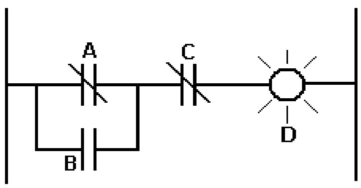
ECE 3510 Exam 3 given: Spring 16 (The space between problems has been removed.)

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.

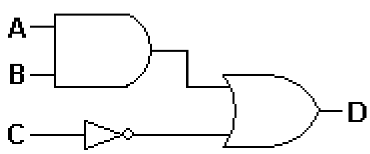
1. (11 pts) a) Ladder logic was originally developed to help design logic circuits based on what type(s) of part(s)?

   b) Give the ladder-logic symbols of the following:
   i) Normally-open switch or contact   ii) Normally-closed switch or contact

   c) Show the Boolean expression or the equivalent logic gates for the ladder-logic shown below.
   Inputs A, B and C control a light, D.



   d) Show the ladder-logic equivalent of the Boolean expression and the logic gates shown below.
   Let the output, D, be a light.



$A \cdot B + \overline{C}$

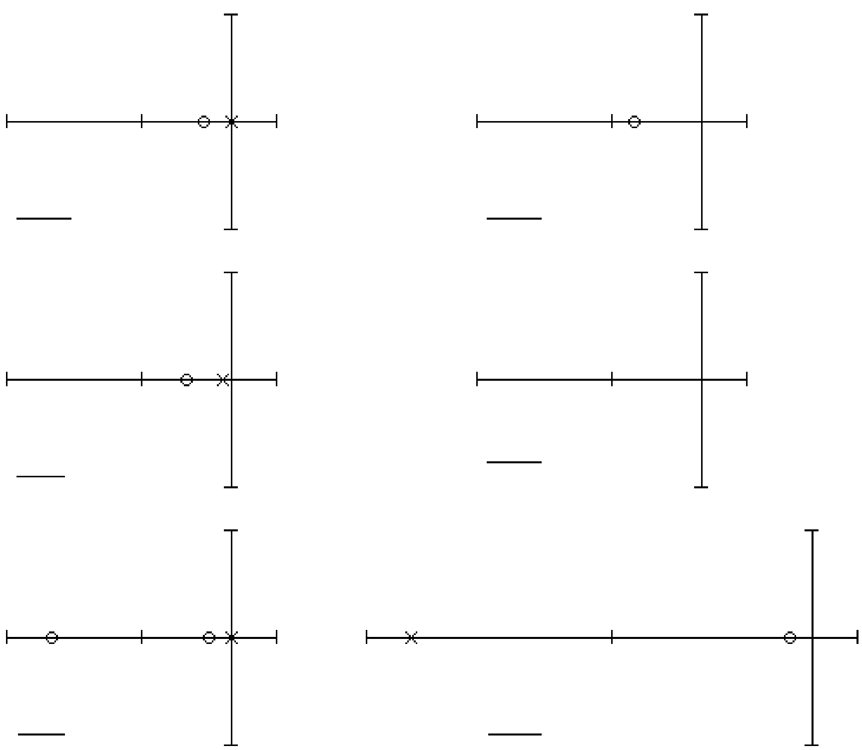
2. (2 pts) An instrumentation amplifier is a good way to implement what function(s) or block(s) in a typical feedback loop?

3. (3 pts) All the compensators in Nise's book are based on what simple op-amp ciruit or amplifier?

4. (3 pts) Some compensators use differentiators, but real differentiators have some serious issues. What is the most important issue (the reason given in lab 5b for moving the differentiator into the feedback part of the loop).

   Extra credit for naming the second most important issue.

5. (12 pts) Each of the pole-zero diagrams below represent a **controller** or **compensator**. Identify each of them with the possible answers listed.



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

6. (6 pts) a) What is a PD compensator used for?

   b) What other compensator can be used for the same or similar purpose?

