ECE 3510 Exam 2 given: Spring 14 (Some of the space between problems has been removed.)

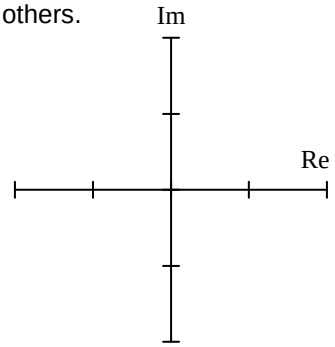
This part of the exam is Closed book, Closed notes, No Calculator.

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.

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



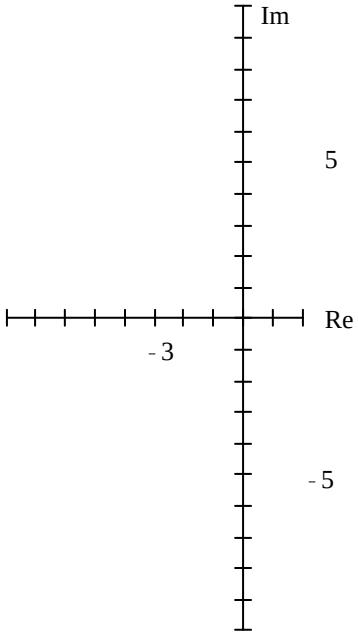
2. (9 pts) The step response of a system is:

$$y(t) = 1.5 \cdot e^{-3 \cdot t} \cdot (4 \cdot \cos(5 \cdot t) + 2 \cdot \sin(5 \cdot t)) \cdot u(t)$$

   a) Draw the poles and/or zeroes of the **system** transfer function on the s-plane at right. Make sure I can tell the values of the real & imaginary parts.

   b) What is the initial value of the output? (where does it start at time $t = 0$?)

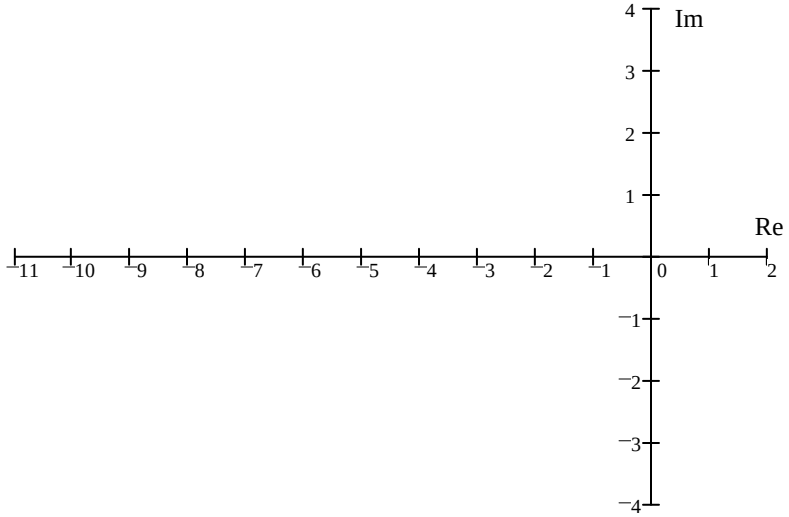
   c) What is the final value of the output? (where does it end at time $t = \infty$?)



The poles and zeroes of the **system**, not the signal.

