ECE 3510 Exam 2 given: Spring 18 (Some of the space between problems has been removed.)

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

1. (26 pts) This system: $\mathbf{H}(s) = \dfrac{8 \cdot s}{s^2 + 4 \cdot s + 40}$ Has this input: $x(t) = 2 \cdot \sin(5 \cdot t) \cdot u(t)$

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

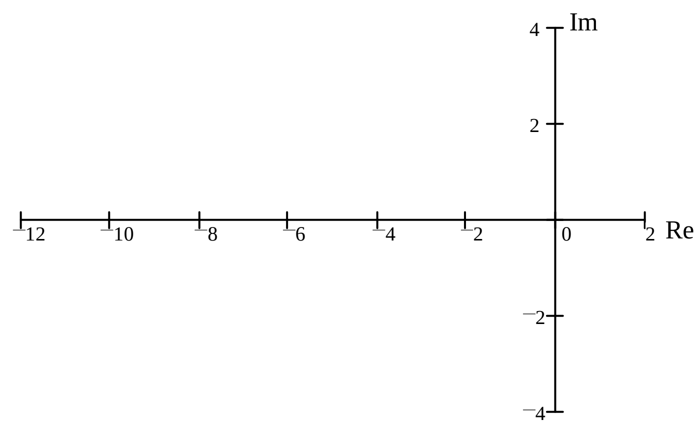
   b) Use steady-state AC analysis to find the phasor representation of the steady-state output in polar form.
   $\mathbf{Y}_{\mathbf{ss}}(j\omega) = ?$

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

   d) What is the time constant of the transient part this expression? $\tau = ?$

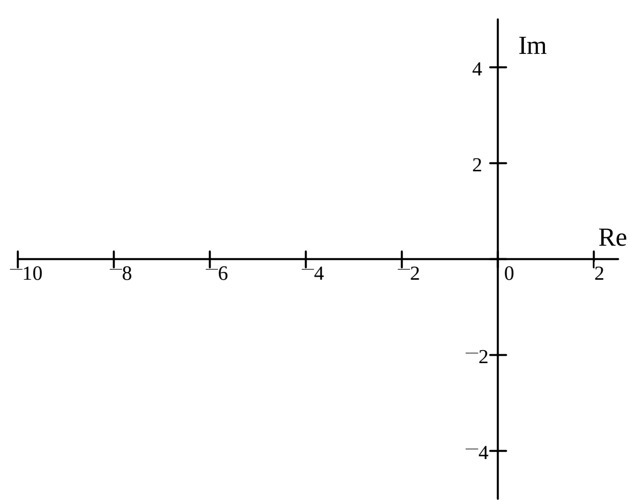
2. (22 pts) a) Sketch the root-locus plot for the open-loop transfers function below.
   Sketch means: You may estimate details like breakaway points and departure angles from complex poles.
   Show your work where needed (like calculation of the centroid). Draw things like the asymptote angles carefully.

   a) $G(s) := \dfrac{(s+8) \cdot (s+10)}{(s-1) \cdot (s+5)}$



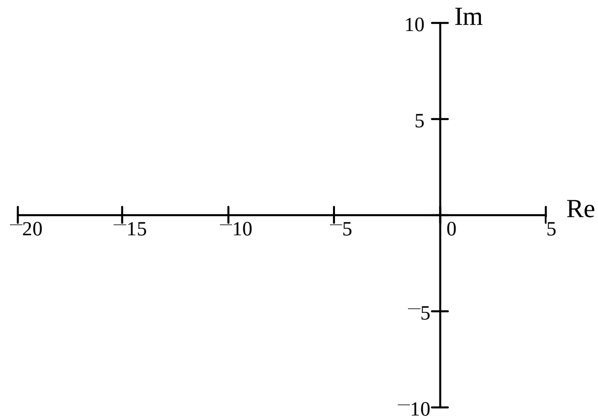
b) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$.

c) $G(s) = \dfrac{1}{\left(s^2 + 2 \cdot s + 10\right) \cdot (s+4) \cdot (s+6)}$



3. (25 pts) a) Sketch the root locus for:

$$G(s) = \frac{s+5}{s^2 - 4\cdot s + 29}$$



b) Does the root locus cross the $j\omega$ axis at 7?
Be sure to show the work and method you used to decide.

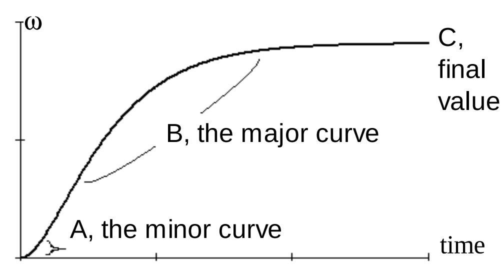
c) Regardless of what you found in part a, continue to assume that the root-locus crosses the $j\omega$ axis at 7.
Give the range of gain k for which the system is closed-loop stable.

d) Determine if there is a break-in point -15. Show your evidence.
I want to see specific calculations and numbers to justify your answer.

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

e) The gain required to place a closed loop pole at -15 is: Answer without making more calculations.
A) LESS than the gain required to place the closed loop poles at the break-in point.
B) THE SAME as the gain required to place the closed loop poles at the break-in point.
C) GREATER than the gain required to place the closed loop poles at the break-in point.

4. (7 pts) In Lab 4 you characterized a DC motor. The curve at right is a typical rotational speed vs time measurement for such a motor. Tell me what motor parameter or characteristic is most responsible for each of the labeled parts of the curve.