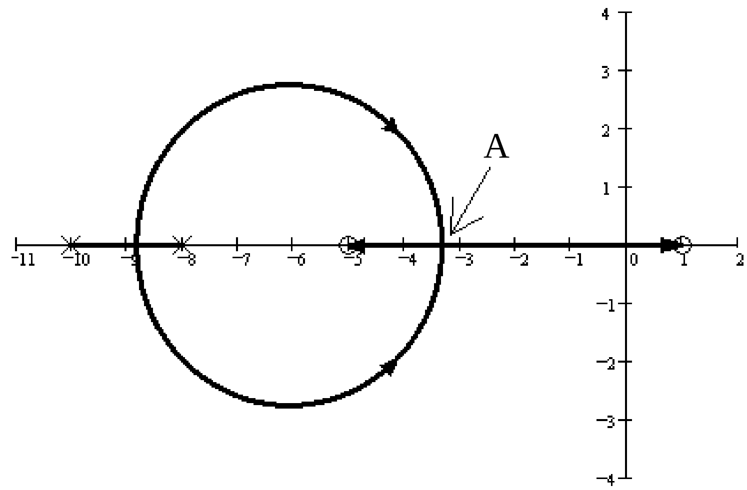
   c) What is a PI compensator used for?

   d) What other compensator can be used for the same or similar purpose as the PI ?

Open book part

1. (10 pts) a) Point "A" is a special point on the root locus plot. What is it called?

   b) Determine if point "A" is at -3.3.
   Show your evidence. I want to see specific calculations and numbers to justify your answer.



   c) The gain required to place a closed loop pole at -3 is:
   Answer without making more calculations.

   A) LESS than the gain required to place the closed loop poles at point "A".

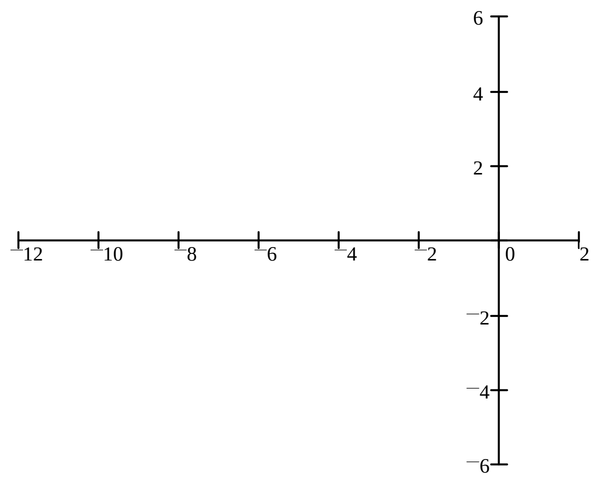
   B) THE SAME as the gain required to place the closed loop poles at point "A".

   C) GREATER than the gain required to place the closed loop poles at point "A".

   D) It isn't possible to answer this without more calculations.

2. (18 pts) a) Sketch the unconventional root-locus plot for the open-loop transfer function below.
   The root-locus should be plotted for an increasing x.

$$G(s) = \frac{k\cdot(x\cdot s+8)}{(s+2\cdot x)\cdot(s+5)} \qquad k = 3 \text{ and is constant}$$



   b) Draw an arrow to the place(s) on your root locus where you would like to place the closed-loop poles for no ringing and the shortest settling time. What is your best guess of s at this location?

   c) Find the value of x needed, based on your best reading of your plot above.
   Your answer will be based on your s value.

   d) If you wanted more ringing (and overshoot), x should be: i) greater than the value found in part c).

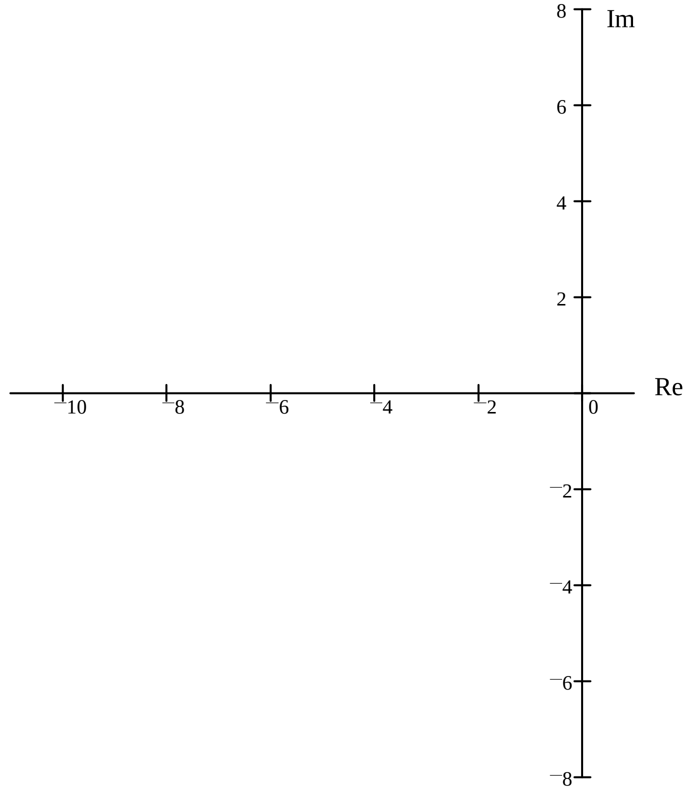
   (circle one) ii) equal to the value found in part c).

