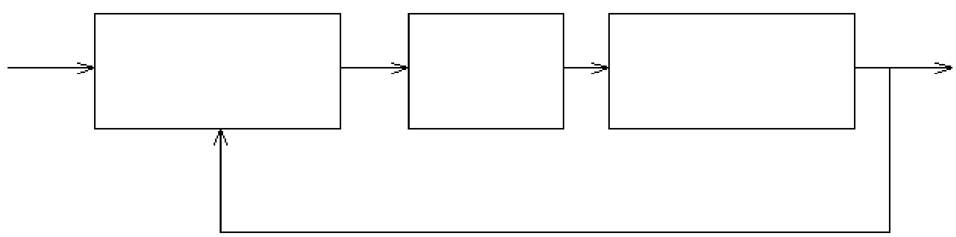
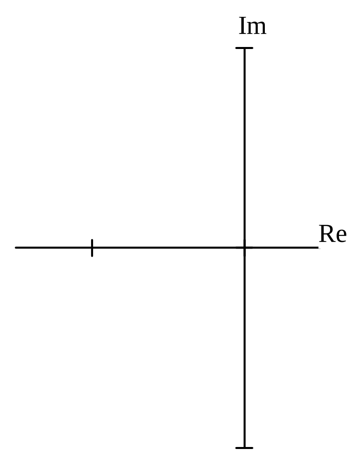
ECE 3510 Final given: Spring 13

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

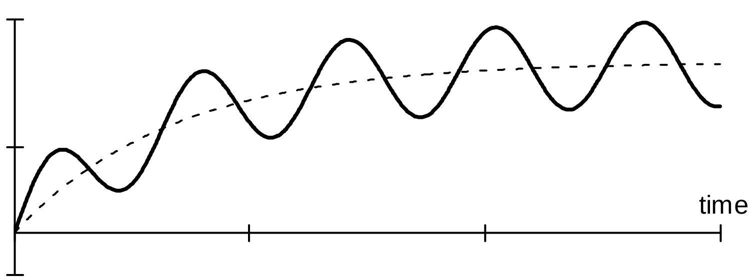
1. (14 pts) The poles and zeros referred to in this problem are of the Laplace transform or transfer function.
   a) A **system** integrates the input signal.
      i) What does that mean in terms of its poles and/or zeros?
      ii) What step response do you expect from this system?
      iii) Give me a real example of such a system also specifying the input and output.
      iv) Is this system BIBO stable? circle one: YES NO Can't tell
   b) A **system** step response dies out to zero.
      i) What does that mean in terms of its poles and/or zeros?
      ii) What mathematical operation does this system perform?
      iii) Is this system BIBO stable? circle one: YES NO Can't tell
   c) If a **signal** has a DC component, what does that mean in terms of its poles and/or zeros?
2. (5 pts) Identify the blocks (in words) in the phase-locked-loop shown below.



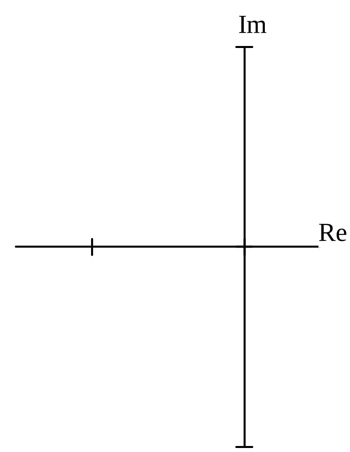
3. (14 pts) For each of the time-domain signals shown, draw the poles of the signal's Laplace transform on the axes provided. All time scales are the same. The axes below all have the same scaling. Your answers should make sense relative to one another. Clearly indicate double poles if there are any.

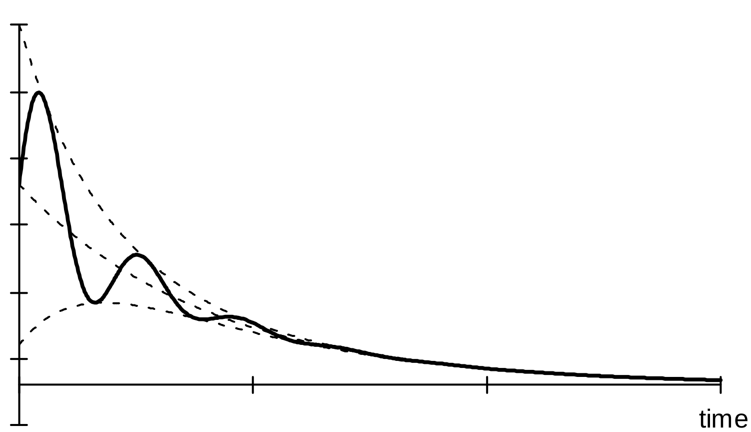


a)



