ECE 3510 Exam 2 given: Spring 20 (Some of the space between problems has been removed.)

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

1. (2 pts) a) Our time-domain signals all start at time = 0 because we use the unilateral Laplace transform to represent the signals. How are conditions and events that happened before time = 0 handled?

2. (4 pts) List Three advantages of state space over classical frequency-domain techniques.

   1

   2

   3

3. (9 pts) When an electrical circuit is used as a representation if a mechanical system of translational motion, what do the following electrical quantities or parts represent in the mechanical system?

   a) Current = d) Resistor =

   b) Voltage = e) Inductor =

   c) Ground = f) Capacitor =

   Also: g) Is the capacitor always hooked up in a certain way? If yes, say what.

   h) Name two things represented by transformers. You may include items that rotate.

   1. 2.

4. (4 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.

   1. 2.

   b) What is the disadvantage of using just an integrator (I) alone?

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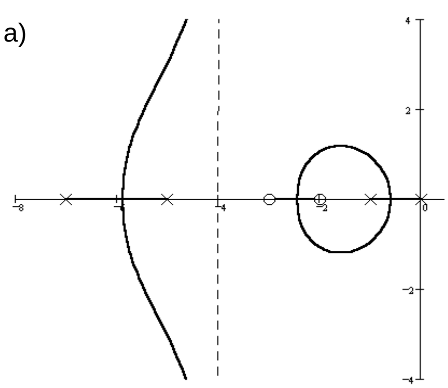
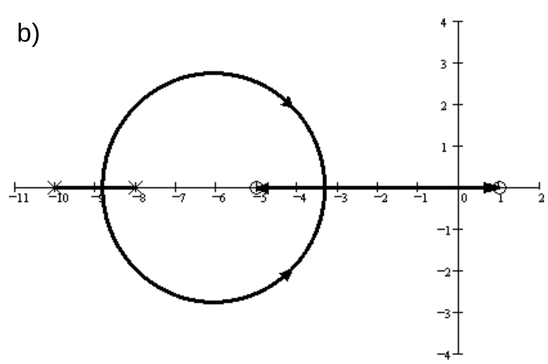
Answers

1. As initial conditions and/or as the initial state of the system.
2. Multiple input / multiple output systems Can model nonlinear systems Can model time varying systems
   Can be used to design optimal control systems Can determine controllability and observability
3. a) Force d) Friction or damping
   b) Velocity e) Spring
   c) Stationary reference of zero velocity f) Mass
   g) Yes, one side is always hooked to ground h) Levers Wheels Belts Gears Electric motors
4. 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.

1. a)



b)



c) $k < 16$

2. a) $\dfrac{s+2}{(s+3)^2 \cdot (s+6)}$

   b) NO c) A)