   iii) less than the value found in part c).

3. (35 pts) Consider the transfer function:

$$\mathbf{G}(s) := \frac{s+5}{(s+1)\cdot\left(s^2+4\cdot s+20\right)}$$

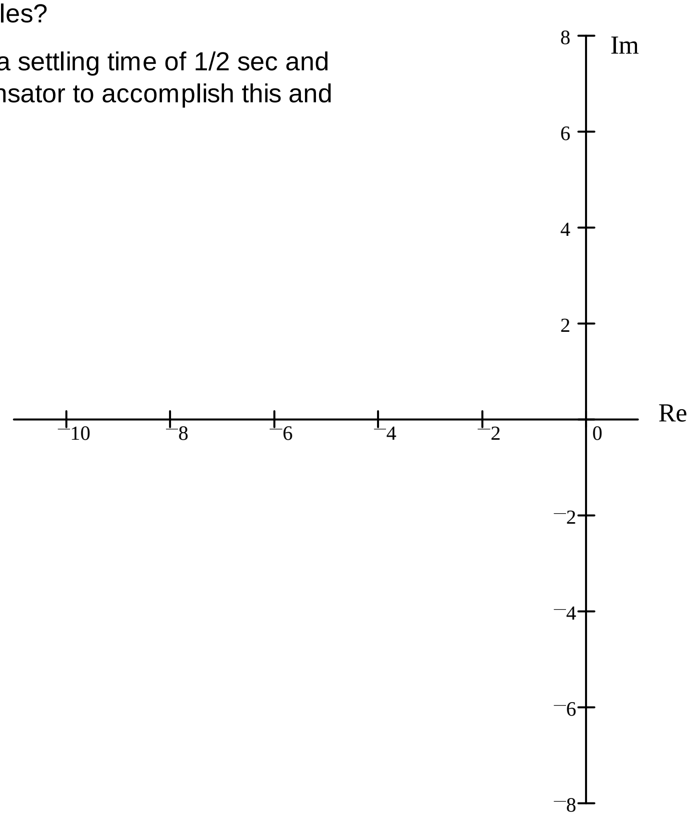
a) Find the departure angle from a complex pole.



b) Draw a root locus plot. Calculate the centroid and accurately draw the departure angle.

c) Is there any decent place to locate the closed-loop poles?

d) You would like to place your closed-loop poles to get a settling time of 1/2 sec and 0.656% overshoot. Add the simplest possible compensator to accomplish this and calculate what the compensator should be.

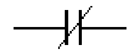


Note: If you can't calculate the zero location or doubt your calculation, assume it is at -3 for the rest of this problem. For the remaining problem, the compensator in place and a closed-loop pole at the location desired in part d)

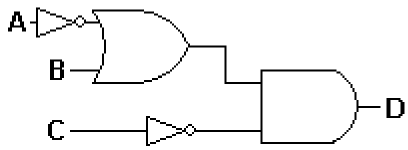
e) What is the gain?

f) What is the steady-state error for a unit-step input?

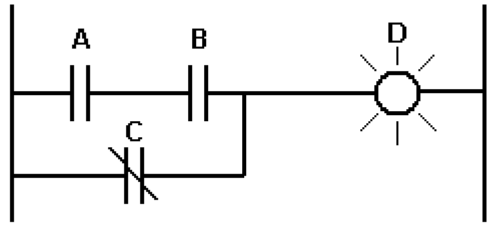
g) If this steady-state error was a little too big, what would be the very simplest way to reduce it?

