ECE 3510 Exam 2 given: Spring 19 (Some of the space between problems has been removed.)

Closed Book, Closed notes, Calculators OK. Two yellow sheets handed out in class and augmented by you, OK

1. (17 pts) This system: $\mathbf{H}(s) = \dfrac{3}{s^2 + 4\cdot s + 40}$ Has this input: $x(t) = 2\cdot\sin(4\cdot t)\cdot u(t)$

   $\mathbf{X}(s) = \dfrac{2\cdot 4}{\left(s^2 + 4^2\right)}$

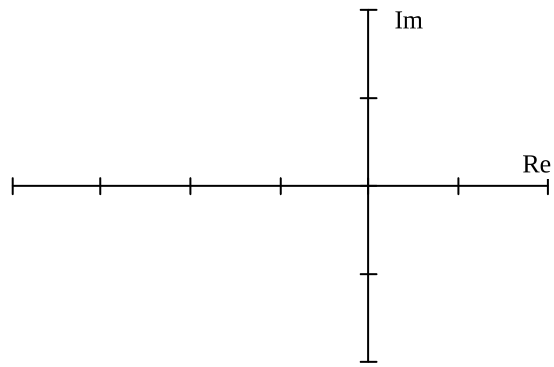
   Resulting in this output: $\mathbf{Y}(s) = \dfrac{3}{s^2 + 4\cdot s + 40}\cdot\dfrac{8}{\left(s^2 + 16\right)}$

   a) Separate $\mathbf{Y}(s)$ that into partial fractions that you can find in the Laplace transform table. Show what they are, but don't find the coefficients.

   b) Continue with the partial fraction expansion just far enough to find the **transient** coefficient(s).

   c) Express the complete (both transient and steady-state) output as a function of time. $y(t)$ = ?
   Use the letters you used in part a) for the coeffieients of the steady-state parts

2. (6 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.

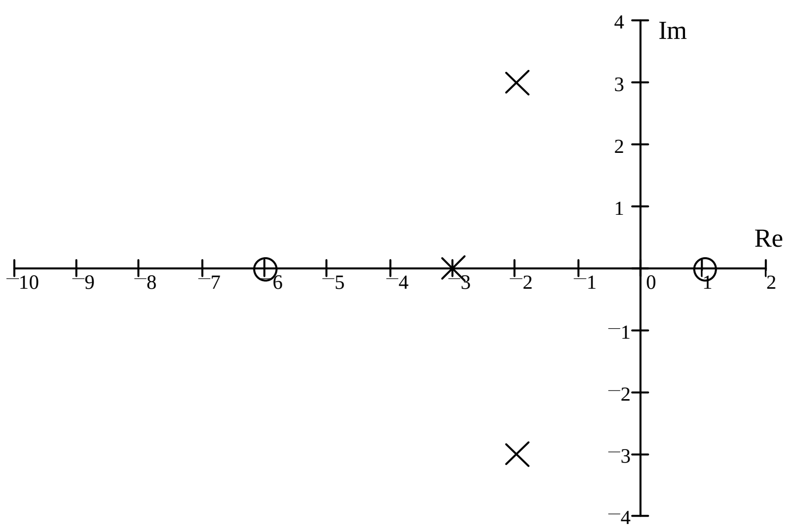


3. (7 pts) a) What should a feedback system have so that it will perfectly reject constant disturbances AND perfectly track constant inputs?

   b) Say the same thing in another way. (Time-domain instead of frequency domain OR vice versa.)

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

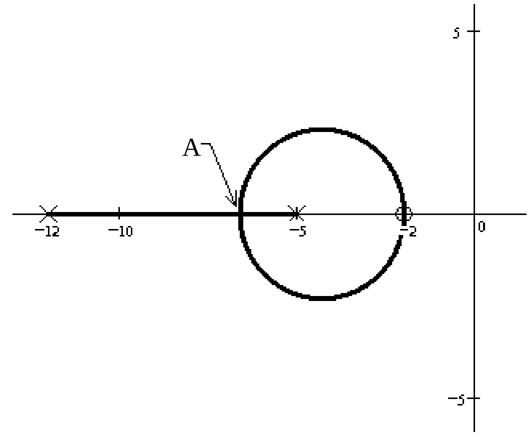
4. (12 pts) a) Sketch the root-locus plots for the open-loop poles and zeros shown.
   Show your work where needed.
   (Like calculation of the centroid, but NOT breakaway points or departure angles.).



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

5. (12 pts) a) Point "A" is a special point on the root locus plot.
   What is it called?

   b) Determine if point "A" is at -7. Show your evidence.
   I want to see specific calculations and numbers to justify your answer.



