ECE 3510 Exam 2 given: Spring 21 (Some of the space between problems has been removed.)

1. (16 pts) Several transfer functions are shown below. Without doing anything more than looking at the transfer function, try to determine if it is BIBO stable. Answer Y, N, or C for each.

Y) definitely BIBO table

N) definitely NOT BIBO table

C) can't tell just by looking

a) $\dfrac{s-4}{s^4+2\cdot s^3+5\cdot s^2+0.8\cdot s+5}$ ____

b) $\dfrac{s+2}{2\cdot s^5+12\cdot s^4+5\cdot s^3+s^2+s+2}$ ____

c) $\dfrac{s+1}{4\cdot\left(s^5+1\cdot s^4+15\cdot s^3+2\cdot s^2+s\right)}$ ____

d) $\dfrac{s\cdot(s+4)}{s^6+4\cdot s^5+s^4+5\cdot s^2+2\cdot s+1}$ ____

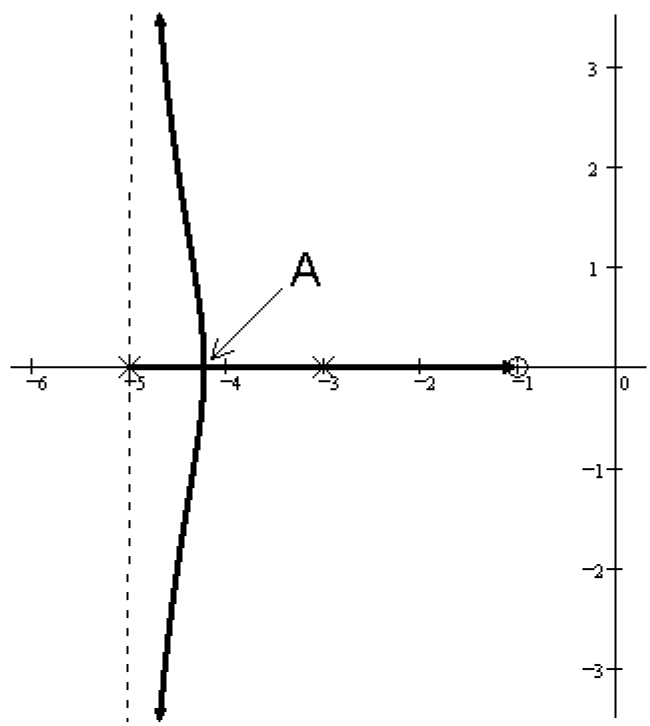
e) $\dfrac{s^4+4\cdot s^2+s}{\left(s^2+2\cdot s+15\right)\cdot\left(s^2+52\cdot s+24\right)}$ ____

f) $\dfrac{10\cdot s+1}{(s+2)\cdot\left(s^2+2\cdot s+4\right)\cdot\left(s^2+4\right)}$ ____

______/ 16

3. (16 pts) a) Point "A" is a special point on the root locus plot. What is it called?

b) Determine if the break-away point is at -4.2. 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 -4.2 is: Answer without making more calculations.

A) LESS than the gain required to place the closed loop poles at the break-away point.

B) THE SAME as the gain required to place the closed loop poles at the break-away point.

