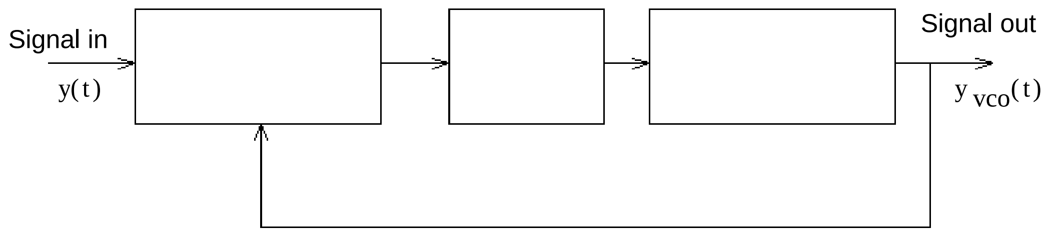
ECE 3510 Exam 3 given: Spring 23 (Some of the space between problems has been removed.)

This part of the exam is Closed book, Closed notes, No Calculator. 4/7/23

1. Identify the blocks (in words) in the phase-locked-loop shown below.

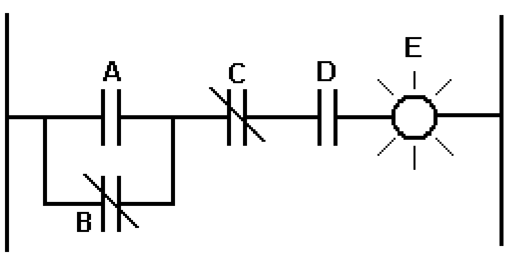


2. An instrumentation amplifier is a good way to implement what function(s) or block(s) in a typical feedback loop?

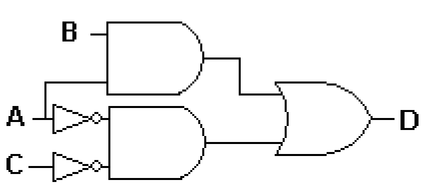
3. Some compensators use differentiators, but real differentiators have some serious issues. What is the most important issue (the reason given in lab 5b for moving the differentiator into the feedback part of the loop).

   Name the second most important issue.

4. a) Show the Boolean expression OR the equivalent logic gates for the ladder-logic shown below.
   Inputs A, B, C and D control a light, E. Show inverters, if necessary.



