ECE 3510 Exam 3 given: Spring 18 (Some of the space between problems has been removed.)

Closed book, Closed notes, may have Exam 1, 2, & 3 info sheets which may have additions.

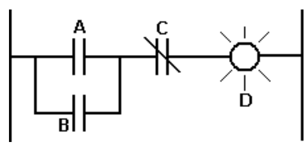
1. (2 pts) You have a feedback system that doesn't work as well as you would like, but you don't know the open-loop transfer function. You've tried adjusting the gain, and have found the best balance of speed and overshoot that you can. Is it likely still possible to improve its performance? What would you use? What might you do?

2. (10 pts) a) Ladder logic was originally developed to help design logic circuits based on what type(s) of part(s)?

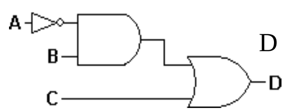
   b) Give the ladder-logic symbols of the following:
      i) Normally-closed switch or contact

      ii) Normally-open 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.



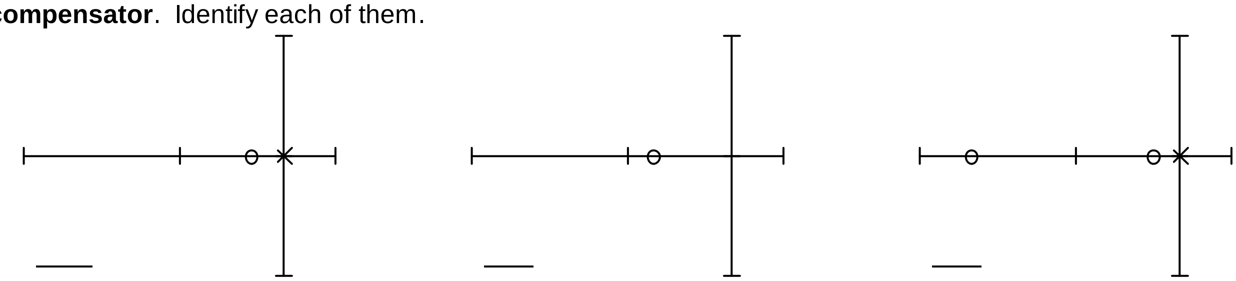
   d) Show the ladder-logic equivalent of the Boolean expression and the logic gates shown below.
      Let the output, D, be a light.



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

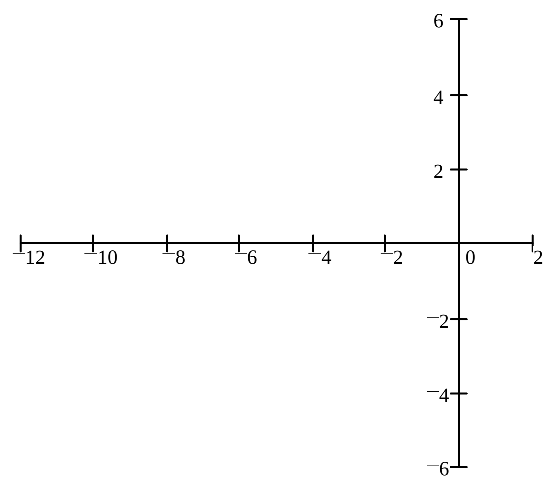
3. (3 pts) An instrumentation amplifier is a good way to implement what function(s) or block(s) in a typical feedback loop?

4. (6 pts) Each of the pole-zero diagrams below represent a **controller** or **compensator**. Identify each of them.



5. (19 pts) Sketch the unconventional root-locus plot for the open-loop transfer function below.
   The root-locus should be plotted for an increasing g.

$$G(s) = \frac{k\cdot s\cdot(g\cdot s+1)}{(s+4\cdot g)\cdot(s+5)} \qquad k = 2 \quad \text{and is constant}$$