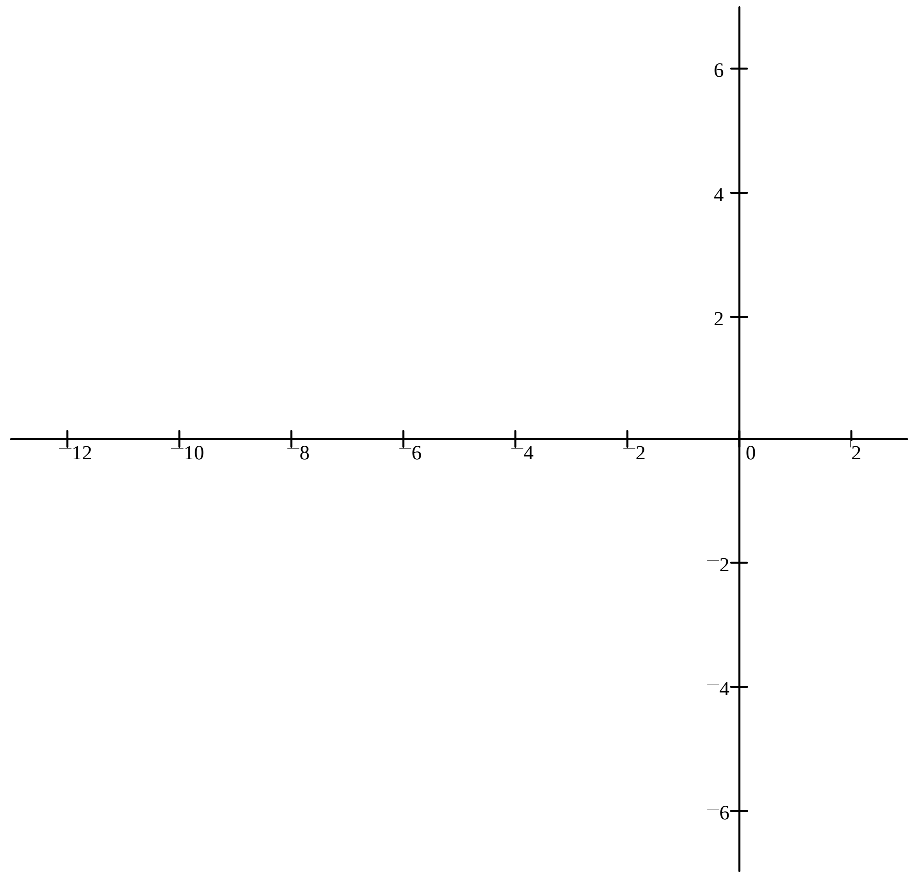
C) GREATER than the gain required to place the closed loop poles at the break-away point.

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

______/ 16

2. (17 pts) a) Sketch the root-locus plot for the open-loop transfer function below
Sketch means: You may estimate details like breakaway points and departure angles from complex poles.
Show your work where needed (like calculation of the centroid).

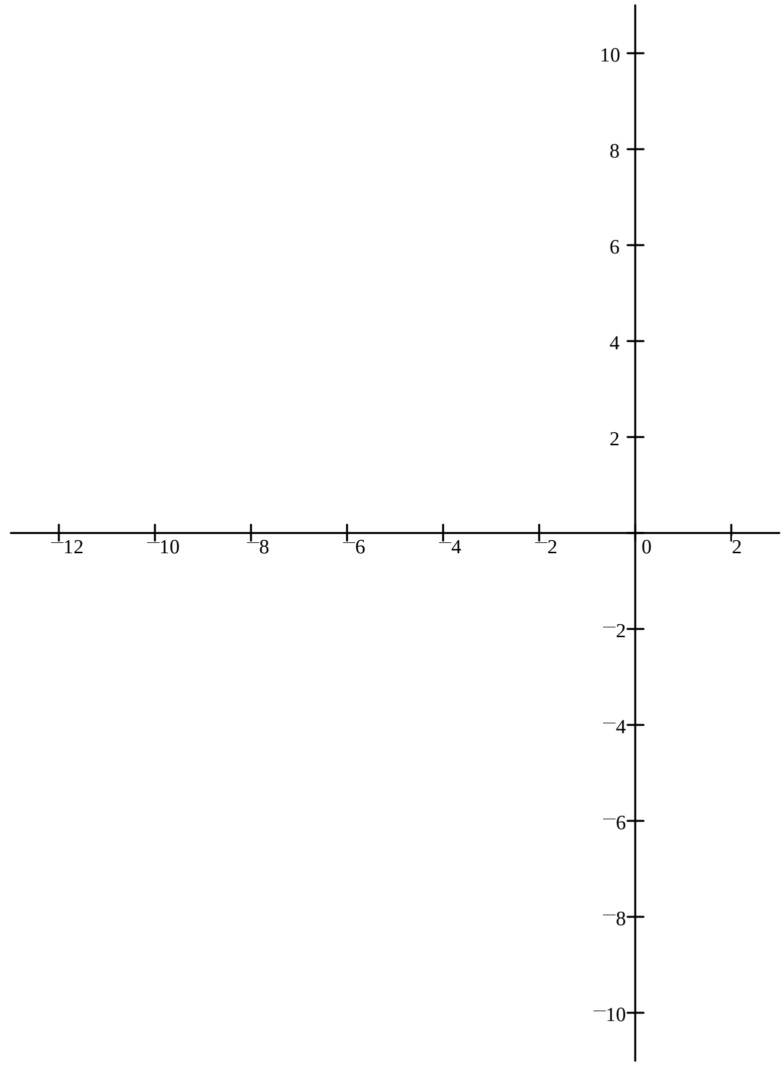
$$\mathbf{G}(s) = \frac{s^2 + 8\cdot s + 41}{(s-1)\cdot(s+6)\cdot\left(s^2 + 10\cdot s + 34\right)\cdot(s+9)}$$



b) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$. The answer may be left as a fraction.

