ECE 3510 Exam 3 given: Spring 14

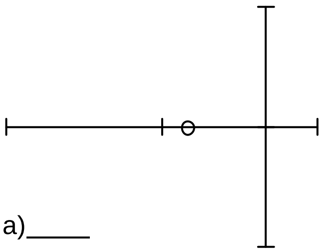
(The space between problems has been removed.)

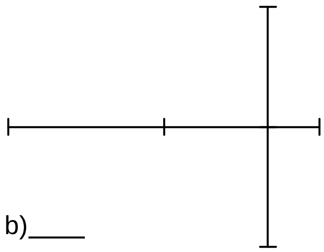
This part of the exam is Closed book, Closed notes, No Calculator.
Your answers should specific, clear, concise, and legible, or I'll assume you don't know.

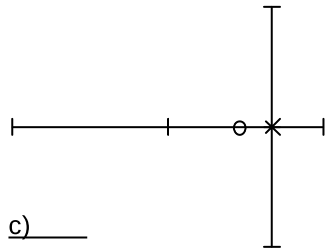
Listed below are the possible answers. You may use some answers more than once. Some answers may not be used at all.

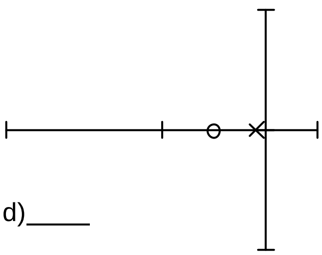
P
PD
PI
I
D
PID
Lag
Lead
Zig
Zag
Over
Under

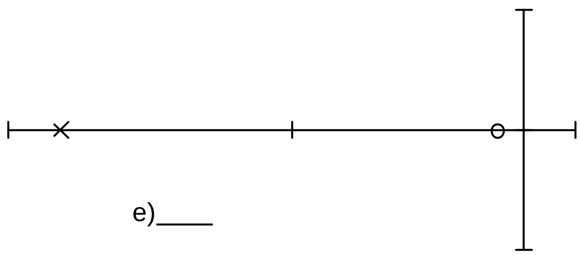
1. (10 pts) Each of the pole-zero diagrams below represent a **controller** or **compensator**. Identify each of them with the possible answers listed.

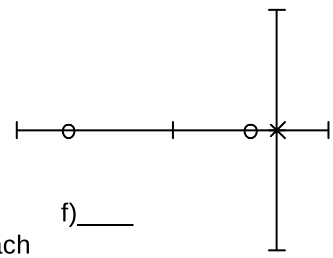

a)_____


b)____


c)_____


d)_____


e)____


f)____

2. (11 pts) Below is a list of reasons to add a compensator to a feedback system. After each of the reasons, list all of the compensators that would be a good choice for the achieving the desired result without significant extra parts or negative side-effects. Select your answers from the list of possible answers above. Answers may be used more than once or not at all. Each blank may have more than one answer, list all reasonable answers.

   a) Increase the speed of the system response ____________________
   b) Decrease overshoot ____________________
   c) Decrease the settling time ____________________
   d) Reduce the steady-state error ____________________
   e) Eliminate the steady-state error for a DC input ____________________
   f) Mostly reject constant disturbances ____________________
   g) Completely reject constant disturbances ____________________
   h) All of the above ____________________

3. (5 pts) in Homework FC1 you explored ways to use a compensator with a system who's transfer function is unknown.
   a) What type of compensator?

   b) What is this method called? (What would you type into Google to learn more?)

   c) Where would the data come from for the type of calculations you made in FC1?

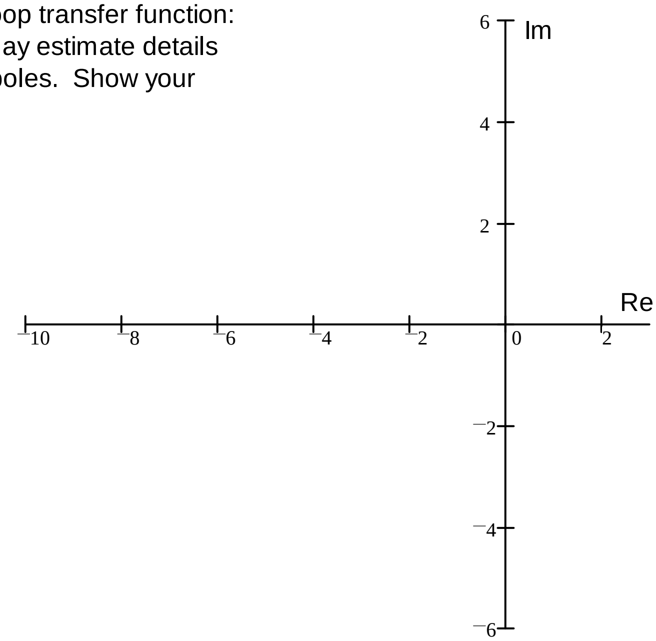
4. (5 pts) In the Basic PLL lab you designed something which later provided the impetus for the unconventional root-locus plot. In the Advanced PLL lab you improved this item

   a) What was it that you designed, and what two items was it hooked between?

   b) At or near the end of both of these labs you tested your PLL at a specific task to see how well your filter was performing. What was the special task your PLL was performing?