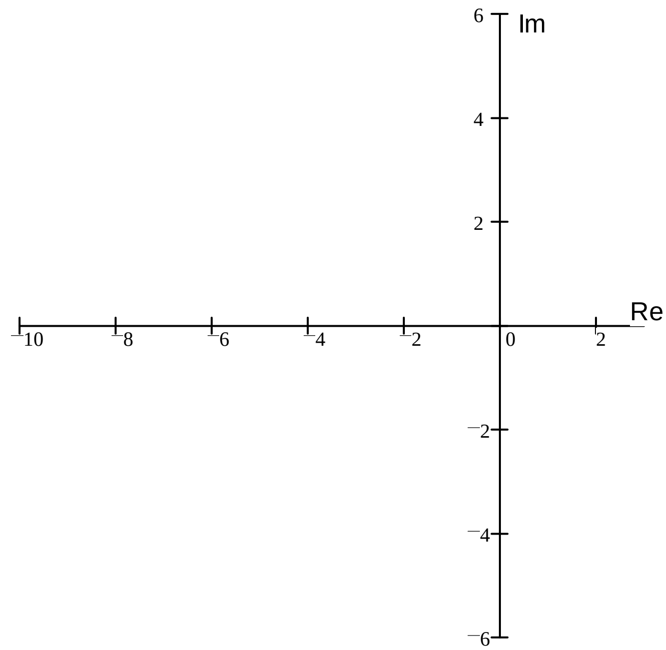
b)



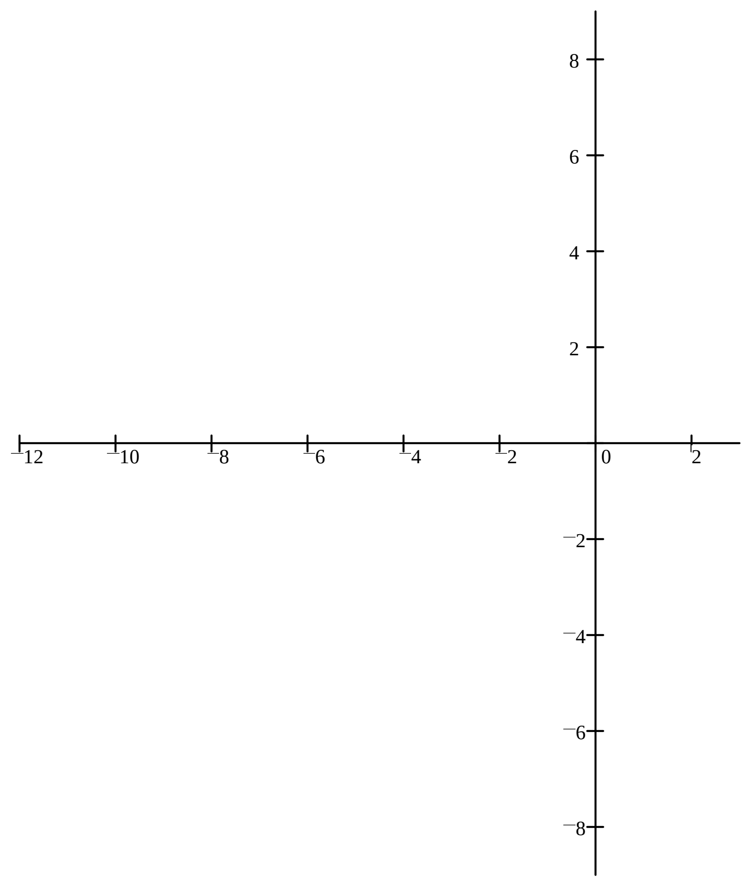


4. (18 pts) Sketch the root-locus plots for the following open-loop transfer functions:
   Use only the rules you were told to memorize, that is, you may estimate details like breakaway points and departure angles from complex poles. Show your work where needed (like calculation of the centroid).
   Draw things like the asymptote angles carefully.