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

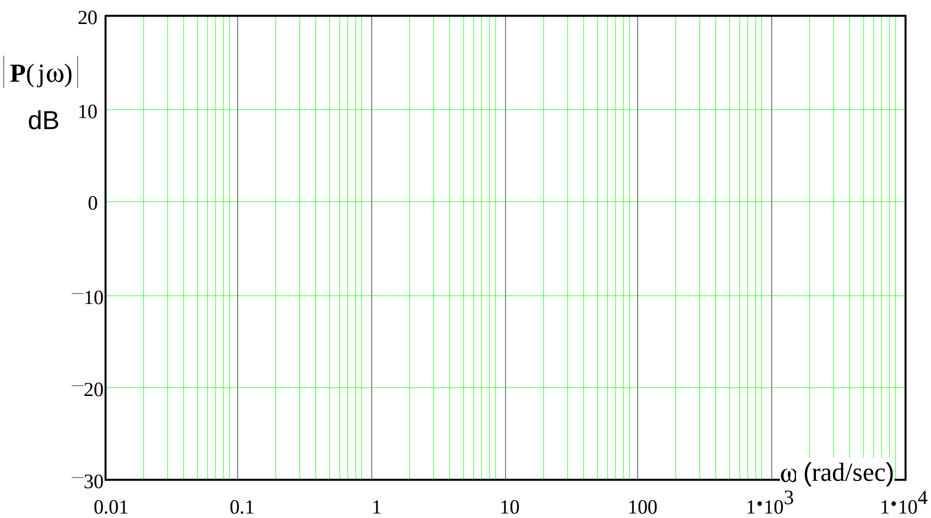


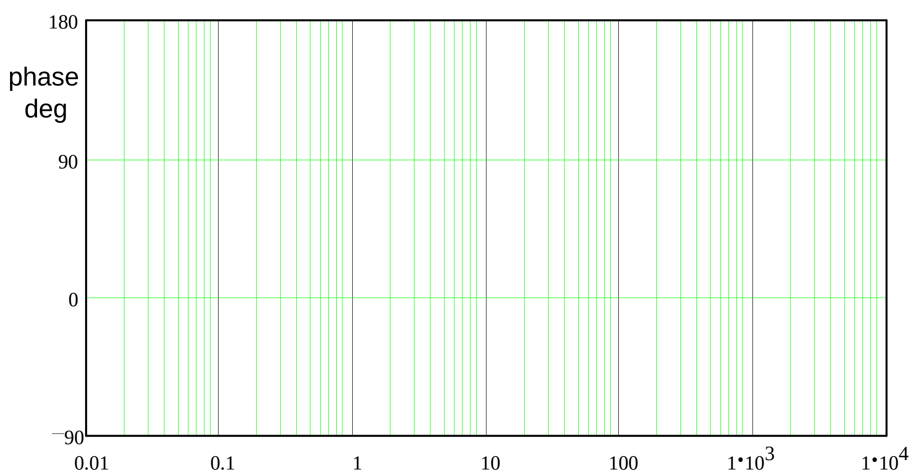
$= A \cdot B + \overline{A} \cdot \overline{C}$

_____ / 14 pts

1. (30 pts) Sketch the Bode plots for the following transfer functions. Use plots provided or legible semilog paper. Use the method I taught in class to find magnitudes, slopes and angles and to check yourself. Also draw the "smooth" lines.

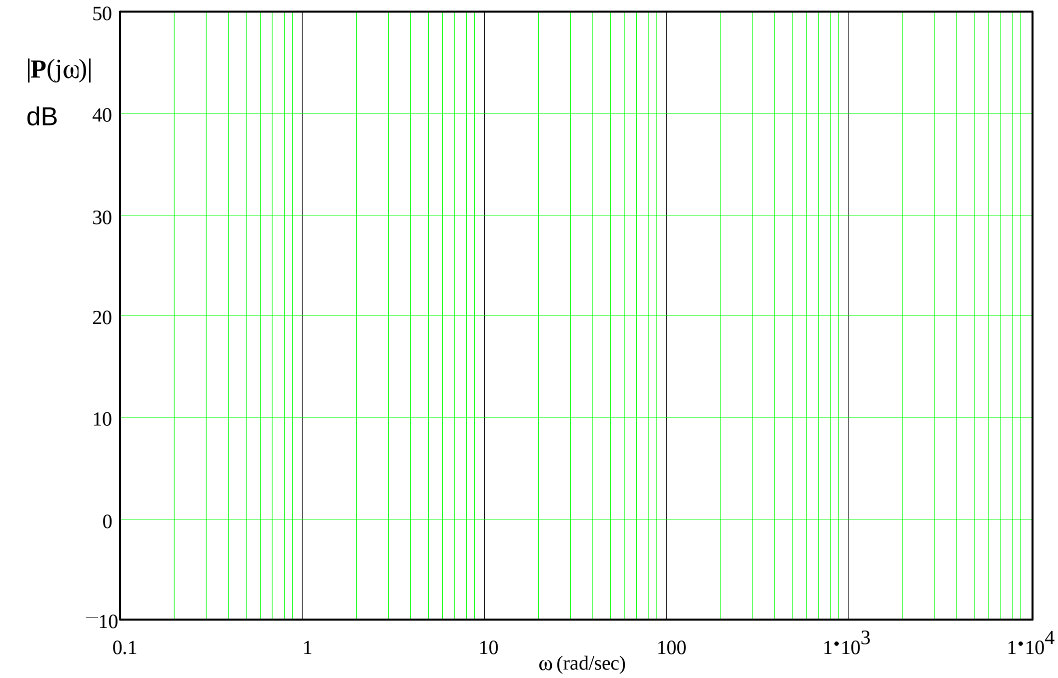
$$\mathbf{P}(s) = \frac{5000 \cdot s \cdot (s+4)}{(s+0.2)\cdot(s+20)\cdot(s+1000)}$$