5. (9 pts) Sketch the root-locus plots 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 Draw things like the asymptote angles carefully. ɔid).

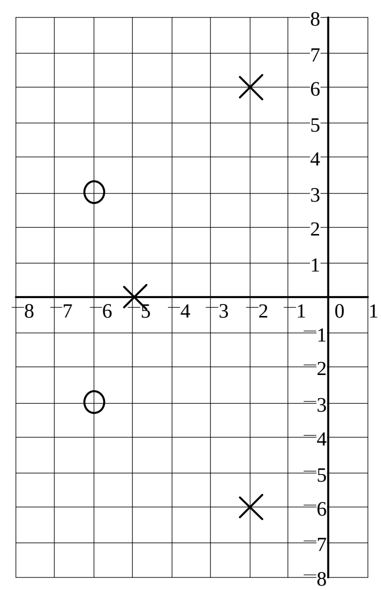
$$\mathbf{G}(s) = \frac{1}{s\cdot\left(s^2 + 10\cdot s + 41\right)\cdot(s+2)}$$



Open book part

1. (18 pts) a) The poles and zeroes of an OL transfer function are shown. Find $\mathbf{G}(s)$.

   $\mathbf{G}(s)$ = ?

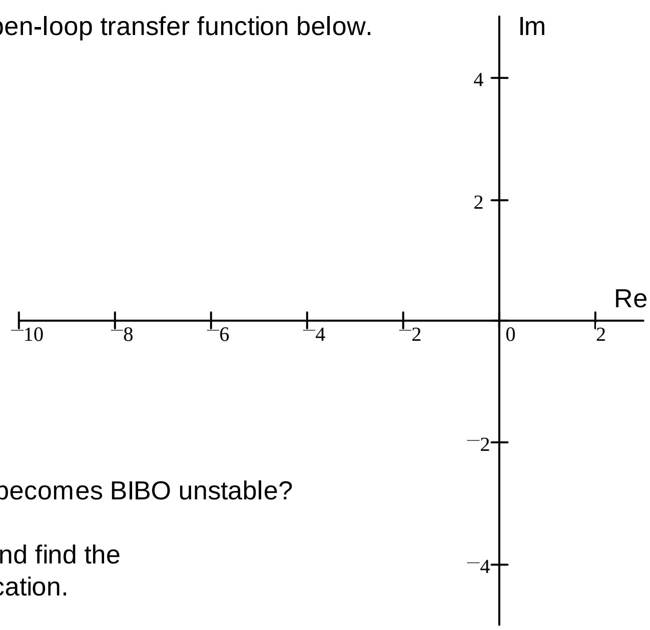


   b) Find the departure angle from one of the complex poles.

   c) Draw an accurate root locus drawing above, using the departure angle you just found.

2. (17 pts) Sketch the unconventional root-locus plot for the open-loop transfer function below. The root-locus should be plotted for an increasing x.

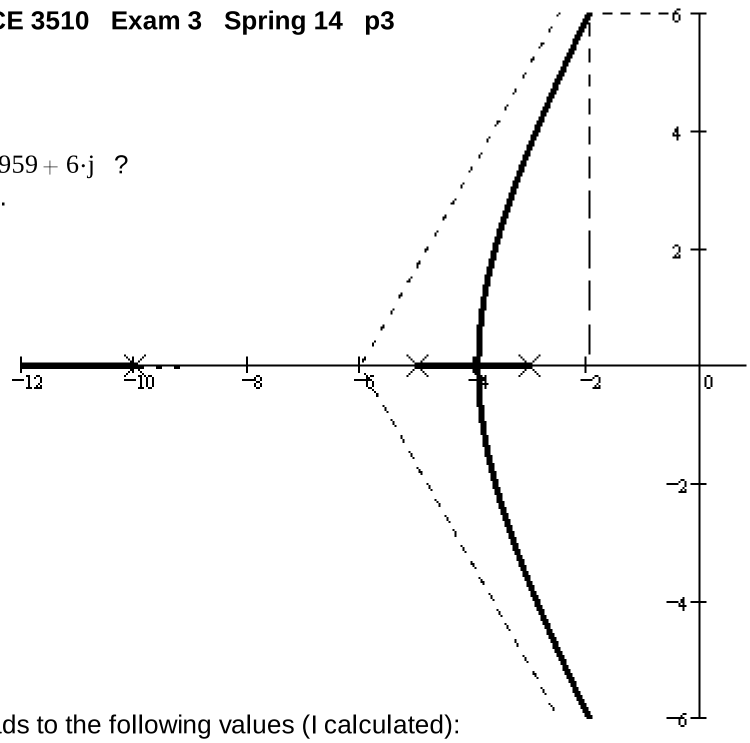
$$G(s) = k\cdot\frac{s^2 + 2\cdot s\cdot(x+2) + 20}{s\cdot(s\cdot x + 6) + 15 - 16\cdot x} \qquad k = 3 \text{ and is fixed}$$