   a) $\mathbf{G}(s) = \dfrac{1}{s\cdot\left(s^2 + 10\cdot s + 41\right)\cdot(s+2)}$

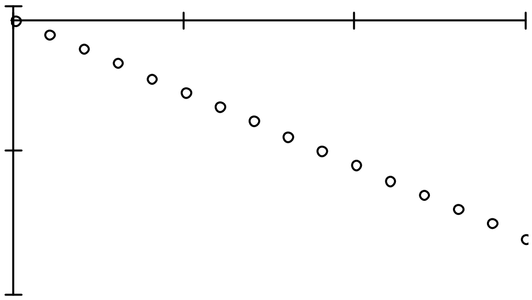


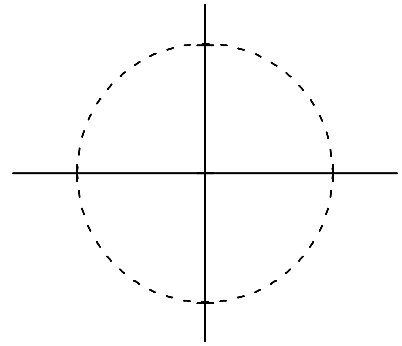
   b) $\mathbf{G}(s) = \dfrac{\left[(s+6)^2 + 3^2\right]}{\left[(s+2)^2 + 6^2\right]\cdot(s+5)}$



5. (22 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..

a)





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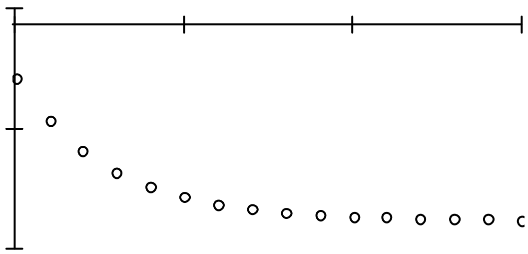
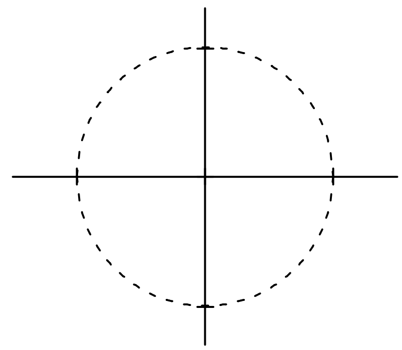
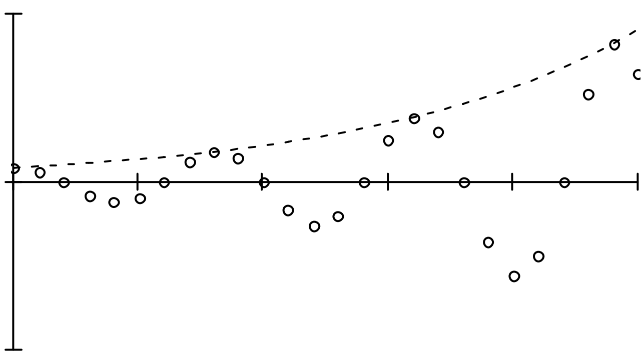
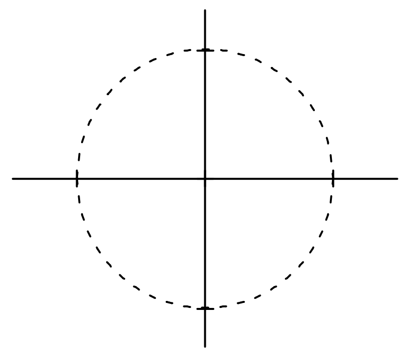


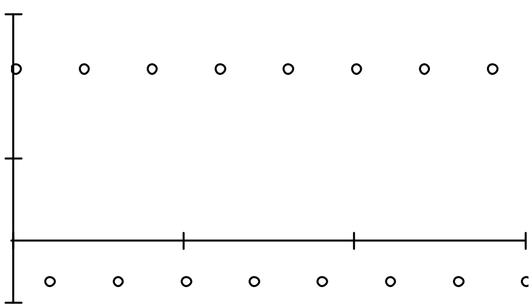


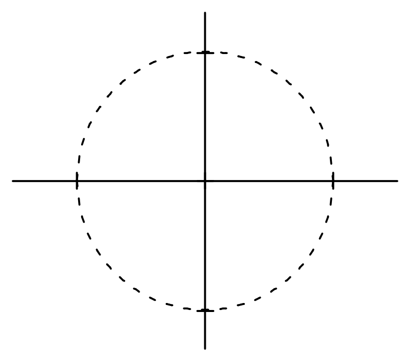
c)