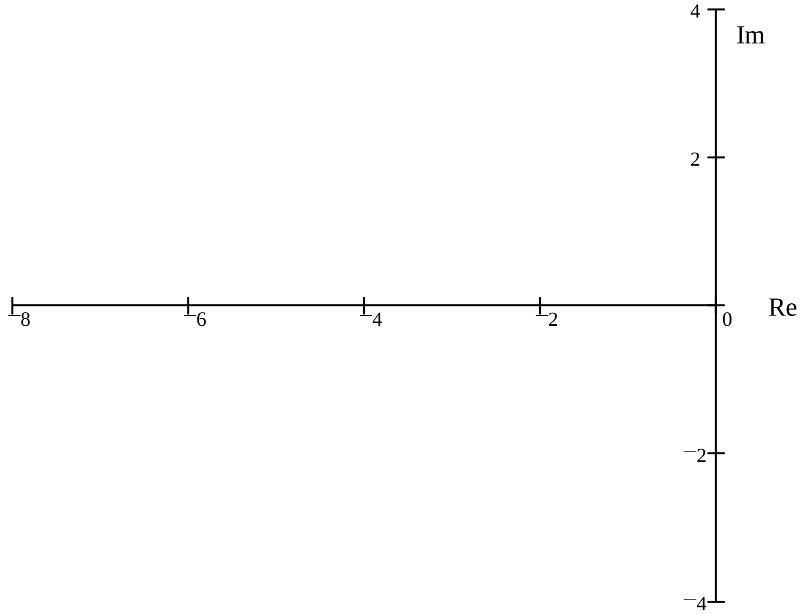
3. a) YES

   b) $k > 10$

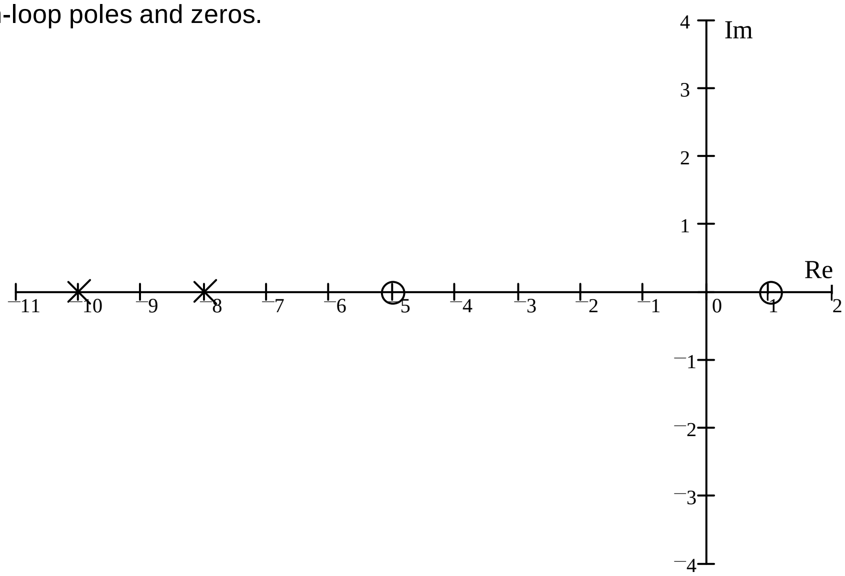
This part of the exam is Closed book, Closed notes except colored note sheets, Calculator OK.

1. (18 pts) Sketch the root-locus plots for the following open-loop transfer function and pole-zero plot.
   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) $\mathbf{G}(s) = \dfrac{(s+2)\cdot(s+3)}{s\cdot(s+1)\cdot(s+5)\cdot(s+7)}$

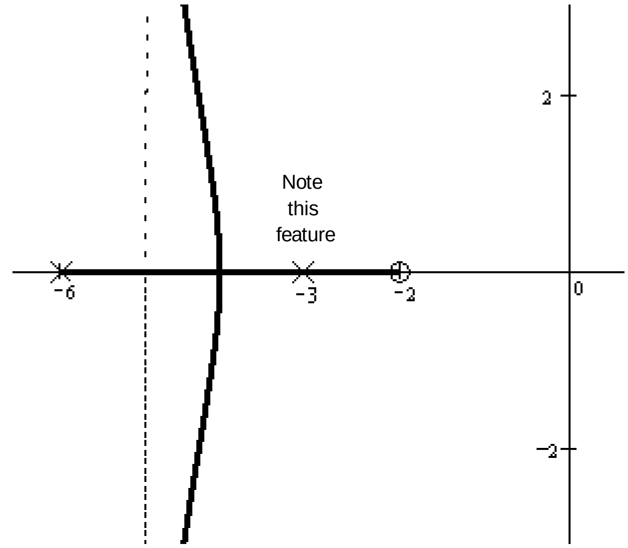


   b) Sketch the root-locus for the given open-loop poles and zeros.



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

2. (12 pts) a) $\mathbf{G}(s) =$?



b) Determine if the break-away point is at -4.5.
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 -4.5 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.

