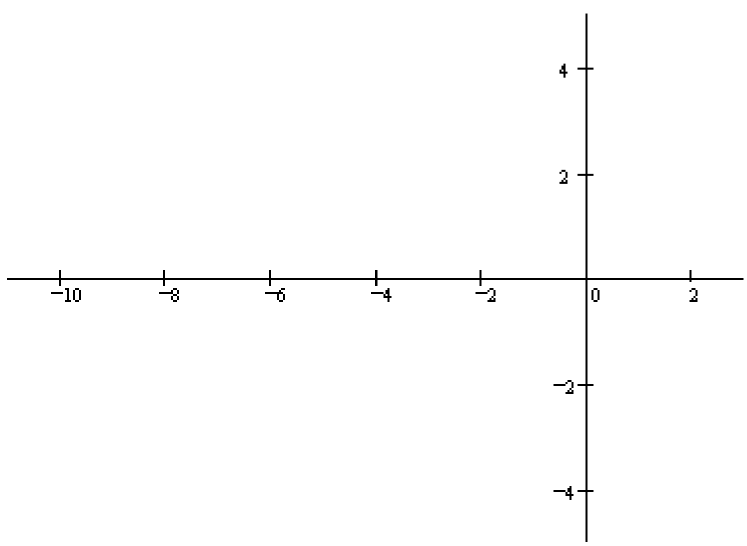


2. (13 pts)

   a) sketch

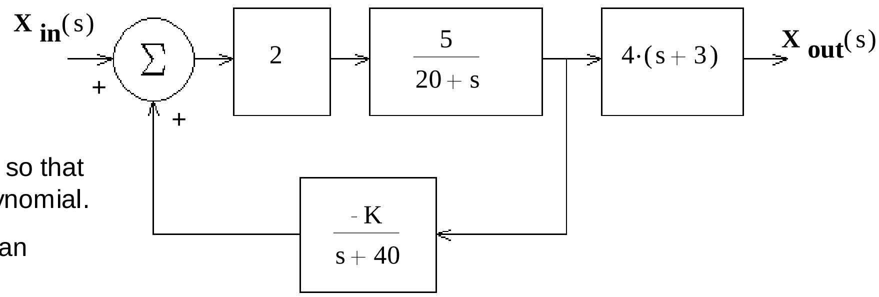
   b) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$.

3. (11 pts) $G(s) = \dfrac{1}{(s^2 + 2\cdot s + 10)\cdot(s+4)\cdot(s+6)}$



1. (14 pts) a) A feedback system is shown in the figure. What is the transfer function of the whole system, with feedback.

$$\mathbf{H}(s) = \frac{X_{out}(s)}{X_{in}(s)} = ?$$



Simplify your expression for H(s) so that the denominator is a simple polynomial.

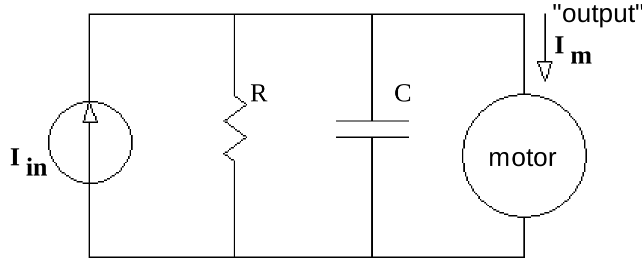
Be clear about your signs, so I can tell you know what you're doing.

b) Find the value of K to make the transfer function critically damped.

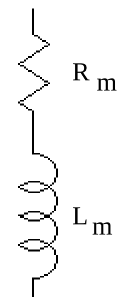
2. (13 pts) a) Find the s-type transfer function of the circuit shown. Consider the motor current ($\mathbf{I_m}$) as the "output".

You MUST show work to get credit. Simplify your expression for H(s) so that the denominator is a simple polynomial.