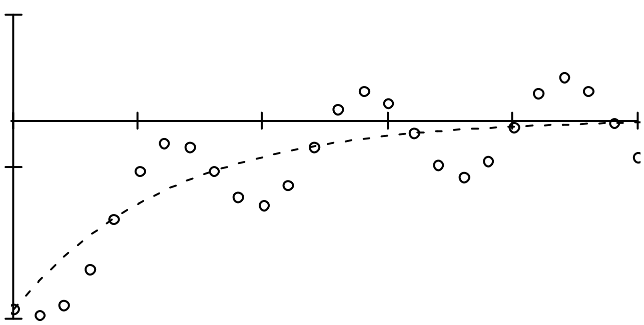


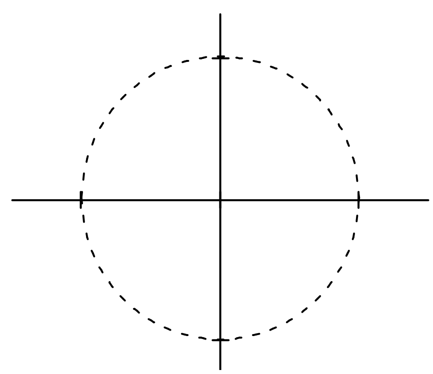
d)





e)





ECE 3510 Final given: Spring 13 p3

Open-book Part

1. (23 pts) Consider the transfer function shown. $\mathbf{G}(s) := \dfrac{1}{(s+3)\cdot(s+5)\cdot(s+10)}$

   a) Does the root-locus pass through the point $s := -1.959 + 6\cdot j$?
   Show your work or state what did in your calculator.

   Assuming the closed-loop pole is at $-1.959 + 6\cdot$ leads to the following values (I calculated):

   Gain: 411 Settling time: $2.04\cdot \text{sec}$ Overshoot: 36%

   Steady-state error to a unit-step input: 27%

   b) Add a compensator so that the settling time will decrease to 0.8 sec.
   Leave the ringing frequency at 6 rad/sec. Use the second-order approximation.

   Note: If you can't calculate the zero location or doubt your calculation,
   assume it is at -8 for the rest of this problem.

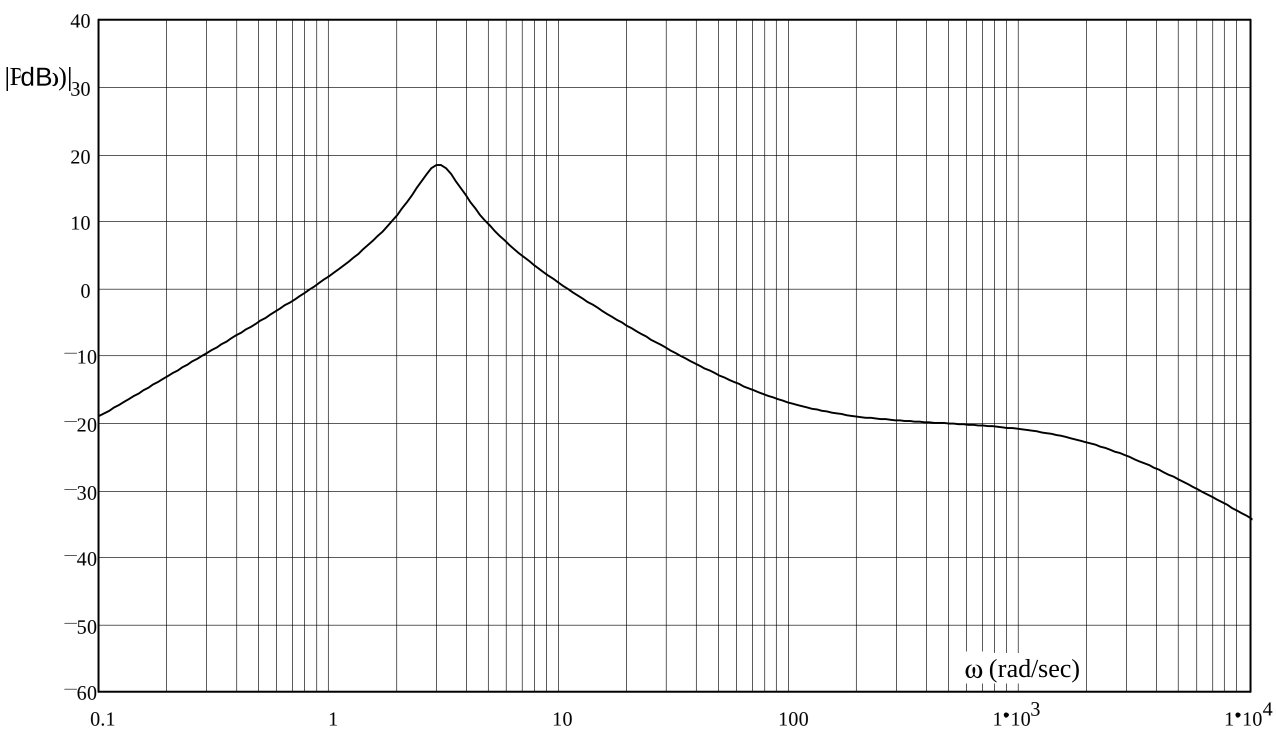
   c) With the compensator in place and a closed-loop pole at the desired position of part b)
   i) What is the gain?