   b) Is there a value of x above which the closed-loop system becomes BIBO unstable?
   If **YES**, find the range of x needed for BIBO stability.
   If **NO**, draw an arow to any other point on the root locus and find the value of x needed to place the closed-loop pole at that location.

3. (25 pts) Consider the transfer fumction shown.

$$G(s) := \frac{1}{(s+3)\cdot(s+5)\cdot(s+10)}$$



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: $2.04 \cdot sec$ 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. Show your work or state what did in your calculator.

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? Use the second-order approximation.
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 another compensator, give specifics (numbers) and show that our desired pole location is still pretty close to the root locus.

Answers

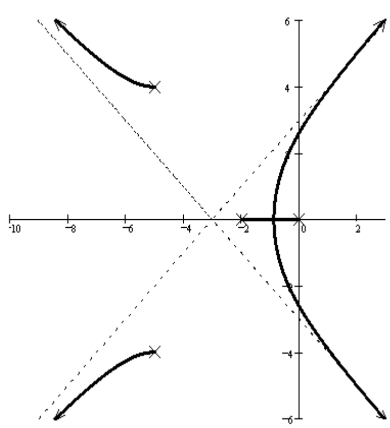
1. a) PD b) P c) PI d) Lag e) Lead f) PID

2. a), b), & c) PD & Lead d) PI & Lag e) PI f) Lag (& PI) g) PI h) PID

3. a) PID b) PID tuning OR Ziegler Nicols c) Experimental measurements

4. a) The filter between the phase detector and the VCO b) FM demodulation

5.

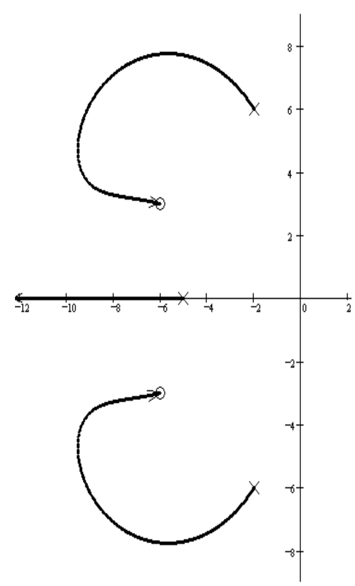


OPEN BOOK

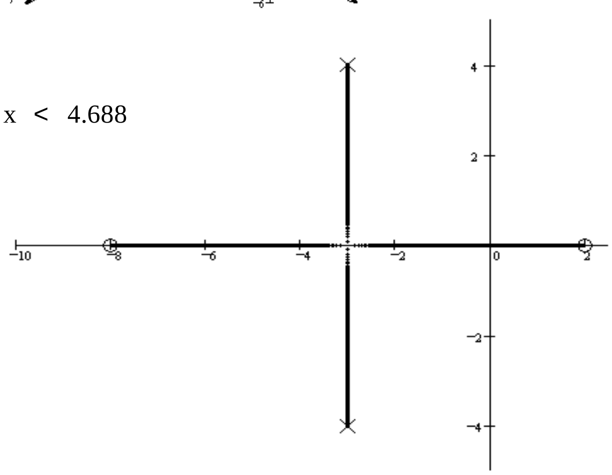
1. a) $\dfrac{\left[(s+6)^2+3^2\right]}{\left[(s+2)^2+6^2\right]\cdot(s+5)}$

b) $129.5\cdot deg$

c)



2. a)



b) $x < 4.688$

3. a) YES

b) $C(s) = s+7.348$

c) i) 46

ii) $7.3\cdot\%$

iii) $30.7\cdot\%$

d) Add a PI, & show that $\angle G(s) \sim 180^o$