1. a) Electromechanical relays and simple switches b) i)  ii) 

   c) $\left(\overline{A}+B\right)\cdot\overline{C}$ OR



   d)

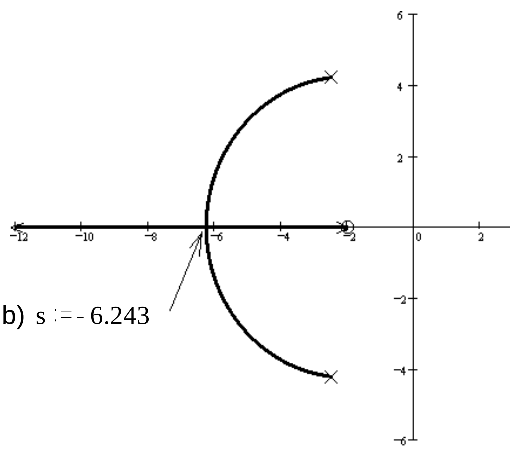


2. The summer with + and - , and the gain block
3. In inverting amplifier
4. A true differentiator would produce an impulse when the input is a step. No real differentiator can do this. Differentiators are high-pass filters and accentuate the noise.
5. <u>PI</u> <u>PD</u>
   <u>Lag</u> <u>P</u>
   <u>PID</u> <u>Lead</u>

6. a) To increase speed and/or decrease overshoot. b) Lead
   c) To eliminate steady-state error and reject disturbances d) Lag

1. a) Break-in point b) $s := -3.3$ $\frac{1}{s+10}+\frac{1}{s+8}=0.362 \overset{?}{=} \frac{1}{s+5}+\frac{1}{s-1}=0.356$ NO, they are not equal
   c) C)

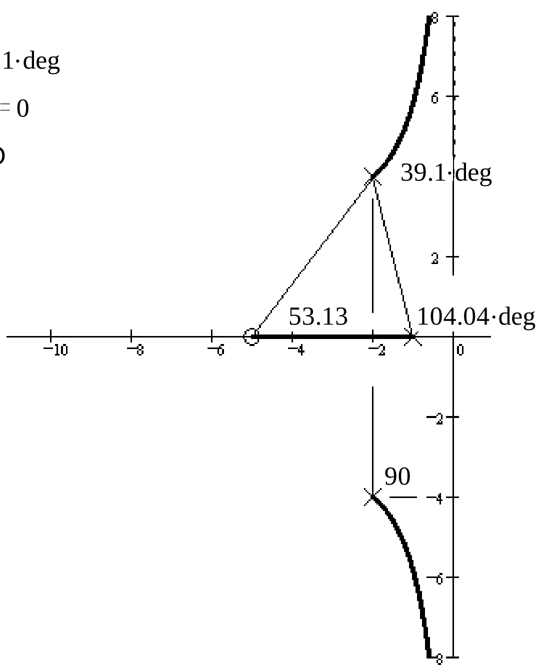
2. a)



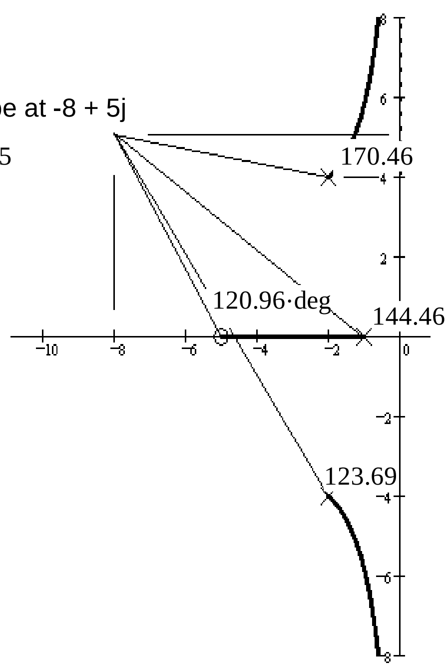
   b) $s := -6.243$

   c) 1.497 Your answer may vary, based on your s value.
   d) iii)

3. a) $39.1\cdot deg$
   b) $\sigma := 0$
   c) NO



   d) Pole should be at -8 + 5j
   $C(s) = s + 2.5$



   e) 13.06 f) $10.91\cdot\%$ g) turn up the gain