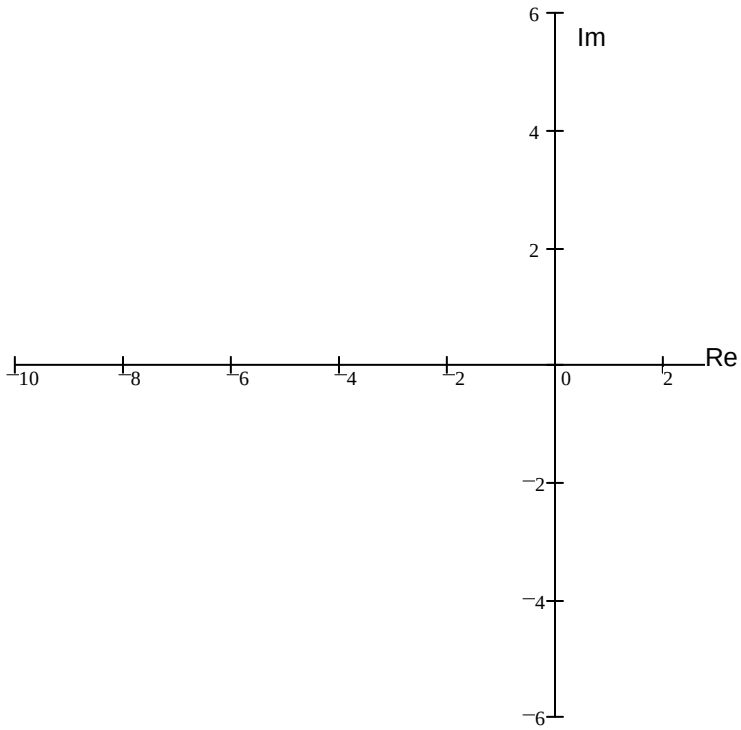
3. (19 pts) Sketch the root-locus plots for the following open-loop transfer functions:
   Use only the rules you were told to memorize, that is, you may estimate details like breakaway points and departure angles from complex poles. Show your work where needed (like calculation of the centroid). Draw things like the asymptote angles carefully.

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



b) sketch

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



Open-book part

1. (40 pts) This system: $\mathbf{H}(s) = \frac{8\cdot s}{s^2 + 4\cdot s + 40}$ 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) Continue with the partial fraction expansion just far enough to find the **transient** coefficient(s).

1. continued (**NOTE**, This part can be done without the answers from the parts)

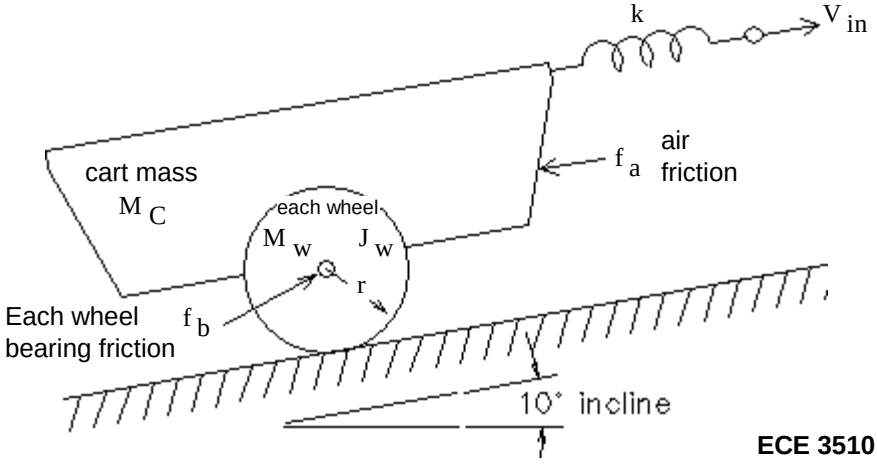
   c) Use steady-state AC analysis to find the phasor representation of the steady-state output in polar form.

   $\mathbf{Y}_{ss}(j\omega)$ = ?

   d) 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.
   If you don't have an answer for part b), assume the coefficients are 1.8 and -2.5

   e) What is the time constant of the transient part this expression? τ = ?

2. (22 pts) Find the equivalent electric circuit for the mechanical system shown. It is a cart with 2 wheels. **EACH** wheel has has mass, M_w, moment of inertia, J_w, bearing friction, f_b, and radius, r. V_{in} is a velocity input. The cart is being pulled up a 10° incline. You can model this as a constant force against the motion of the cart, but you do have to determine how much force. The acceleration of gravity is g.

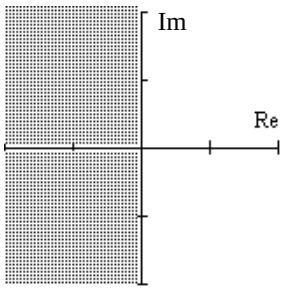


a) Show the circuit with one or more transformers.
Show the parts in terms of M's, k's, B's, etc., above. Indicate the cart velocity, V_C, on your drawing.