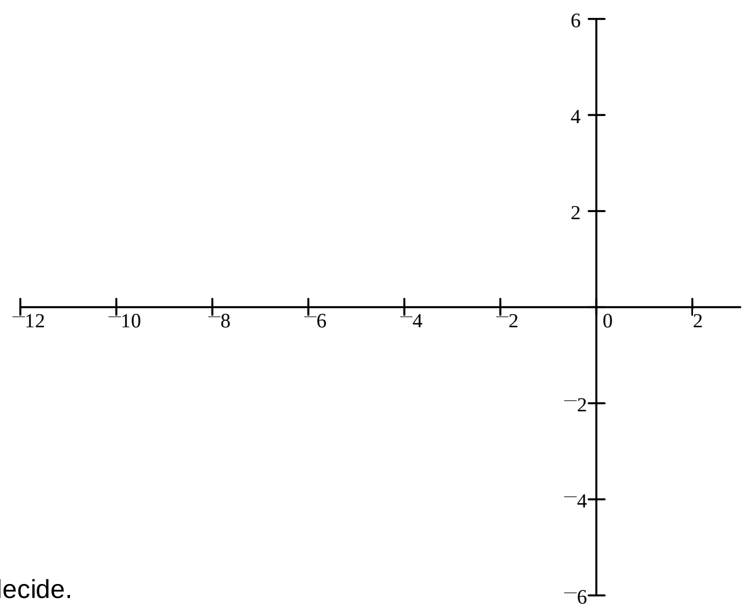
   c) The gain required to place a closed loop pole at -7 is:
   Answer without making more calculations.
   A) LESS than the gain required to place the closed loop poles at point "A".
   B) THE SAME as the gain required to place the closed loop poles at point "A".
   C) GREATER than the gain required to place the closed loop poles at point "A".
   D) It isn't possible to answer this without more calculations.

6. (6 pts) a) Can you practically and effectively cancel a pole in the RHP with a zero? Why or why not?

   b) Can you practically and effectively cancel a pole in the LHP with a zero? Why or why not?

7. (20 pts) a) Sketch the root locus for the OL transfer function shown below.

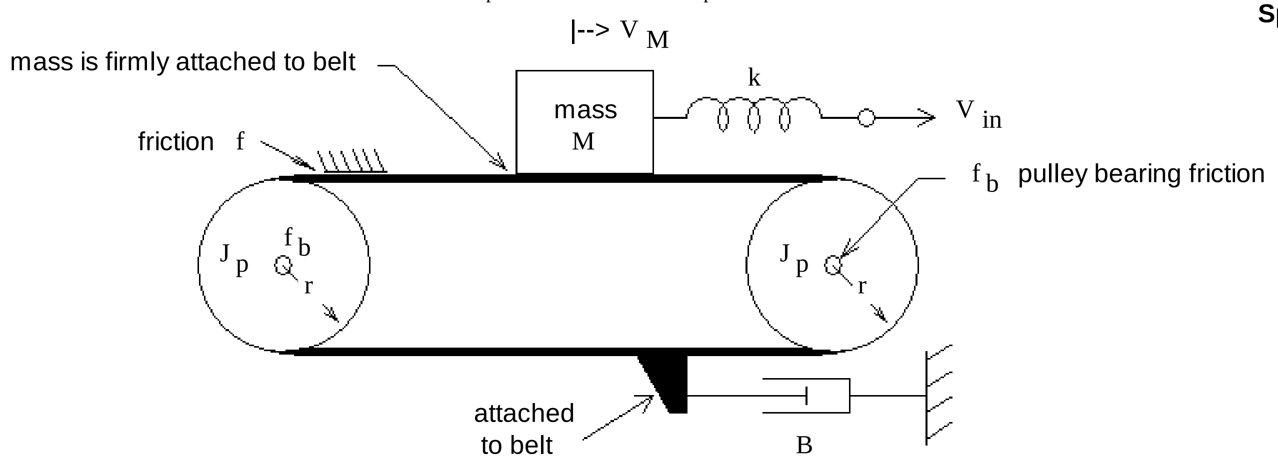
$$G(s) = \frac{s+9}{(s+1)\cdot\left(s^2+4\cdot s+8\right)}$$



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

   c) 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.

8. (20 pts) Find the equivalent electric circuit for the mechanical system shown. It is a belt and 2 pulleys. Each pulley has has a moment of inertia, J_p, bearing friction, f_p, 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's, k's, B's, etc., above. Indicate the mass velocity, V_M, on your drawing.