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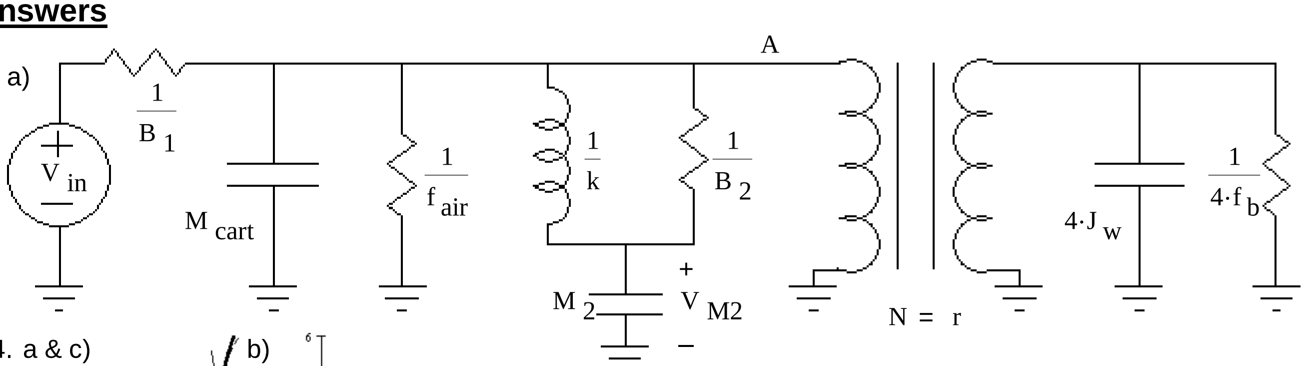
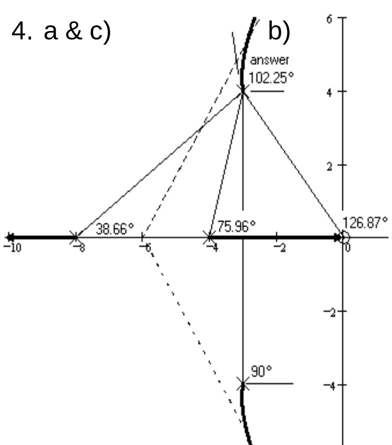
<u>Answers</u>

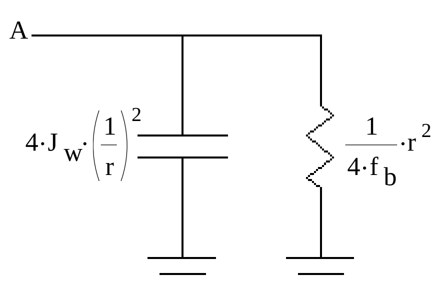
5. a)



4. a & c) b)

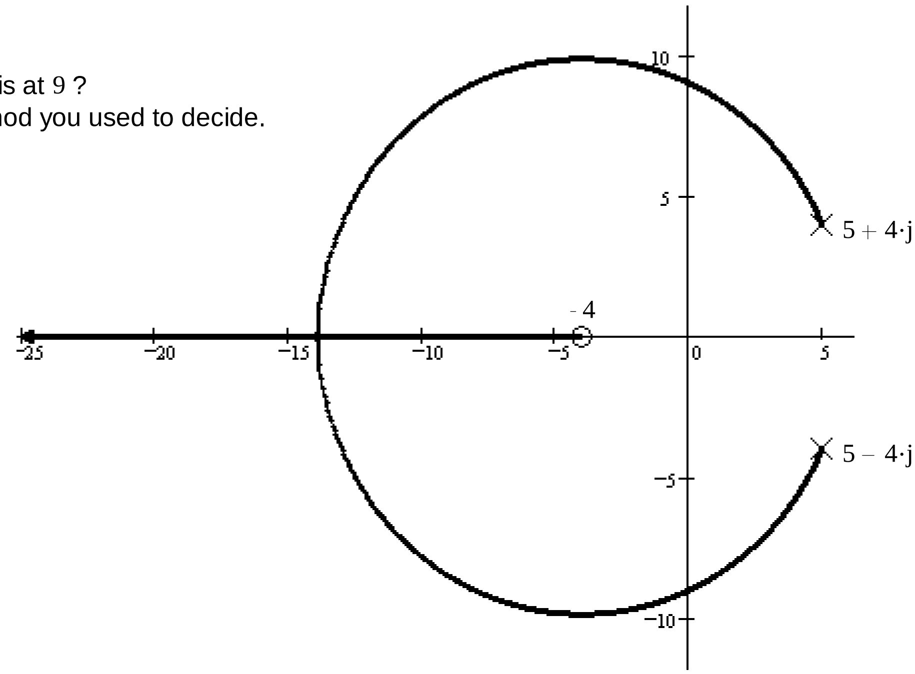


5. b)



3. (14 pts) A root locus is shown at right.