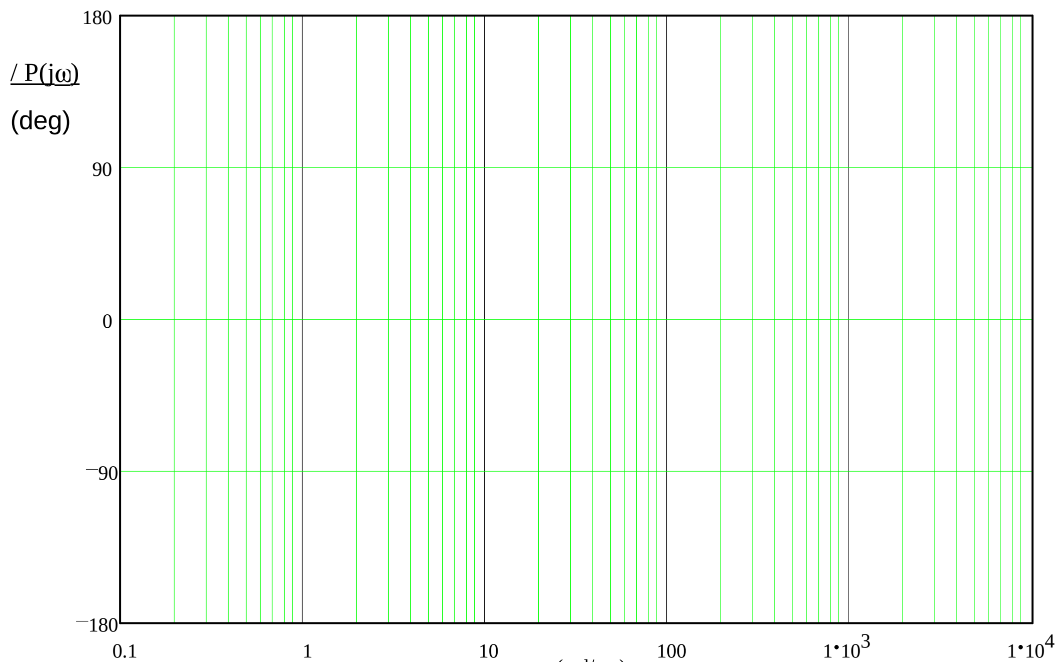




b) Sketch the Bode plot for the following transfer function. Make sure to label the graphs as necessary to show the magnitudes and slopes. Also draw the "smooth" lines.

$$P(s) := \frac{10^5 \cdot s \cdot (s + 100)}{(s + 2) \cdot \left(s^2 + 400 \cdot s + 10^6\right)}$$





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2. (10 pts) You have designed a compensator with the following:

A pole at the origin   A zero at -2   A zero at -30   Gain of 12

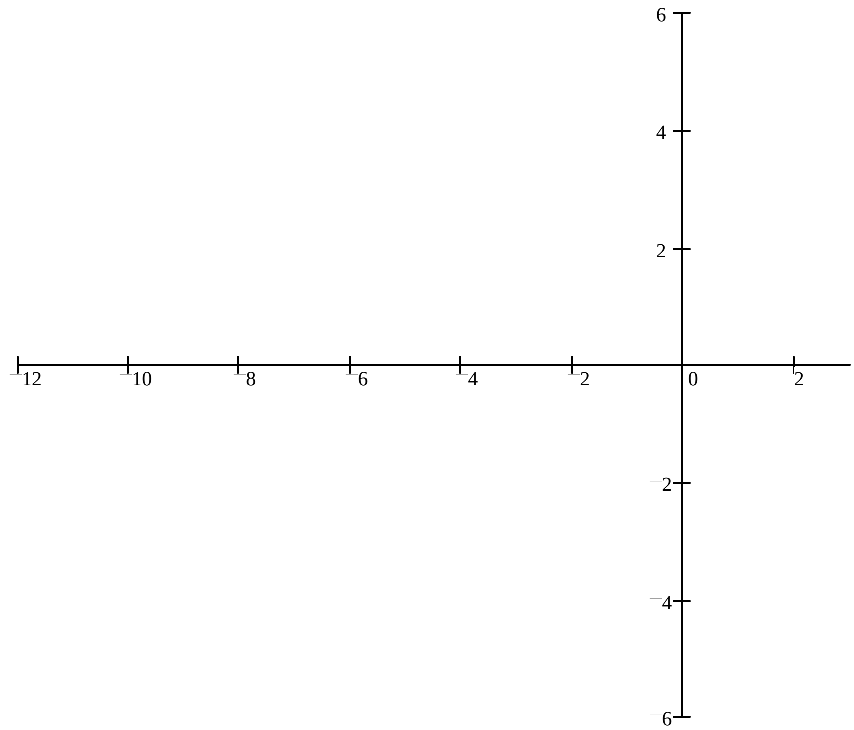
a) Draw the block diagram of a PID compensator.
Use the factors k_P, k_I, and k_D as the respective gains.

b) Find the k_p, k_i, & k_d of the PID compensator.