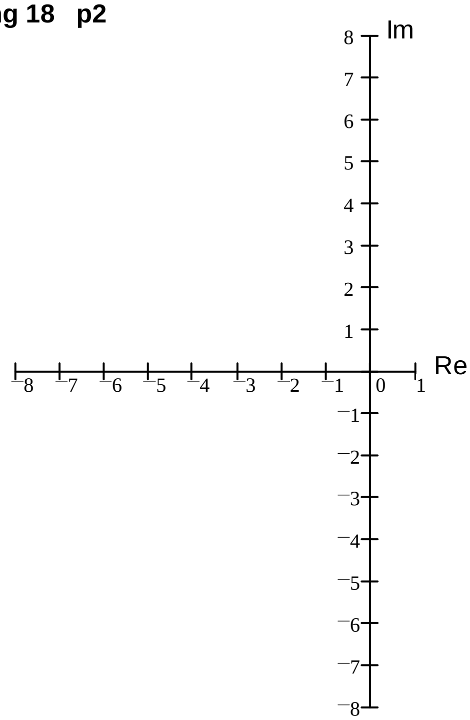


   b) Draw an arrow to the place(s) on your root locus where you would like to place the closed-loop poles for minimal ringing and the shortest settling time.

   c) Find the value of g needed, based on your best reading of your plot above.

6. (19 pts) a) Draw the pole(s) and zero(s) of the following open-loop transfer function on the axis.

$$\mathbf{G}(s) = \frac{(s+5)}{\left[(s+2)^2+4^2\right]\cdot\left[(s+5)^2+3^2\right]}$$

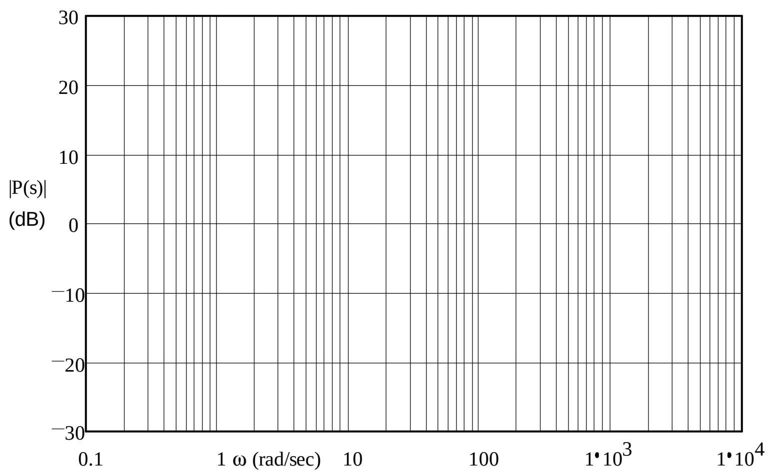


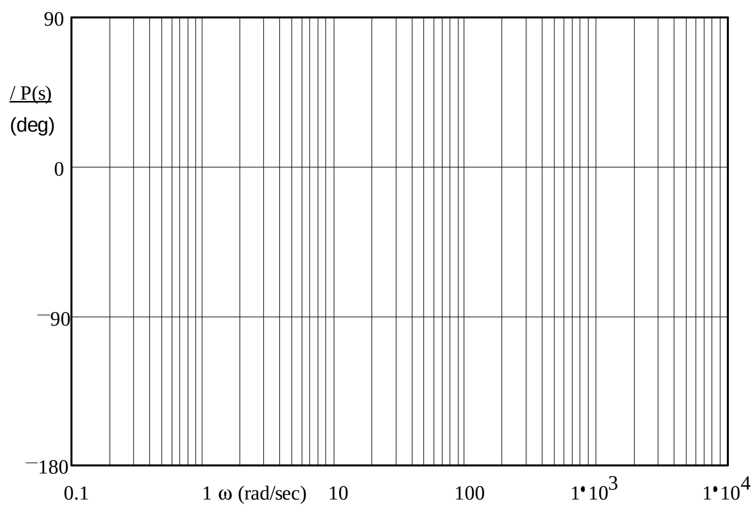
   b) Find the departure angle from one of the poles **Farthest** from the imaginary axis (the **leftmost**).

   c) Draw a root locus plot. Calculate the centroid and accurately draw the departure angle you found. The other departure angle is about 60º.

7. (13 pts) Sketch the Bode plot for the following transfer function. Make sure to label the graphs, and to give the slopes of the lines in the magnitude plot. Also draw the "smooth" lines.

