ECE 3510 Exam 2 given: Spring 07

(The space between problems has been removed.)

1. (12 pts) This system: $H(s) = \frac{k \cdot s}{s + b}$

   Has this input: Sine input: $x(t) = \sin(\omega_o \cdot t) \cdot u(t)$ $\qquad X(s) = \frac{\omega_o}{s^2 + \omega_o^2}$

   This results in an output, $Y(s)$. Show $Y(s)$ below and separate it into 3 partial fractions that you can find in the laplace transform table. Show what they are, but don't find the coefficients.

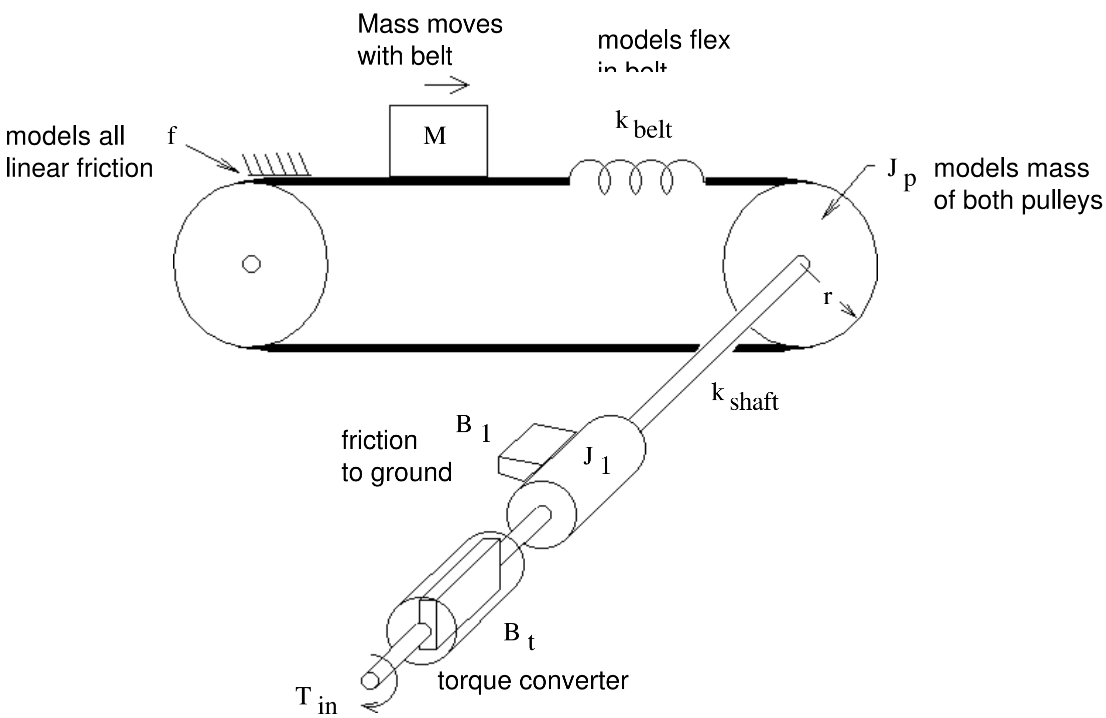
   $Y(s) = \qquad\qquad\qquad =$

   Continue with the partial fraction expansion just far enough to find the **transient** coefficient.

2. (8 pts) Characteristic equation of a feedback sytem is shown below.
   Use the Routh-Hurwitz method to determine the value range of K that will produce a stable system.

   $0 = 2 \cdot s^3 + 10 \cdot s^2 + (4 + K) \cdot s + 5$

3. (25 pts) Find the equivalent electric circuit for the mechanical system shown. T_{in} is the input.

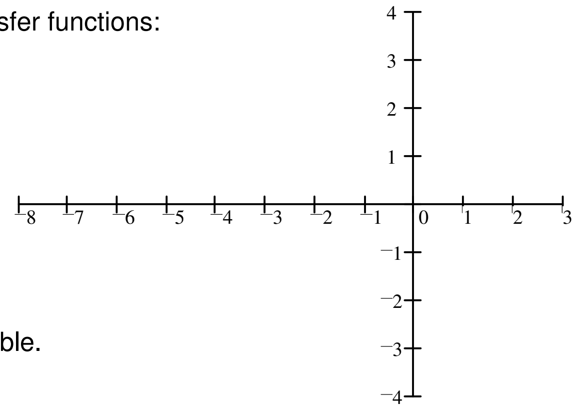


a) show the circuit with a transformer.

b) Show the circuit without a transformer, just like you did in the homework.