____ / 10

3. (20 pts) Sketch the unconventional root-locus plot for the open-loop transfer function below. The root-locus should be plotted for an increasing m.

$$G(s) = \frac{k\cdot(s+30)}{(m\cdot s + s - 10)\cdot(s+4)} \qquad k = 2 \text{ and is fixed}$$



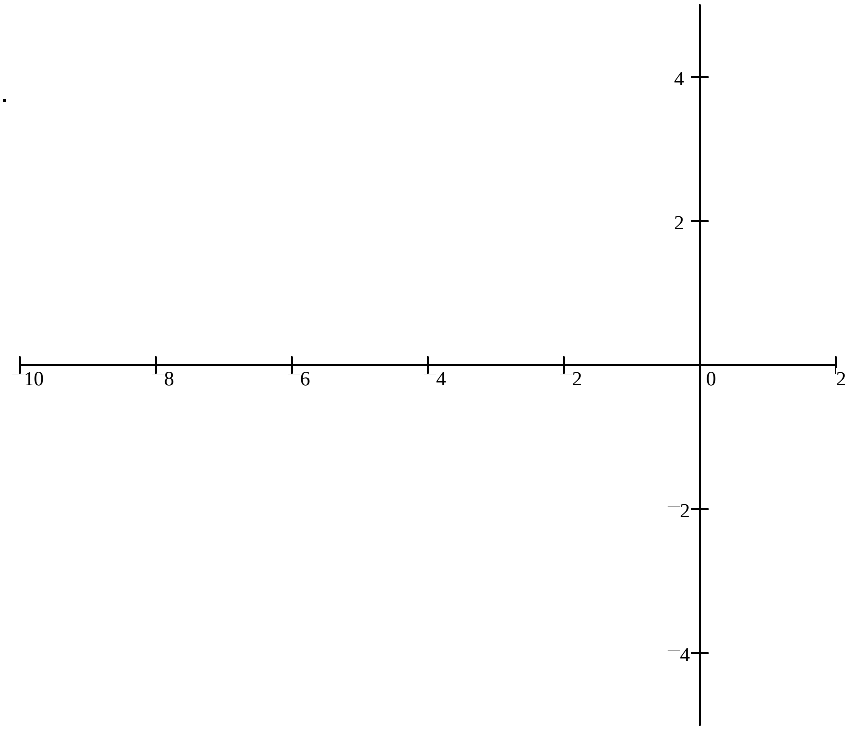
b) Can you place a closed-loop pole on the real axis at -2?
If **YES**, find the value of m needed to place the pole at this location.
If **NO**, draw an arrow to what you think the best point on the real axis is, and find the value of m needed to place the pole at that location.

4. (26 pts) Consider the transfer function below.

$$G(s) := \frac{s+3}{s \cdot \left(s^2 + 2 \cdot s + 5\right)}$$

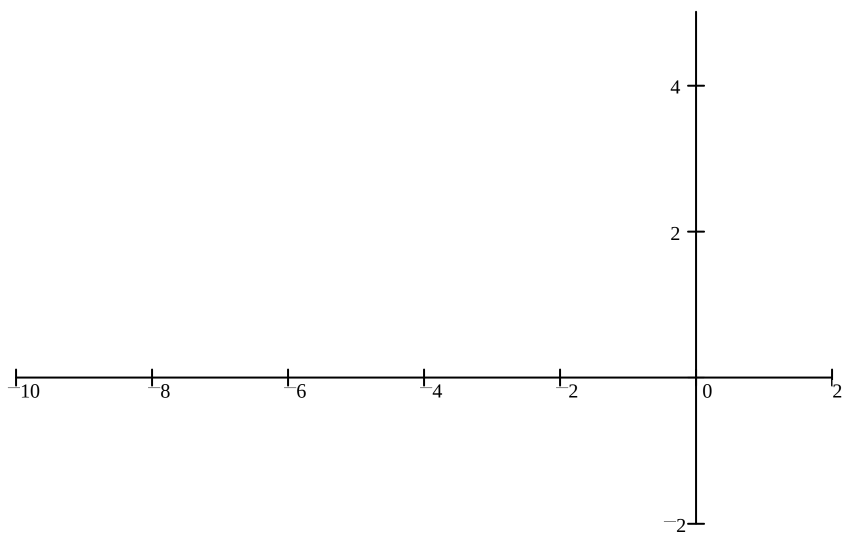
a) Draw a root locus plot using just the main rules.