4. (26 pts) a) Sketch the root locus for the OL transfer function shown below.

$$\mathbf{G}(s) = \frac{s+10}{(s+1)\cdot\left(s^2+6\cdot s+18\right)}$$



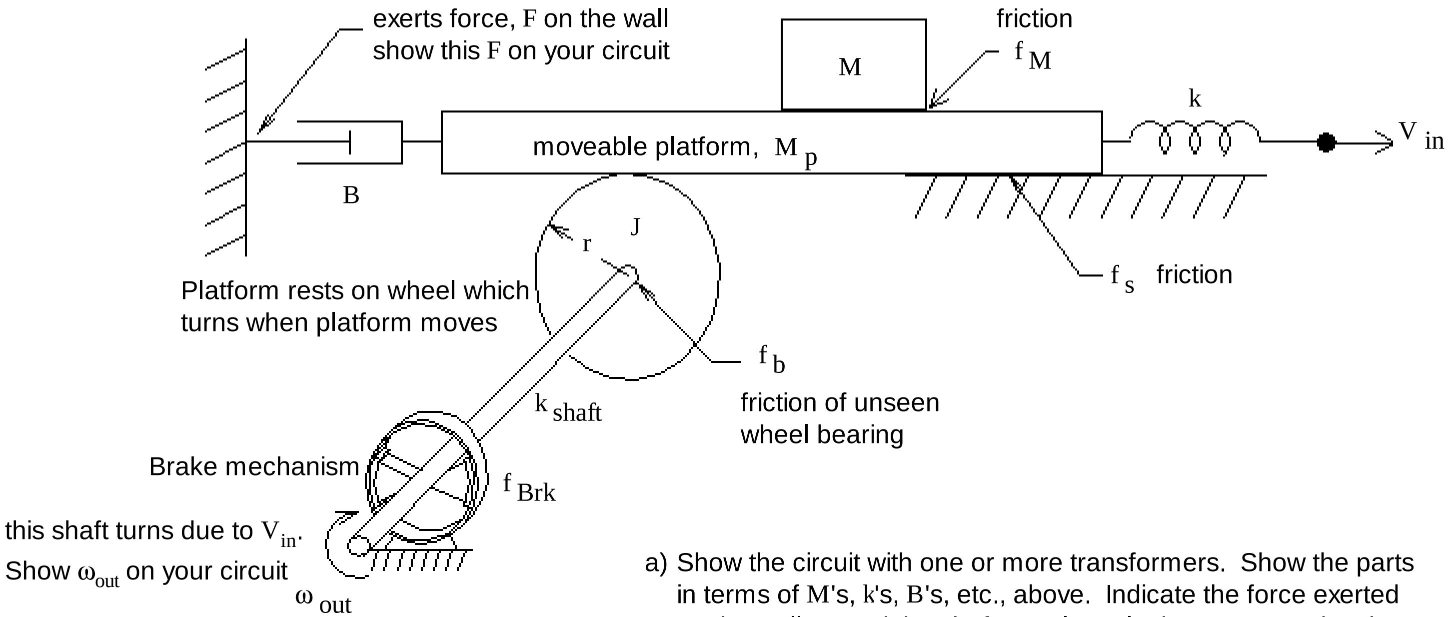
b) Find the departure angle from one of the complex poles.

c) Does the root locus cross the $j\omega$ axis at 8.6?
Be sure to show the work and method you used to decide.

d) Using the additional information from previous parts, draw a more accurate root locus.

e) Regardless of what you found in part c), continue to assume that the root-locus crosses the $j\omega$ axis at 8.6.
Give the range of gain k for which the system is closed-loop stable. (Only the lower limit is needed)

5. (25 pts) Find the equivalent electric circuit for the mechanical system shown. It is a moveable platform of mass, M_p, which rests on one wheel and slides on a surface with friction f_S. The input to the system is the velocity, V_{in}.



a) Show the circuit with one or more transformers. Show the parts in terms of M's, k's, B's, etc., above. Indicate the force exerted on the wall, F, and the shaft angular velocity, ω_{out}, your drawing.

b) Show how to eliminate the transformer just like you did in the homework. Show the equivalent parts in terms of M's, k's, J's, etc., above. You don't have to redraw the whole circuit as long as I can tell how the section of the circuit you draw would connect above.

