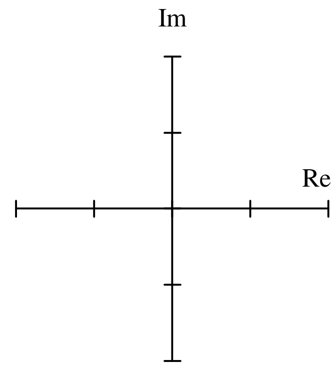
ECE 3510 Exam 2   given: Spring 12

(The space between problems has been removed.)

This part of the exam is   Closed book, Closed notes, No Calculator.

1. (10 pts) a) Give the one characteristic of a feedback system that is more important than all others. Without this nothing else matters, you haven't even got a useable system.

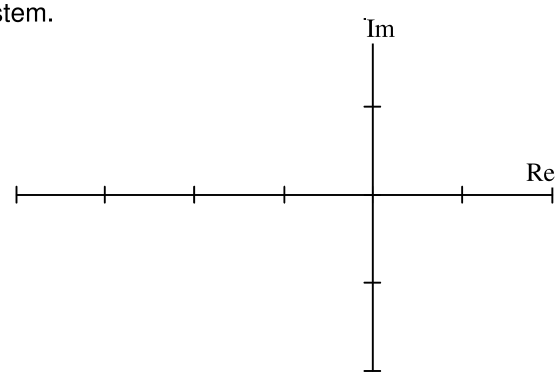


   b) To meet the requirement of part a), the system poles must lie in a certain region of the s-plane. Show that area on drawing at right. Make it clear where the poles must lie. Both axes have the same scale.

   c) "Tracking" is considered an objective of a feedback system. List two characteristics of "good" tracking.
      1
      2

   d) List one more characteristic or objective of a "good" feedback system.

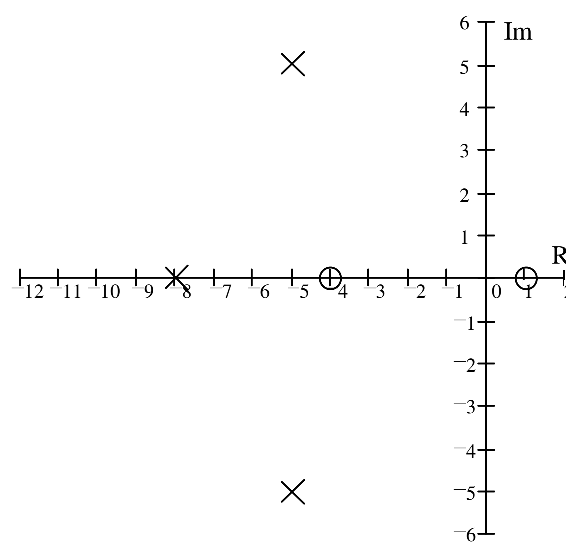
2. (5 pts) The time constant of a system's step response must better than 0.2 sec and the overshoot must be less than 4%. Does that mean the system's poles must lie in a certain region of the s-plane? If yes, show that area on drawing at right, including numbers where appropriate. Make it clear where the poles must lie. If no, write NO below.



3. (6 pts) The following question is about a compensator ($C(s)$) in a standard unity-feedback system.
   a) List 2 advantages of having an integrator in the compensator.
   b) What is the disadvantage of using just an integrator (I) alone?

4. (14 pts) Sketch the root-locus plots for the following open-loop transfer functions:
   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 work where needed (like calculation of the centroid). Draw things like the asymptote angles carefully.

   a) sketch

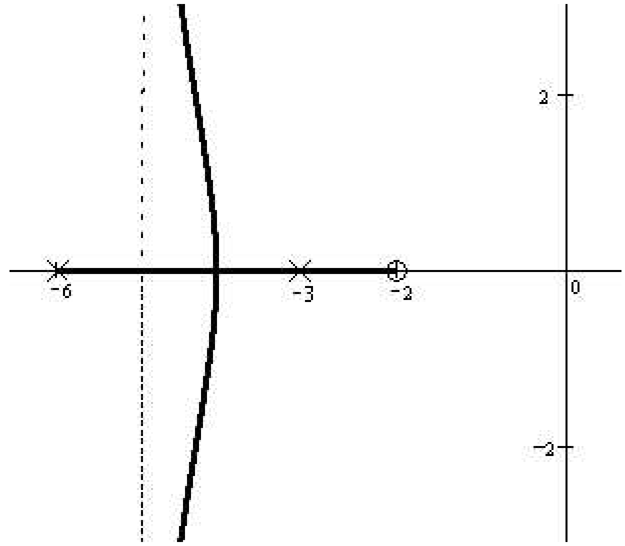


   b) Find the open-loop transfer function. $G(s) = ?$

   c) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$.