$$\sigma := \frac{3 - 1 - 1}{2} \qquad \sigma = 0.5$$



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

c) You would like to place your closed-loop poles to get a settling time of 4/3 sec and 4% overshoot (using the second-order assumption). Add the simplest possible compensator to accomplish this and calculate what the compensator should be.



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Note: If you can't calculate the zero location or doubt your calculation, mark here ___ and assume it is at -1 for the rest of this problem.

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

i) What is the gain?

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

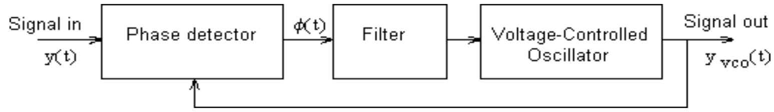
e) OK, now that this compensator is in place, is a settling time of 4/3 sec and 4% overshoot really the best you can do? If not, what should be done. Justify your answer.

_____ / 26 pts

 CB____ / 14 Total ______ / 100 pts

Answers

1\.

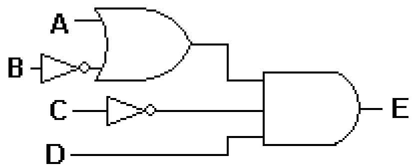


2\. The summer with + and - , and the gain block

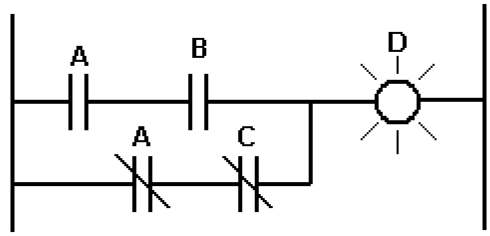
3\. 1st A true differentiator would produce an impulse when the input is a step. No real differentiator can do this.

2nd Differentiators are high-pass filters and accentuate the noise.

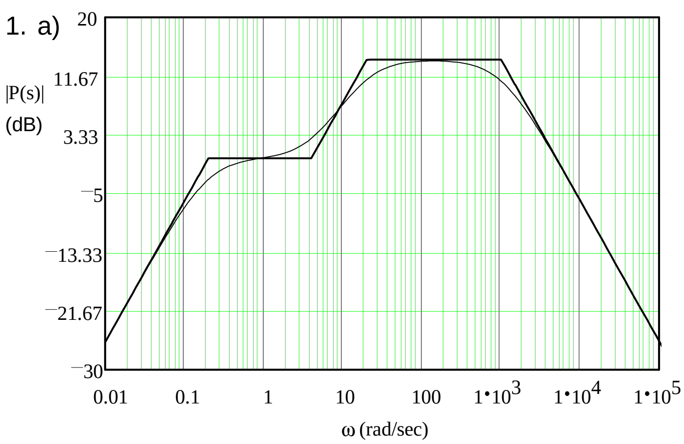
4\. a) $\left(A+\overline{B}\right)\cdot\overline{C}\cdot D$ OR

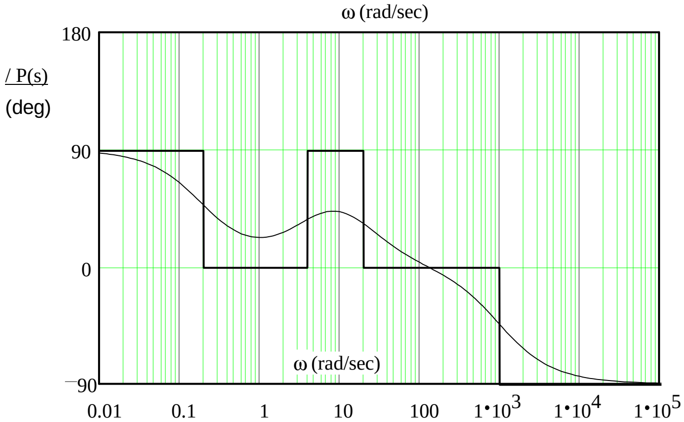


b)