Prob 5 ______/ 25

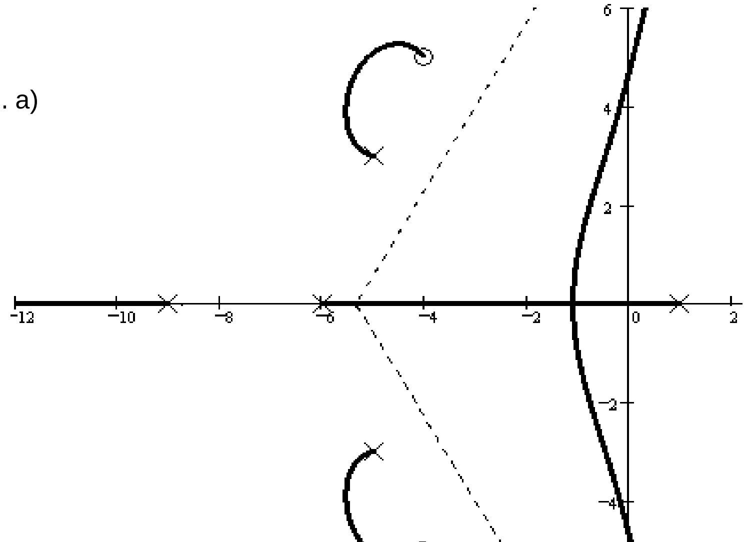
Total ___________ / 100

Answers

1. a) C b) C
   c) N d) N
   e) Y f) N

2. a) Break-away point
   b) NO
   c) A

3. a)



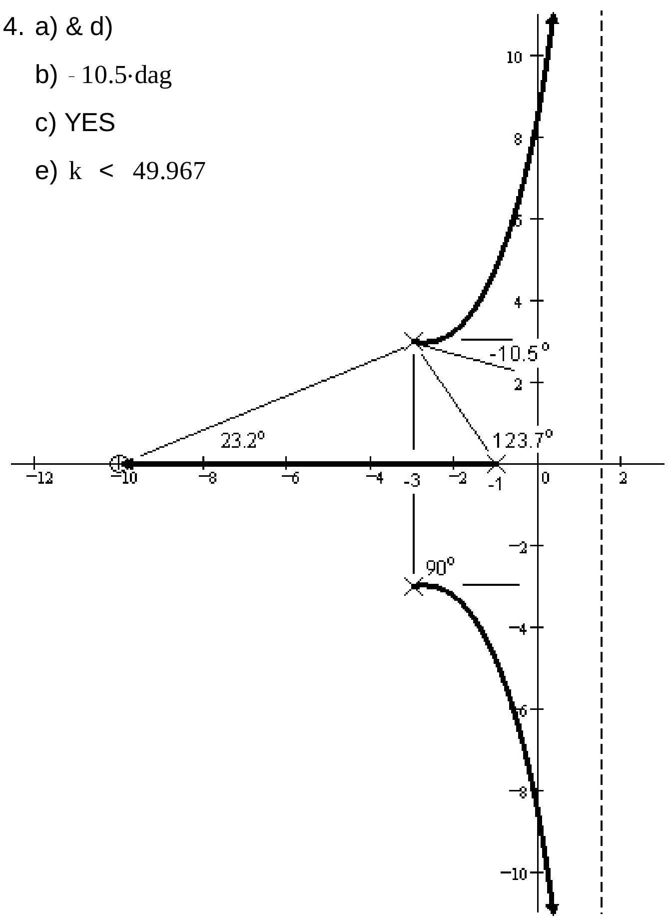
b) $44.78 < k < 424.33$
Only the lower limit is needed

4. a) & d)

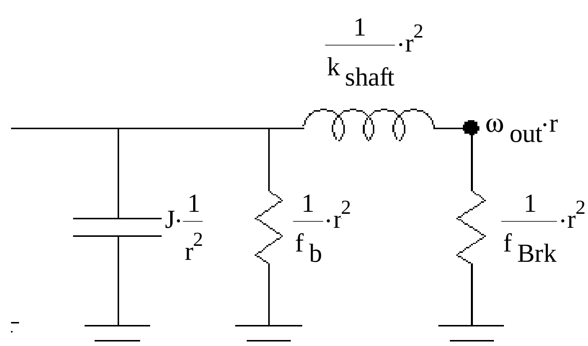
   b) $-10.5 \cdot \mathrm{dag}$

   c) YES

   e) $k < 49.967$



5. b)



5. a)