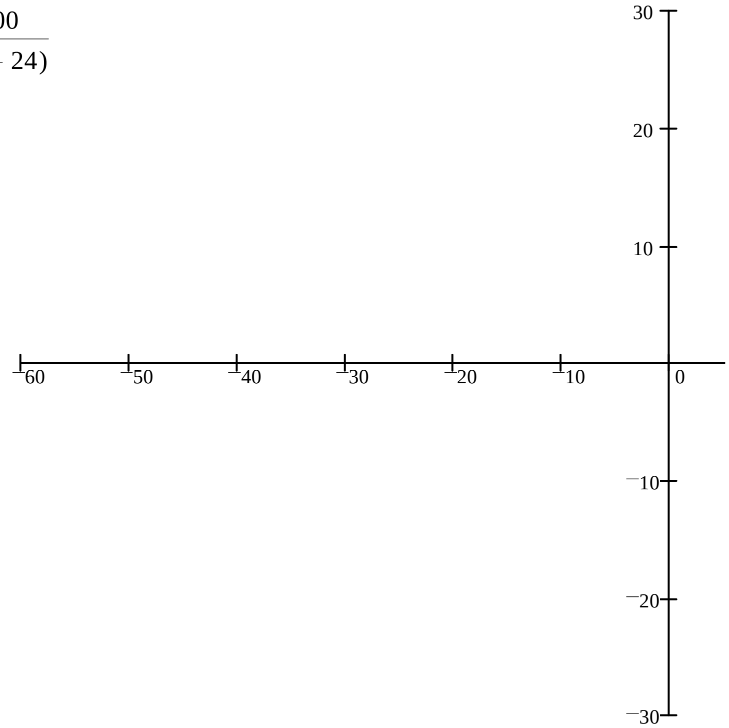
$$P(s) = \frac{(s+4)\cdot(s+200)}{s\cdot(s+1000)}$$





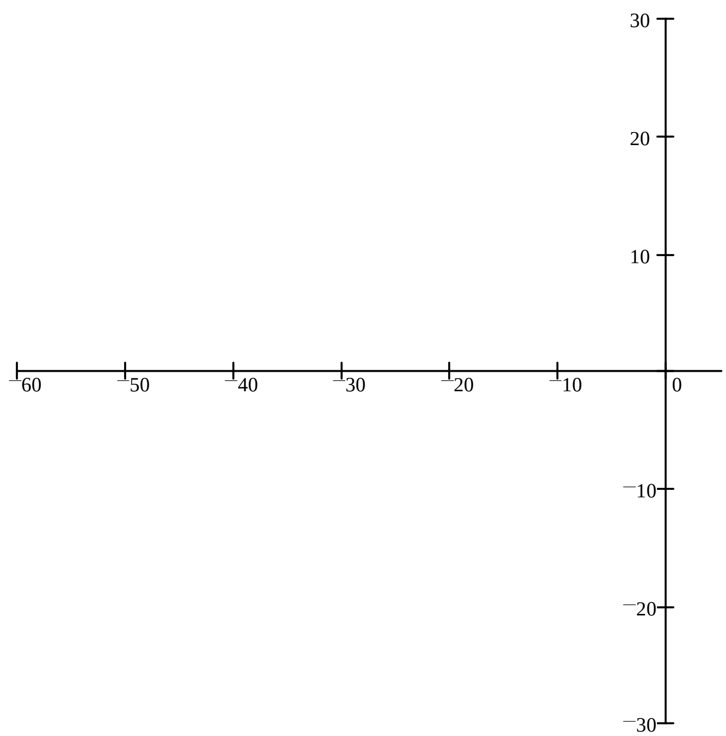
8. (28 pts) Consider this transfer function. $G(s) := \dfrac{100}{s(s+24)}$

a) Sketch the root-locus plot



b) Can the closed-loop poles be set to get ringing at 20 rad/sec and a settling time of 0.1sec?

c) You wish to add a compensator to get the conditions of part b). Add a lead compensator so that you will be able to do this. Set the lead compensator's pole at -60.



d) With the compensator in place and a closed-loop pole at the location desired in part b)

i) What is the gain?

ii) What is the % overshoot?

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

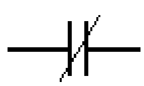
iv) Is there possibility for improvement (quicker response without overshooting more than 4.4%)? If yes, what would be the simplest thing to do? Justify your answer.