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

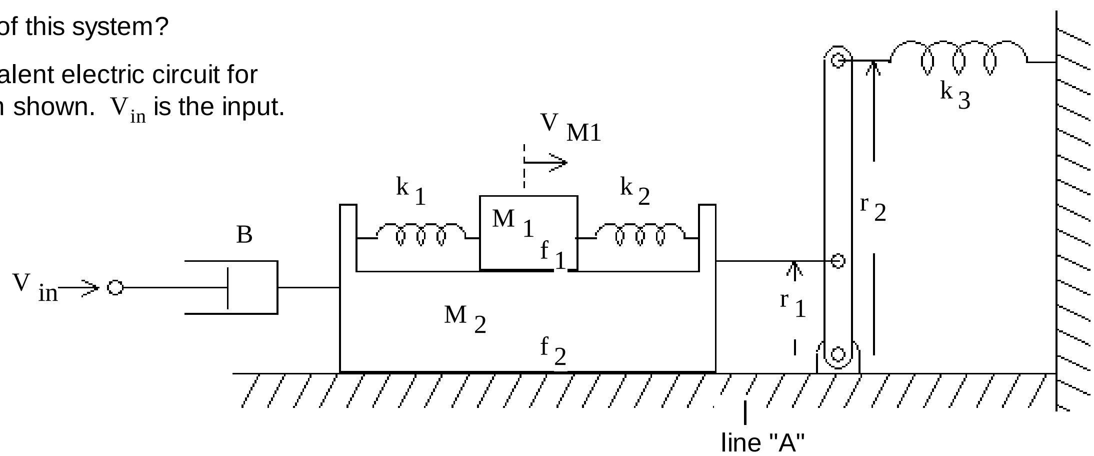


The motor may be modeled as a resistor in series with an inductor, like this:



b) What is the "order" of this system?

3. (22 pts) Find the equivalent electric circuit for the mechanical system shown. V_{in} is the input.



a) Show the circuit with a transformer. Show the parts in terms of M's, k's, B's, etc., above. Indicate V_{M1} on your drawing.

b) Show the circuit to the right of line "A" without a transformer, just like you did in the homework. Show the parts in terms of M's, k's, B's, etc., above.

NOTE: Problems 7 & 8 are out of order here

7. (16 pts) Find the x(k) whose z-transform is given. Use partial fraction expansion. Answers should not have complex numbers

$$X(z) = \frac{z^2 + 4\cdot z}{z^2 - 1.6\cdot z + 0.8}$$

8. (16 pts) a) Draw the block diagram of a simple direct implementation of the difference equation.

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

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

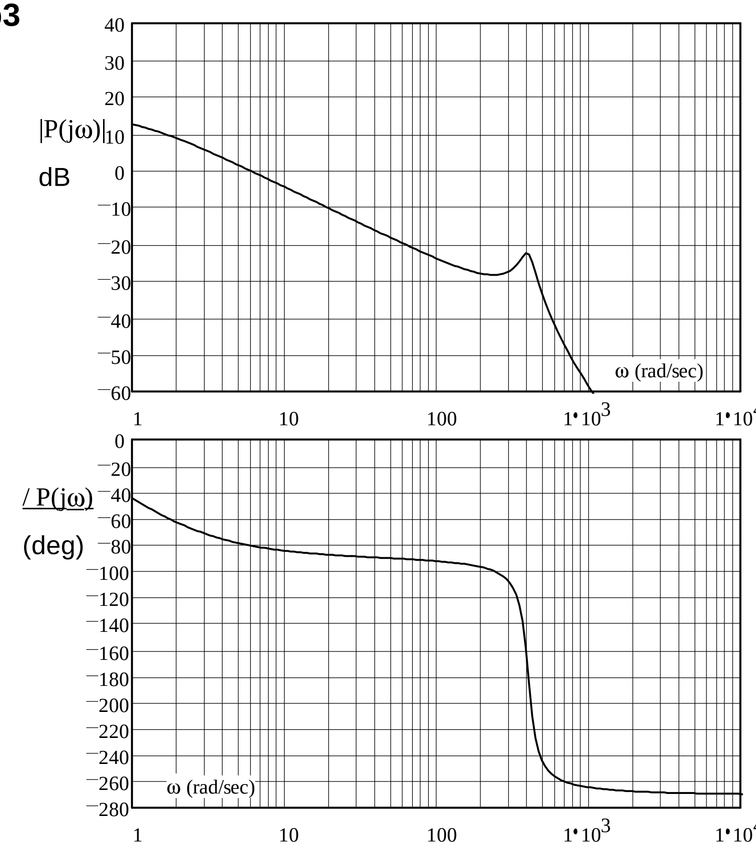
c) List the poles of H(z). Indicate multiple poles if there are any.

d) Is this system BIBO stable?