   ii) What is the % overshoot?
   Show how to calculate this.

   iii) What is the steady-state error to a unit-step input?

   d) Is there still a performance issue that the compensator hasn't significantly improved? If yes how would you improve that? If it is anothUse the second-order approximation. :rs) and show that our desired pole location is still pretty close to the root locus.

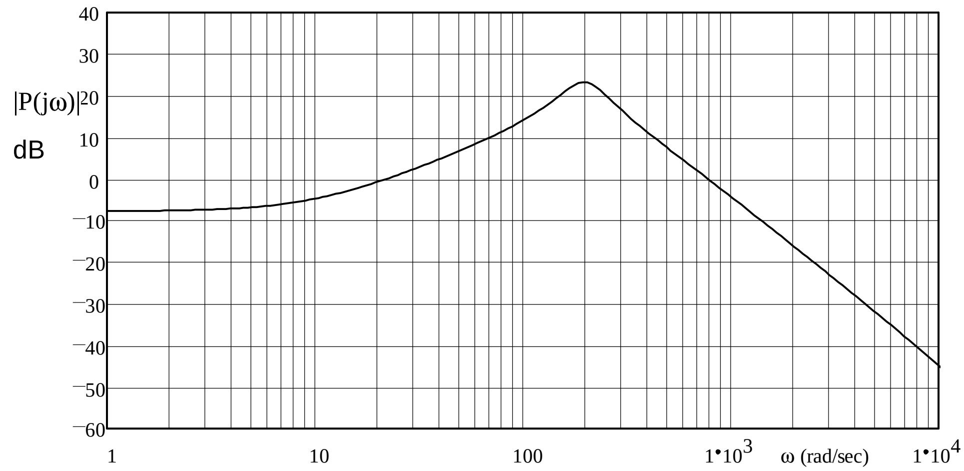
2. (17 pts) Given the magnitude Bode plot of a system, estimate the transfer function of the system.
   Assume there are no negative signs in the transfer function (all poles and zeros are in the left-half plane).
   Use a straight edge and show your work (how you made your estimate).