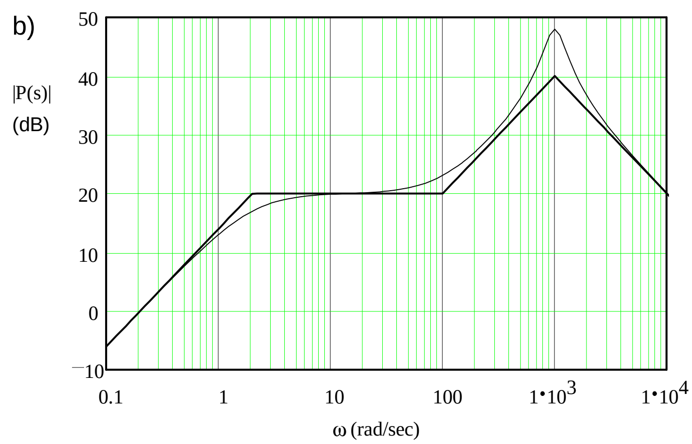


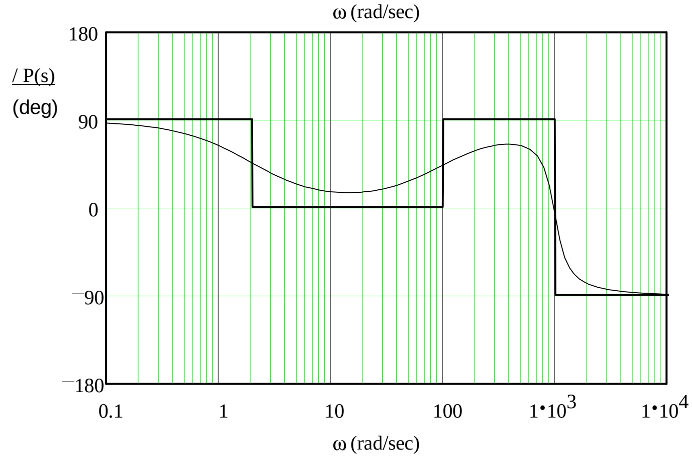
1\. a)



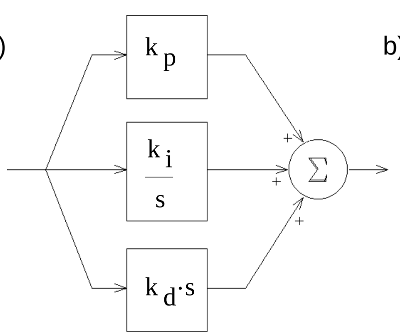


b)





2\. a)

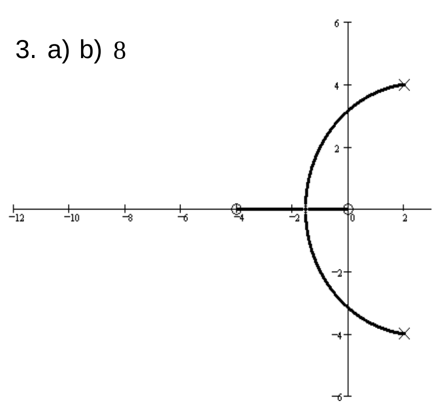


b) 12

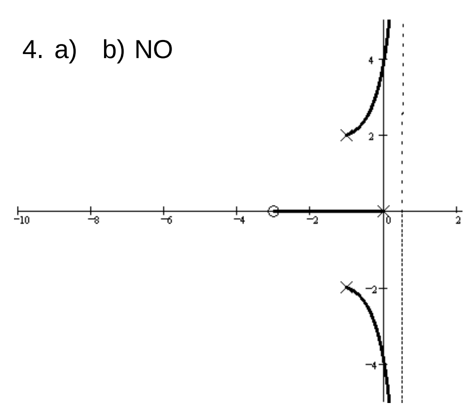
720

384

3\. a) b) 8



4\. a) b) NO



c) $s + 0.462$ d) i) 4.334 ii) $0 \cdot \%$

e) Draw and look at the new root-locus... Obviously turning up the gain so that the closed-loop poles move to points near -6 would result in a significant improvement in both speed and much less ringing.