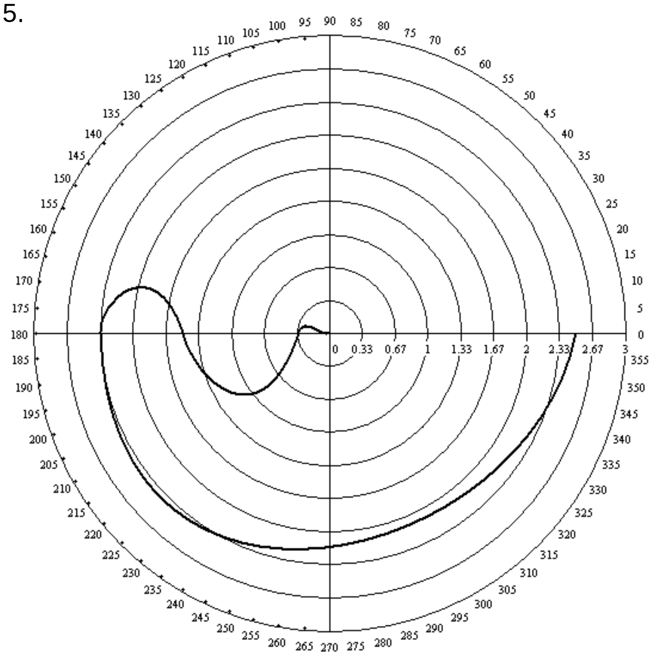
4. (12 pts) The open-loop Bode plots of a system are given at right.

   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.



(15 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 at the origin

d) Number of poles in RHP, given the closed-loop system is stable at the current gain.

Find the following for the closed-loop system:

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

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

6. (10 pts) An open-loop system has:

   2 unstable poles

   A DC gain of 5

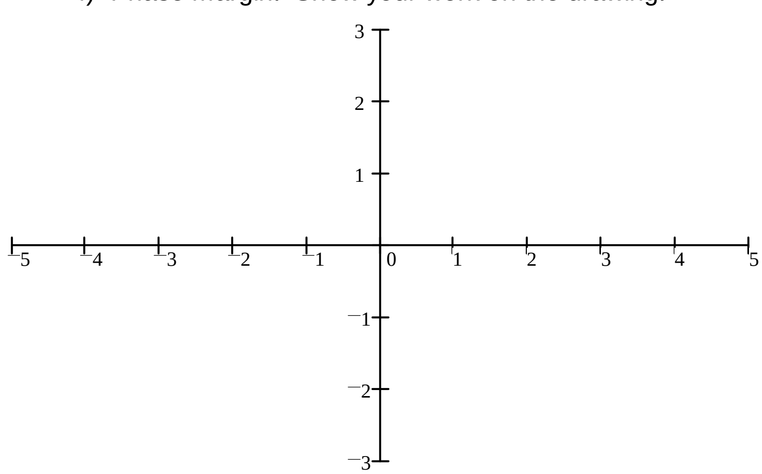
   1 more pole than zeros

   The closed-loop gain margin is

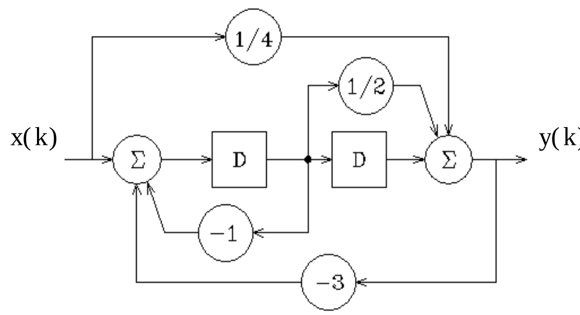
   $$GM = \left[\frac{1}{4} \;,\; 2 \right]$$

   Draw a possible Nyquist plot for this system so that $Z = 0$.

   label important points, like crossings



9. (18 pts) Find the transfer function $H(z) = Y(z)/X(z)$.



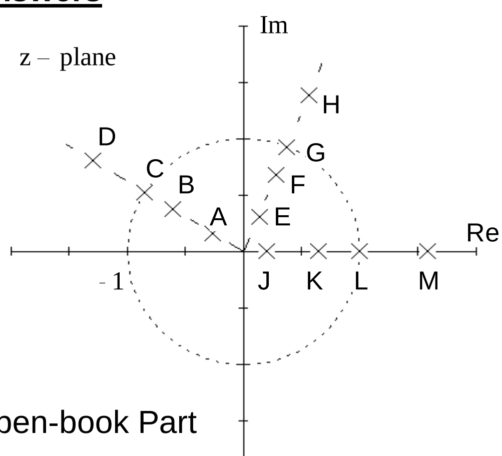
10. Do you want your grade and scores posted on the Internet?
If your answer is YES, then provide some sort of alias
or password: ______________________________

If NO, leave blank

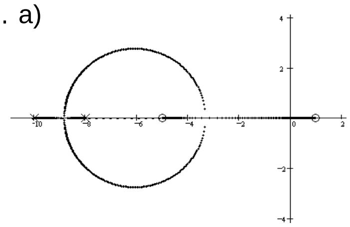
The grades will be posted as a pdf file which you can download. It will show the homework, lab, and exam scores of everyone who provides an alias here in alphabetical order of that alias. I will not post grades under your real name.