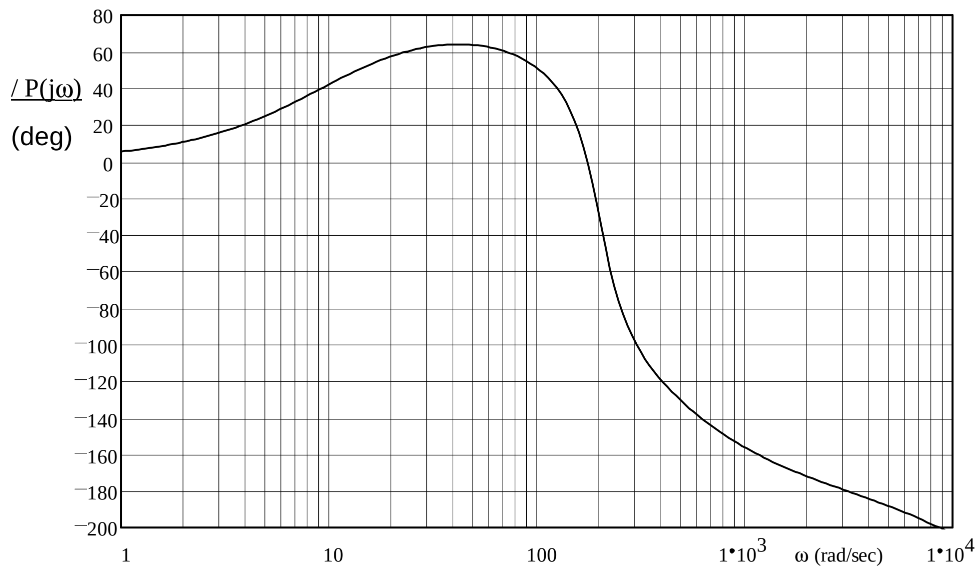


3. (12 pts) The open-loop Bode plots of a system are given at right.

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

   b) Find the delay margin.





4. (11 pts) For the given Nyquist plot, find the following for the open-loop system:

   a) the DC gain

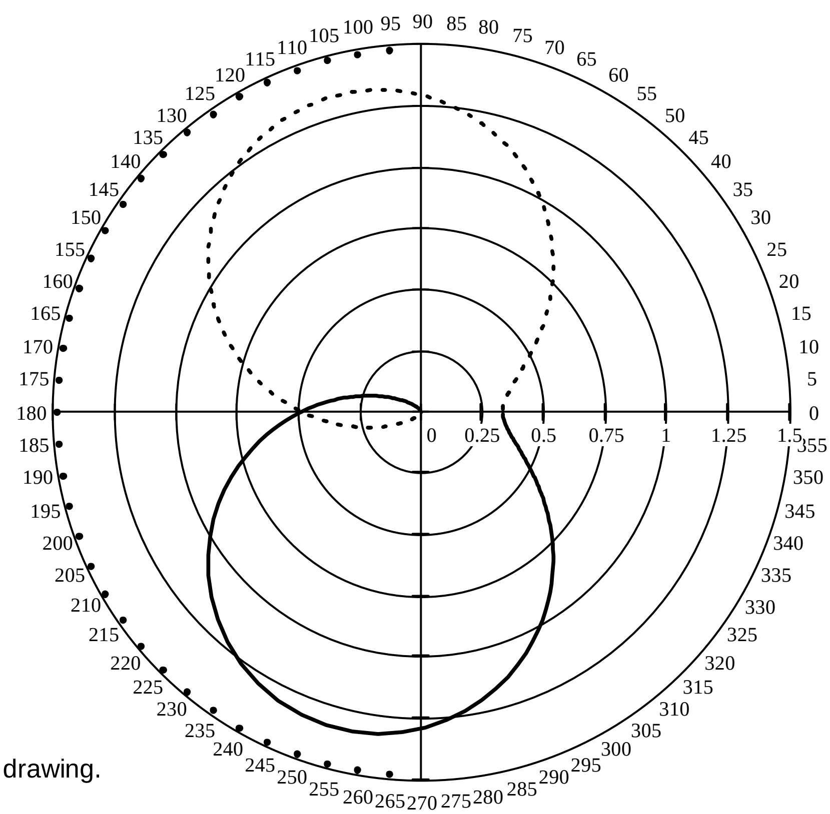
   b) $n - m$

      (number of poles - number of zeros)

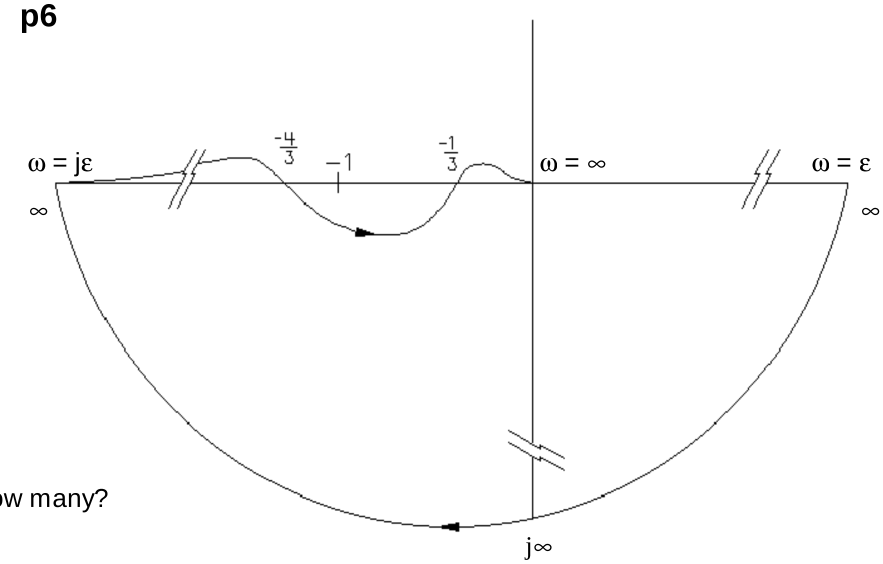
   Find the following for the closed-loop system, assuming it is stable:

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

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



5. (13 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.

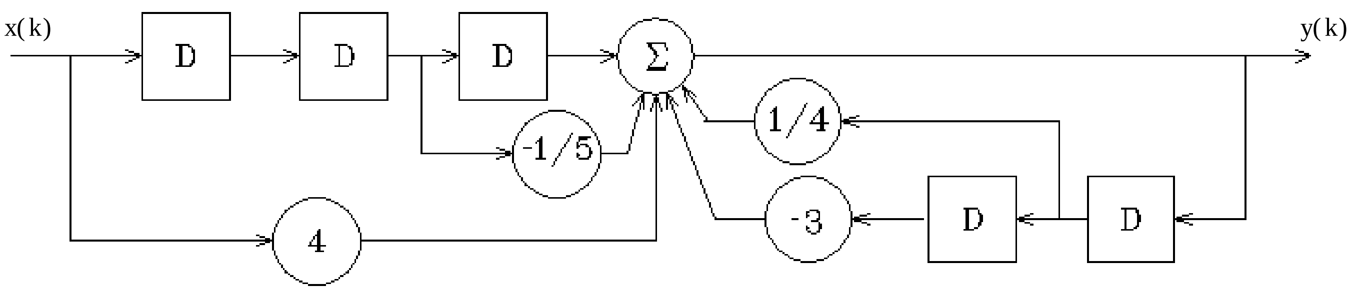
   b) Does the open-loop system have any poles at the origin?

      How do you know? If yes, how many?

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

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

6. (19 pts) a) Find the difference equation that describes the following block diagram.



   b) Find the $H(z)$ corresponding to the block diagram and 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. The answer should not have complex numbers

$$X(z) = \frac{4\cdot z}{(z-0.4)\cdot(z+0.7)\cdot(z+1)}$$

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

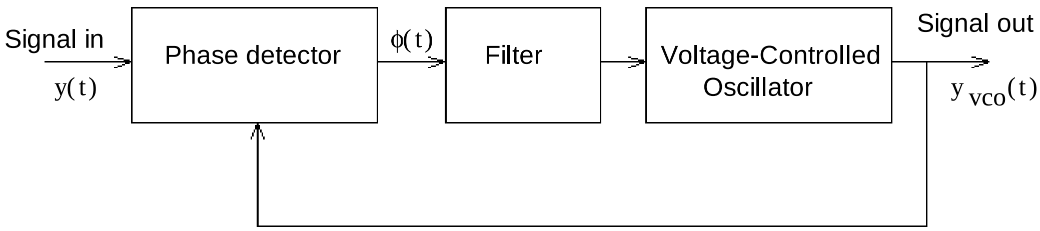
The grades will be posted on line in pdf form in alphabetical order under the alias that you provide here. I will not post grades under your real name. The pdf will show the homework, lab, and exam scores of everyone who answers here.

1. a) i) It has a pole at origin ii) The output signal will ramp to an unbounded value.
   iii) A DC motor with voltage as input and position as output. iv) NO

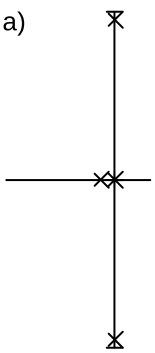
   b) i) It has a zero at origin ii) It differentiates the input iii) YES

   c) It has a pole at origin

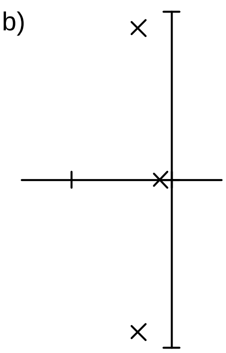
2.