4. (21 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).

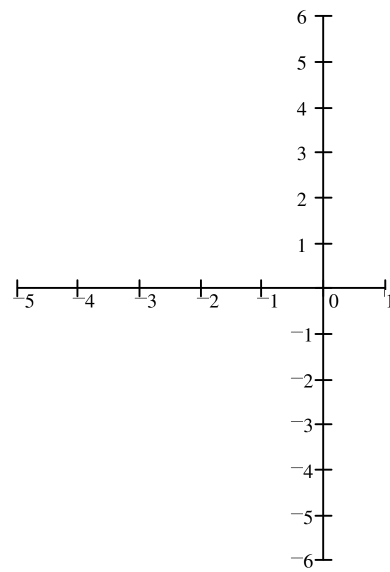
   a) $G(s) = \dfrac{(s-2)\cdot(s+4)}{(s+2)^2\cdot(s+6)}$



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

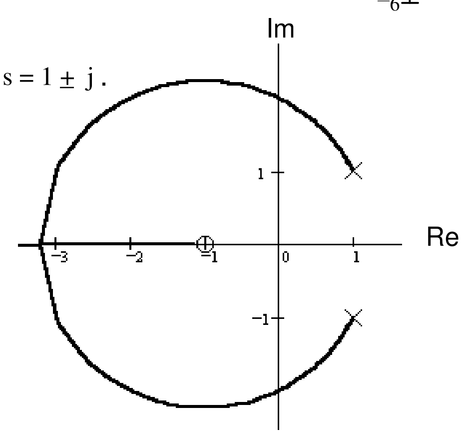
   Remember, I asked for a **range** for stability

   c) $G(s) = \dfrac{s+2}{\left(s^2+1\right)\cdot(s+4)}$



5. (25 pts) A root - locus is sketched at right.
   The open - loop transfer function has one zero at $s = -1$ and two poles at $s = 1 \pm j$.

   $G(s) = \dfrac{s+1}{(s-1-j)\cdot(s-1+j)}$



   a) Find the departure angle from the complex pole $1 + j$.

   b) It looks like the root-locus crosses the $j\omega$ axis at 2

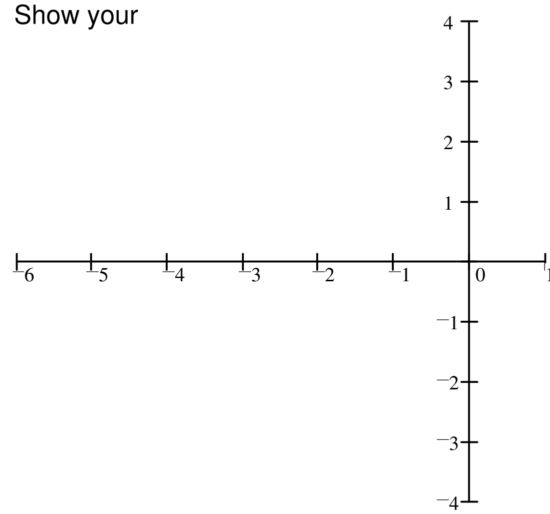
   Determine if this is true.
   Clearly show your work, guesses don't count.

   c) Regardless of what you found in part b, continue to assume that the root-locus crosses the $j\omega$ axis at 2.
   Give the range of gain k for which the system is closed-loop stable. You may leave your answer as a fraction of radicals, however, I'll give you a couple of extra points if you can reduce it to a simple number.

6. (9 pts) Sketch the root-locus plots for the following open-loop transfer function.