Open-book part

1. (9 pts)
   a) Determine if the break-away point is at -4. Show your evidence. I want to see specific calculations and numbers to justify your answer.



   b) The gain required to place a closed loop pole at -4 is:

   Answer without making more calculations.

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

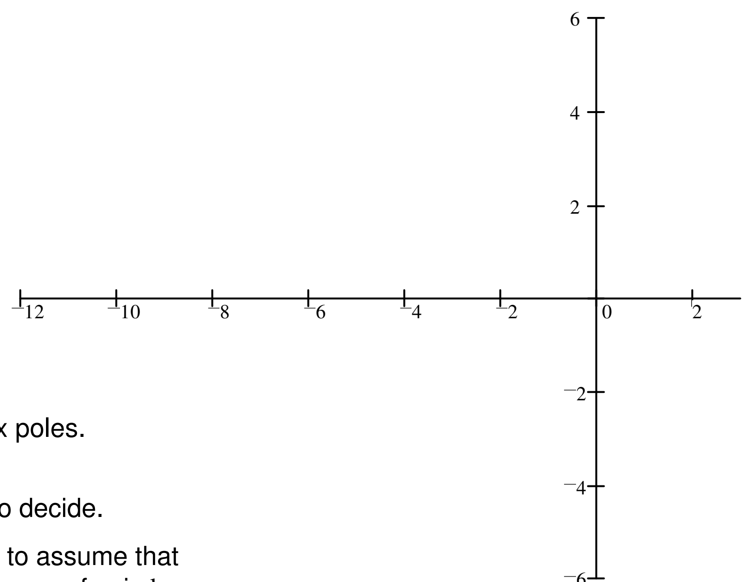
   B) THE SAME as the gain required to place the closed loop poles at the break-away point.

   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.

2. (37 pts) a) Lightly sketch (or use a dotted line) the root locus for the OL transfer function shown below.

$$G(s) = \frac{s+9}{(s+1)\cdot\left(s^2+4\cdot s+8\right)}$$



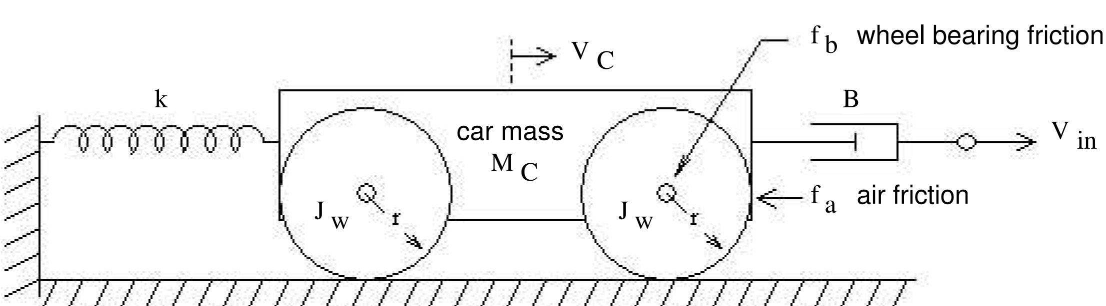
   b) Find the departure angle from one of the complex poles.

   c) Does the root locus cross the $j\omega$ axis at 5?
   Be sure to show the work and method you used to decide.

   d) Regardless of what you found in part c), continue to assume that the root-locus crosses the $j\omega$ axis at 5. Give the range of gain k for which the system is closed-loop stable.

   e) Use what you found in parts b) and c) to draw your final root-locus plot. Clearly show the angle and possibly the crossing (show numbers on the drawing).

3. (19 pts) Find the equivalent electric circuit for the mechanical system shown. The car has 4 wheels. Each wheel has has a moment of inertia, J_w, bearing friction, f_b, and radius, r . V_{in} is a velocity input.



a) Show the circuit with one or more transformers. Show the parts in terms of M' sk' s, B' s, etc., above. Indicate the car velocity, V_C, on your drawing. Hint: since all 4 wheels are identical, it' s not as bad as you think.