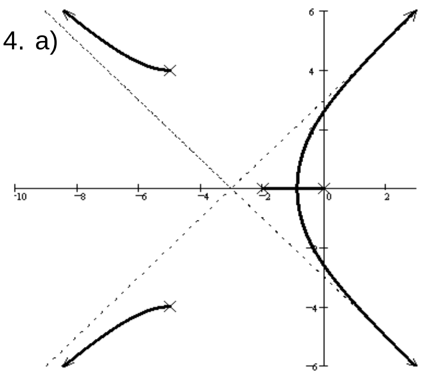
3. a)



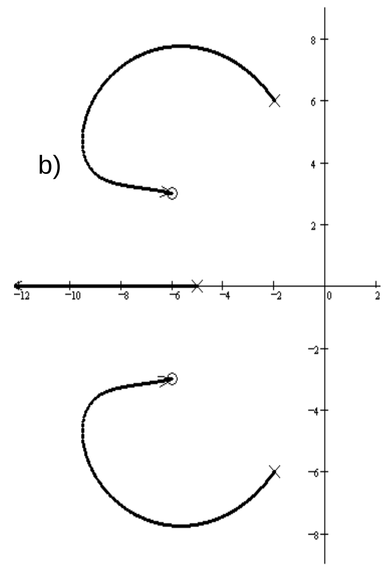
b)



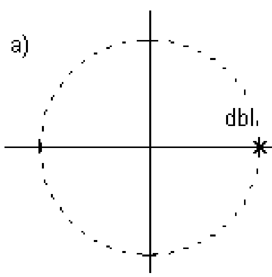
4. a)



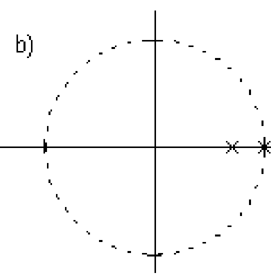
b)



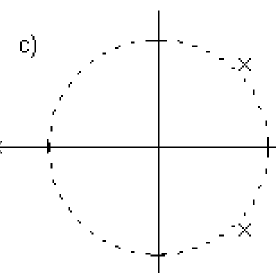
5. a)



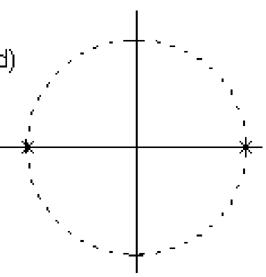
b)



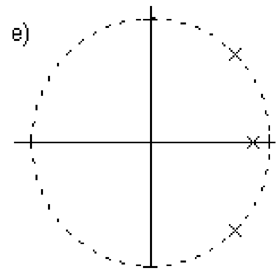
c)



d)



e)



1. a) YES b) $s := -5 + 6 \cdot j$ $C(s) = s + 7.348$

   c) i) 46 ii) 7.3% iii) $31 \cdot \%$ d) Add a PI, say $\dfrac{s+0.1}{s}$ $\arg\left[\dfrac{s+7.348}{(s+3)\cdot(s+5)\cdot(s+10)}\cdot\dfrac{s+0.1}{s}\right] = 179.43 \cdot \mathrm{deg}$

2. $200 \cdot \dfrac{s \cdot (s+100)}{\left(s^2+1.2 \cdot s+9\right)\cdot(s+2000)}$ 3. a) 30^o $24 \cdot \mathrm{dB}$ b) $0.65 \cdot \mathrm{ms}$ 4. a) ~0.33 b) 3 c) 2 d) 31^o

5. a) 0 b) yes 180^o arc at ∞ 2 c) $\left[\dfrac{3}{4}\ ,\ 3\right]$ d) 2

6. a) $4 \cdot x(k) - \dfrac{1}{5} \cdot x(k-2) + x(k-3) + \dfrac{1}{4} \cdot y(k-1) - 3 \cdot y(k-2)$ b) $\dfrac{4 \cdot z^3 - \dfrac{1}{5} \cdot z + 1}{\left(z^2 - \dfrac{1}{4} \cdot z + 3\right) \cdot z}$

   c) 0 $0.125 + 1.728 \cdot j$ $0.125 - 1.728 \cdot j$

   d) NO, TWO poles are outside the unit circle

7. a) $2.597 \cdot (0.4)^k - 12.121 \cdot (-0.7)^k + 9.524 \cdot (-1)^k$