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, 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 in above.

Answers

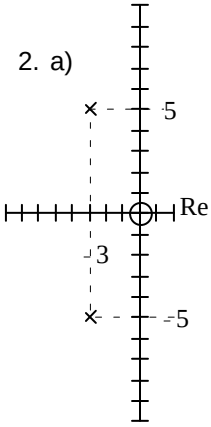
1. a) Stability b)



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

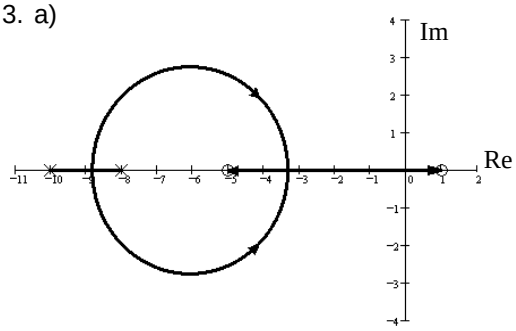
2. a)



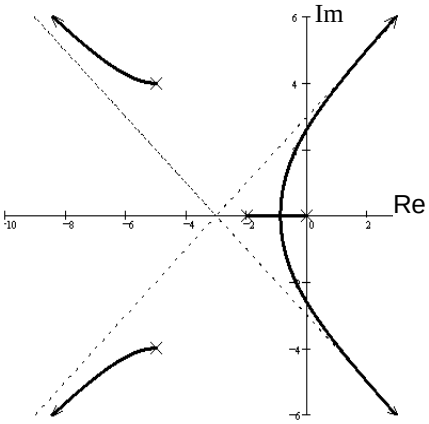
b) 6

c) 0

3. a)



b)



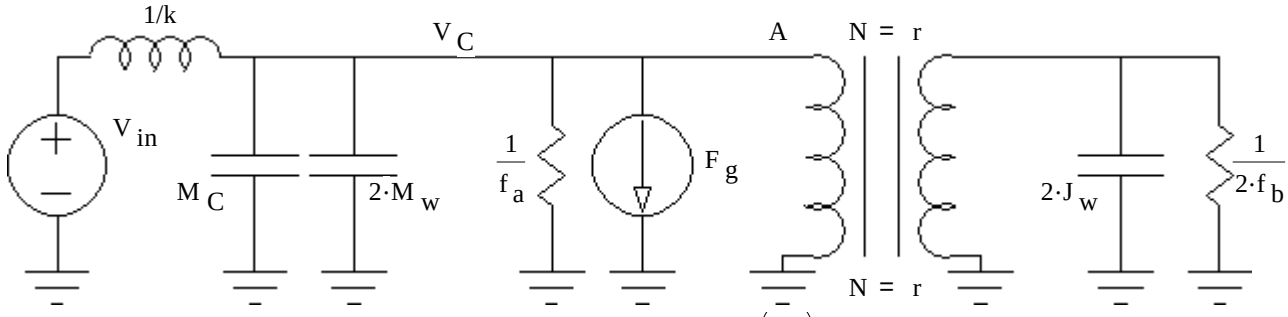
Open-book part

1. a) $\frac{A\cdot(s+2)}{s^2+4\cdot s+40} + \frac{B\cdot 6}{s^2+4\cdot s+40} + \frac{C\cdot s}{(s^2+25)} + \frac{D\cdot 5}{(s^2+25)}$

b) A = -1.92 B = -2.773

c) $3.2\cdot\cos(5\cdot t - 53.13\cdot\text{deg})$ d) $\left[e^{-2\cdot t}\cdot(-1.92\cdot\cos(6\cdot t) - 2.773\cdot\sin(6\cdot t)) + 3.2\cdot\cos(5\cdot t - 53.13\cdot\text{deg})\right]\cdot u(t)$ e) 0.5

2. a)



$F_g = \left(M_C + 2\cdot M_w\right)\cdot g\cdot\sin\left(10^o\right)$

b)