Answers

1.

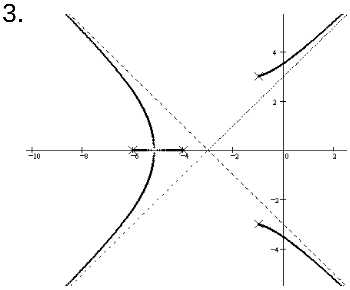


2. a)



b) $k < 16$

3.

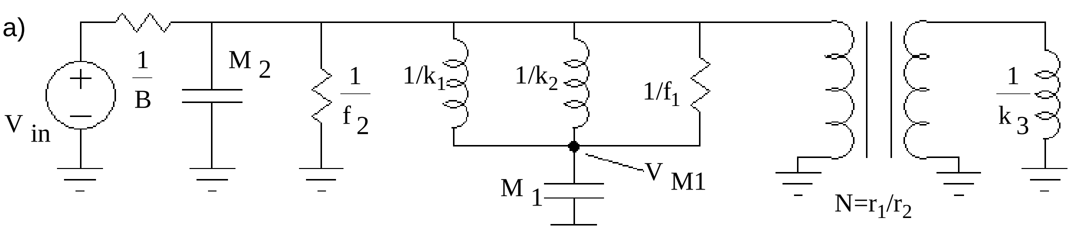


Open-book Part

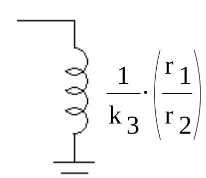
1. a) $\dfrac{40\cdot(s+40)\cdot(s+3)}{s^2+60\cdot s+800+10\cdot K}$ b) 10

2. a) $\dfrac{\dfrac{1}{L_m\cdot C}}{s^2+\left(\dfrac{R_m}{L_m}+\dfrac{1}{R\cdot C}\right)\cdot s+\dfrac{1}{L_m\cdot C}\cdot\left(1+\dfrac{R_m}{R}\right)}$ b) Second

3. a)



b)

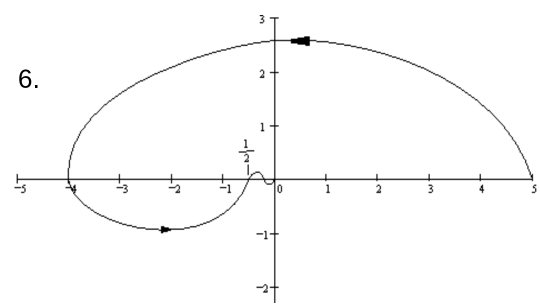


4. a) $23\cdot dB$ $100\cdot deg$ b) $286\cdot ms$

5. a) 2.5 b) 2 c) 0 d) 0

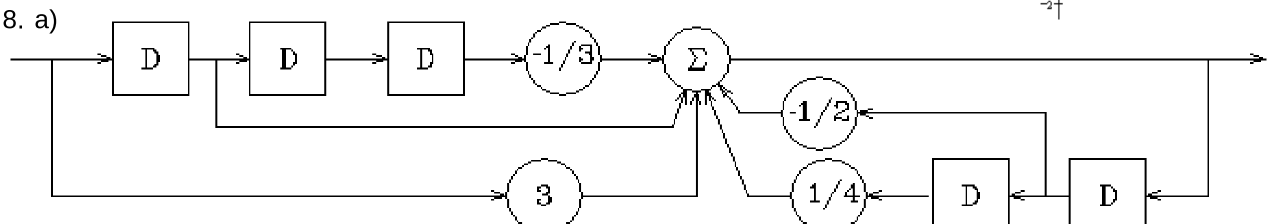
e) $\left[\dfrac{2}{3}, 3\right]$ OR make gain < 0.43 f) $38\cdot deg$

6.



7. $2\cdot 6.021\cdot 0.894^k\cdot\cos(0.464\cdot k-1.488)$

8. a)



b) $\dfrac{3\cdot z^3+z^2-\dfrac{1}{3}}{z\cdot\left(z^2+\dfrac{1}{2}\cdot z-\dfrac{1}{4}\right)}$

c) Poles at: 0 0.309 and -0.809

d) Yes, all poles are inside the unit circle

9. $\dfrac{\dfrac{1}{4}\cdot z^2+\dfrac{3}{4}\cdot z+1}{z^2+\dfrac{5}{2}\cdot z+3}$