   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).

$$G(s) = \frac{1}{\left[(s+3)^2+4\right]\cdot(s+2)}$$

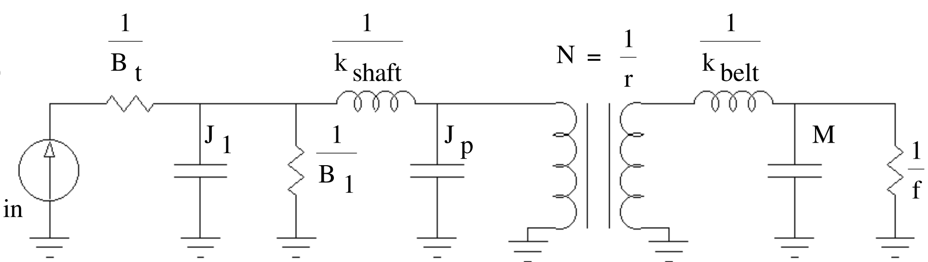


Answers

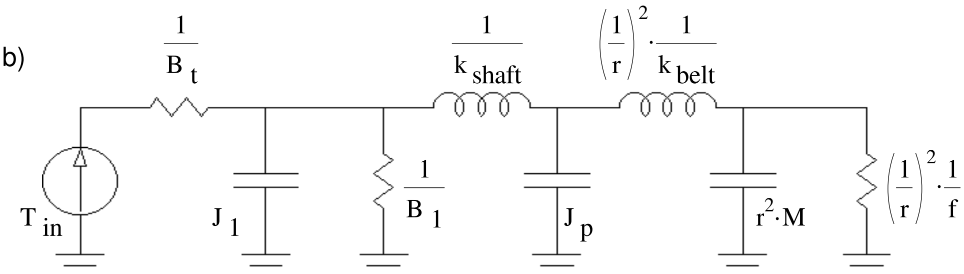
1. $A = \dfrac{-k\cdot b\cdot \omega_o}{b^2+\omega_o^{\,2}}$

2. $K > -3$

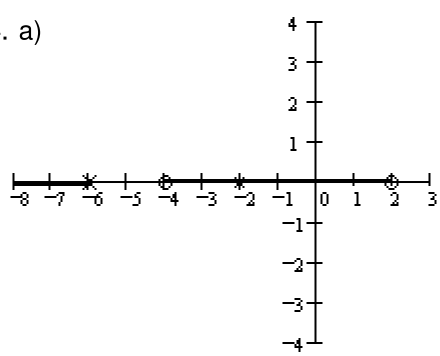
3. a)



b)

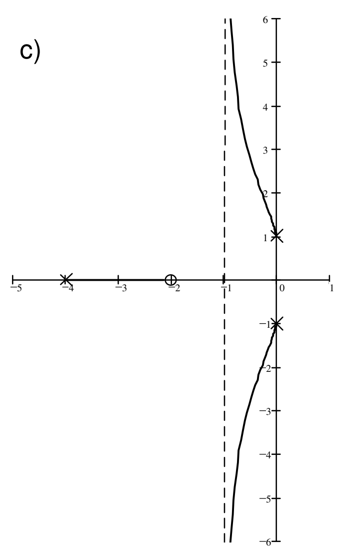


4. a)

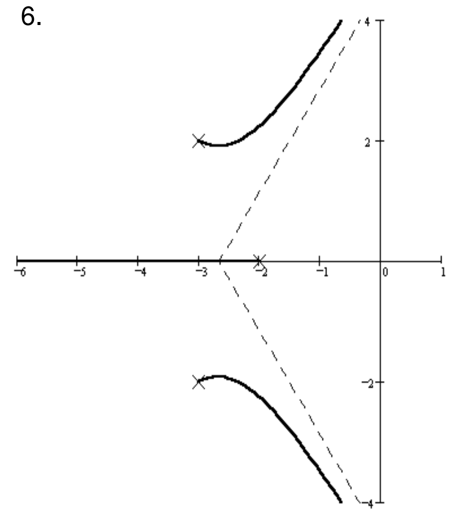


b) $k < 3$

c)



6.



5. a) $116.6\cdot\text{deg}$

b) $\arg(G(2\cdot j)) = 63.4\cdot\text{deg} - (180-45)\cdot\text{deg} - (180-71.6)\cdot\text{deg} = -180\cdot\text{deg}$

YES, the root-locus crosses the $j\omega$ axis at 2

c) $k > 2$

6. above