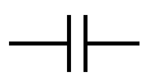
e) Is it desirable to add another compensator to improve the steady-state error? If yes, say what's needed.

Answers

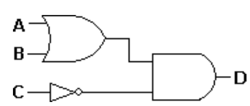
1. Use a PID controller. Use PID tuning techniques.

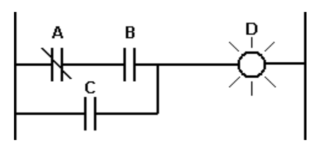
2. a) Electromechanical relays and simple switches

i) 

ii) 

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

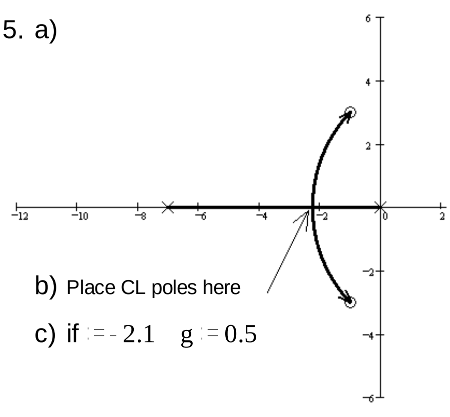


d) 

3. The summer with + and - , and the gain block

4. PI PD PID

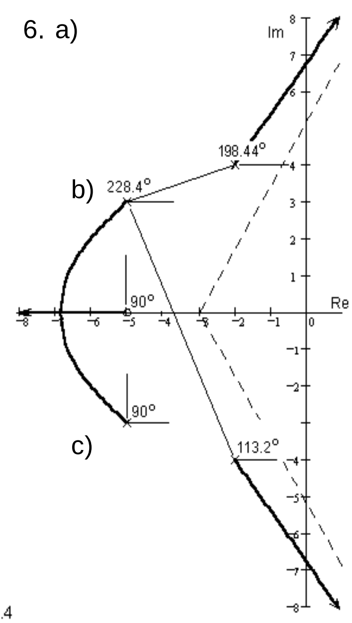
5. a)



b) Place CL poles here

c) if $:= -2.1$ $g := 0.5$

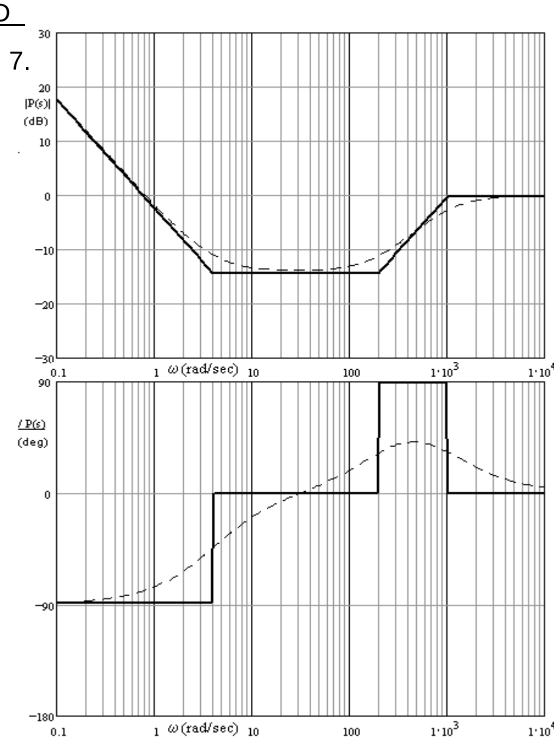
6. a)



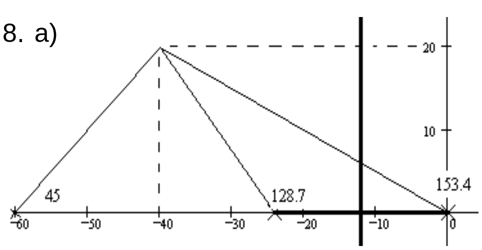
b)

c)

7.



8. a)



b) NO c) $C(s) := \dfrac{s + 9.09}{s + 60}$ d) i) 8.8 ii) $0.19\cdot\%$ iii) $0\cdot\%$

iv) increase the gain e) No