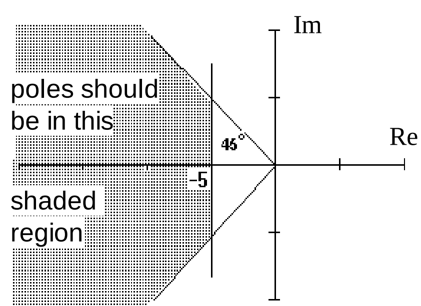
b) Show how to eliminate a transformer, just like you did in the homework. Show the equivalent parts in terms of M's, k's, B's, etc., above. You don't have to redraw the whole circuit as long as I can tell how the section of the circuit you draw would connect in above.

Answers

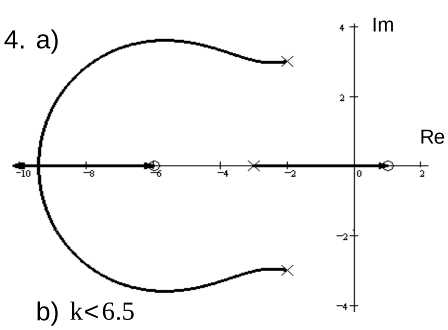
1. a) $\mathbf{Y}(s) = \dfrac{3}{s^2+4\cdot s+40}\cdot\dfrac{8}{(s^2+16)} = \dfrac{A\cdot(s+2)}{s^2+4\cdot s+40} + \dfrac{B\cdot 6}{s^2+4\cdot s+40} + \dfrac{C\cdot s}{(s^2+16)} + \dfrac{D\cdot 4}{(s^2+16)}$

b) $A = \dfrac{3}{26}$ $B = -\dfrac{1}{13}$ c) $y(t) = \left[e^{-2\cdot t}\cdot(0.115\cdot\cos(6\cdot t) - 0.077\cdot\sin(6\cdot t)) + C\cdot\cos(4\cdot t) + D\cdot\sin(4\cdot t)\right]\cdot u(t)$

2.



4. a)

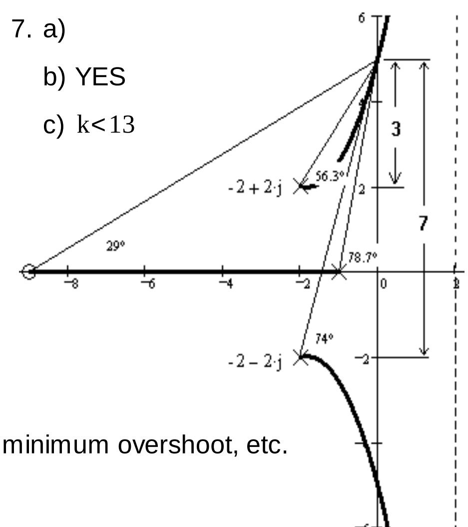


b) k<6.5

7. a)

b) YES

c) k<13



3. a) The controller, C(s), should have a pole at the origin.
 b) The controller, C, should have a an integrator.
 c) fast
 smooth
 minimum error Often measured in steady state but also means minimum overshoot, etc.

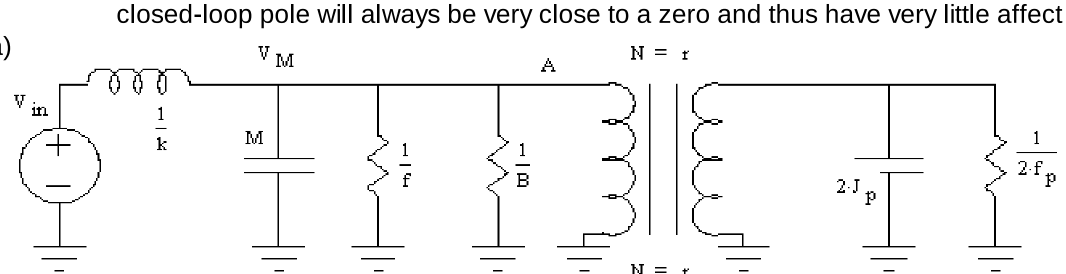
5. a) Break-away point b) No c) A)

6. a) NO The zero will never exactly match the pole, so there will always be a branch of the root-locus in the RHP and that closed-loop pole will always be unstable.

 b) YES Although the zero will never exactly match the pole, it doesn't matter in the LHP.

 The root locus may stop and start where it would otherwise be continuous, it may loop around either the pole or zero or it may have a separate branch from the pole to the zero. In all three cases the remaining closed-loop pole will always be very close to a zero and thus have very little affect on the output.

8. a)



b)