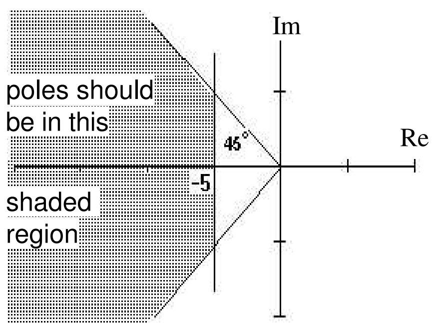
b) Show how to eliminate a transformer, just like you did in the homework. Show the equivalent parts in terms of M' sk' sB' s, etc., above. You don' t have to redraw the whole circuit as long as I can tell how the section of the circuit you draw would connect in above.

Answers

1. a) Stability b) LHP, but not on jω-axis

   c) fast smooth minimum error Often measured in steady state but also means minimum overshoot, etc.

   d) Any of these: Reject disturbances
   Insensitive to plant variations
   Tolerant of noise Or item left out of c) Like overshoot

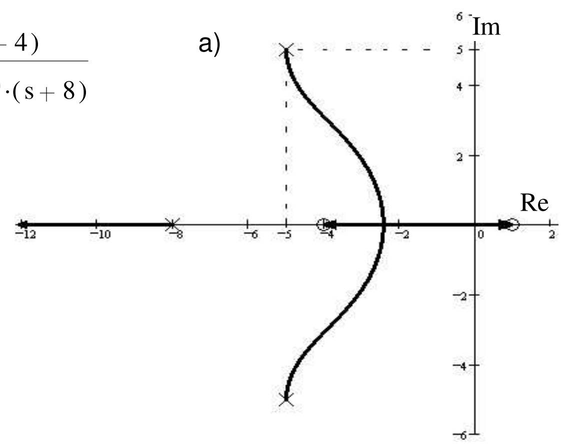
2. 

3. a) 1) Eliminates steady-state error for a step (DC) input.

   2) Eliminates the affects of a DC disturbance.

   b) Slows down the speed of the system.

4. b) $\dfrac{(s-1)\cdot(s+4)}{\left(s^2+10\cdot s+50\right)\cdot(s+8)}$ a)

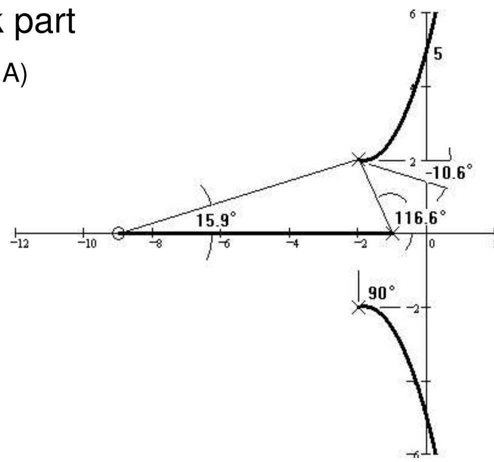


   c) $k < 100$

Open-book part

1. a) No b) A)

2. a)

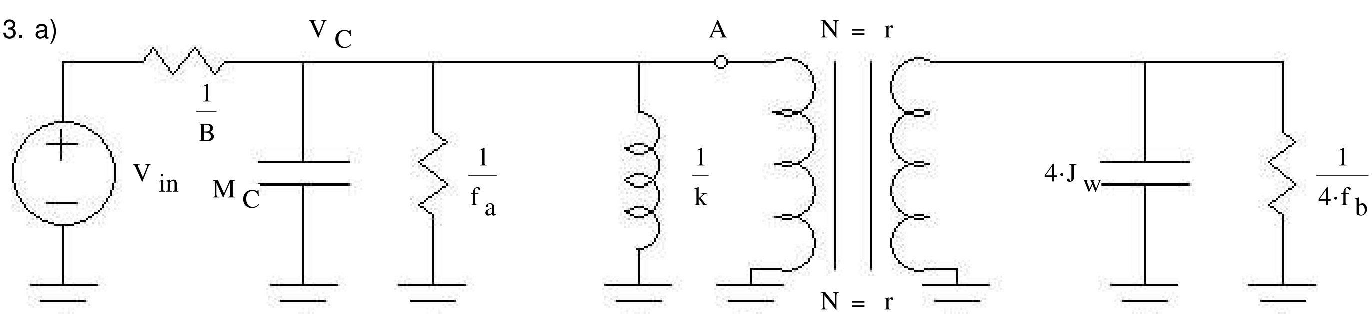


   b) $-10.62\cdot\text{deg}$

   c) YES

   d) $k < 13$

3. a)



b)