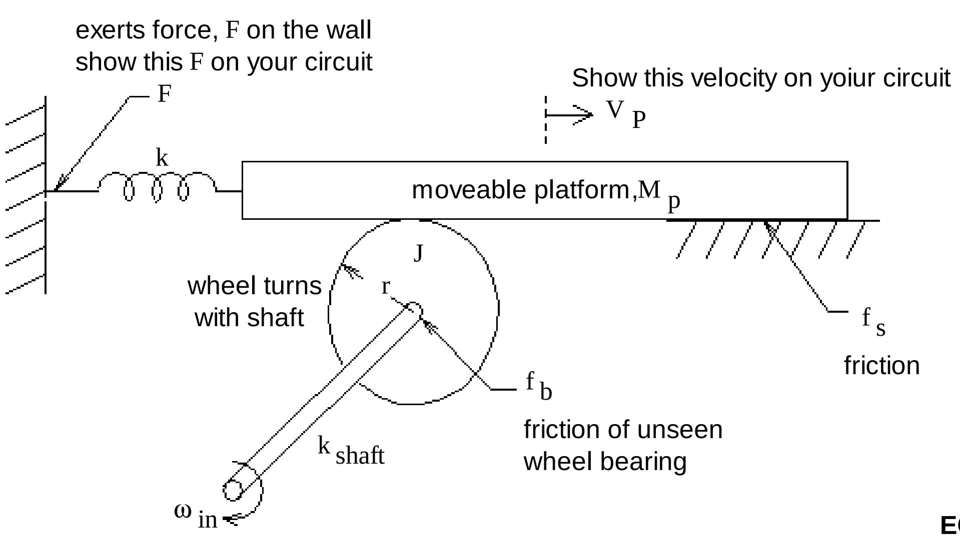


A, the minor curve

B, the major curve

C, final value

5. (20 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 angular velocity, ω_{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 platform velocity, V_P, your drawing.

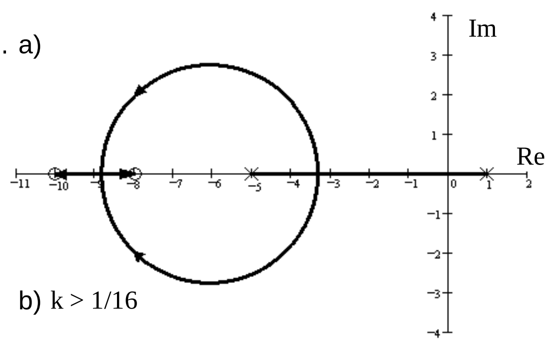
b) Show how to eliminate the transformer just like you did in the homework. Show the equivalent parts in terms of M's, k's, J's, etc., above. You don't have to redraw the whole circuit as long as I can tell how the section of the circuit you draw would connect above.

Answers

1. a) $\frac{A\cdot(s+2)}{s^2+4\cdot s+40} + \frac{B\cdot 6}{s^2+4\cdot s+40} + \frac{C\cdot s}{\left(s^2+25\right)} + \frac{D\cdot 5}{\left(s^2+25\right)}$ b) $3.2\ \angle -53.13\cdot deg$

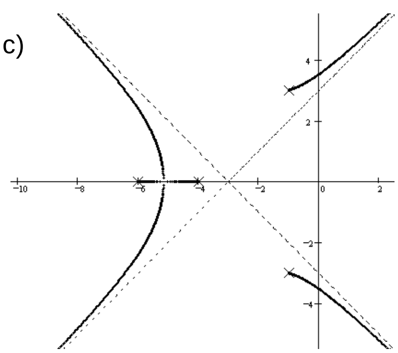
c) $\left[e^{-2\cdot t}\cdot(A\cdot\cos(6\cdot t)+B\cdot\sin(6\cdot t))+3.2\cdot\cos(5\cdot t-53.13\cdot deg)\right]\cdot u(t)$ d) 1/2

2. a)

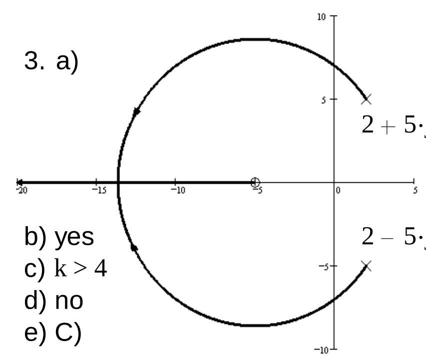


b) $k > 1/16$

c)



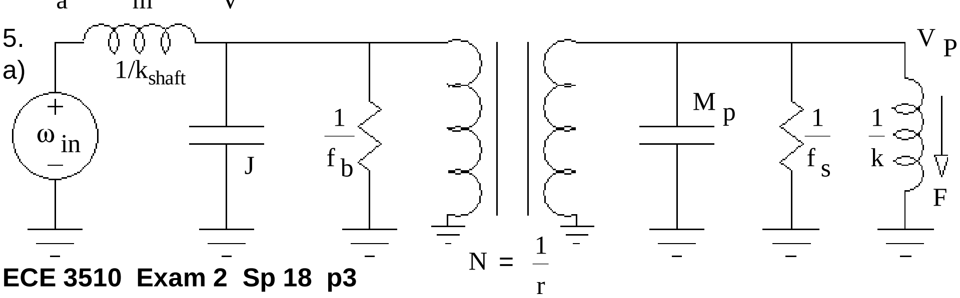
3. a)



b) yes
c) $k > 4$
d) no
e) C)

4. L_a J_m K_V

5. a)



b)