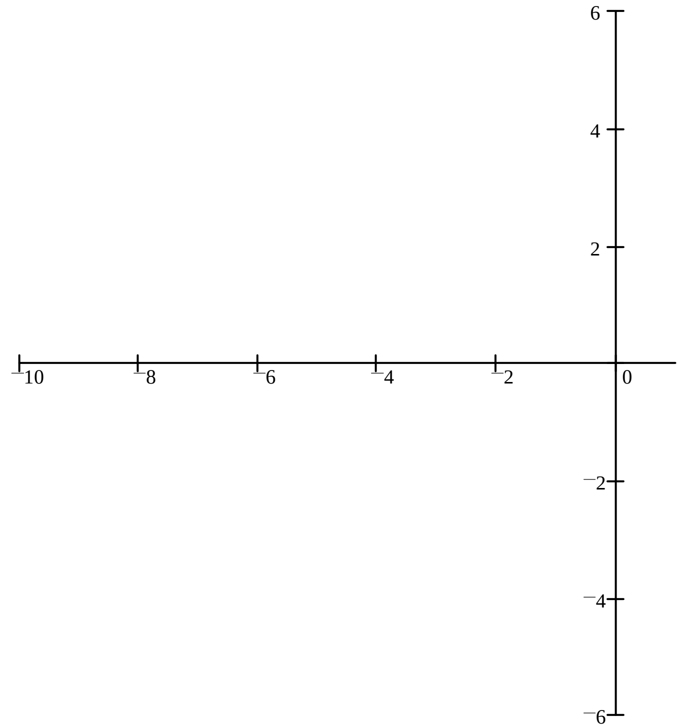
   a) Does the root locus cross the $j\omega$ axis at 9 ?
   Be sure to show the work and method you used to decide.



   b) Regardless of what you found in part a, continue to assume that the root-locus crosses the $j\omega$ axis at 9.
   Give the range of gain k for which the system is closed-loop stable.

4. (18 pts) a) Draw the pole(s) and zero(s) of the following open-loop transfer function on the axis.
DON'T draw the root locus lines just yet.

$$\mathbf{G}(s) = \frac{s}{\left(s^2 + 6 \cdot s + 25\right) \cdot (s+4) \cdot (s+8)}$$



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

c) Draw a root locus plot. Calculate the centroid and accurately draw the departure angle you found.

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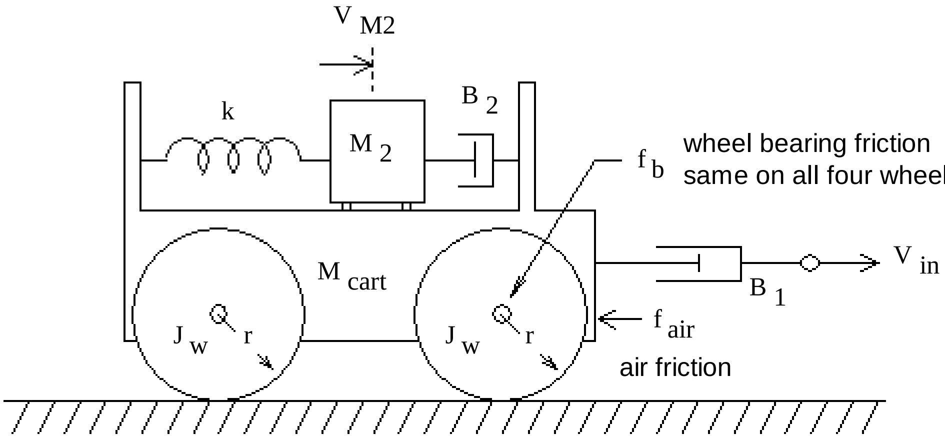
5. (19 pts) Find the equivalent electric circuit for the mechanical system shown. It is a cart with 4 wheels. Each wheel has has a moment of inertia, J_w, bearing friction, f_p, and radius, r. V_{in} is a velocity input.



a) Show the circuit with one or more transformers. Show the parts in terms of M's, k's, B's, etc., above. You may combine parts to simplify the drawing. Indicate the mass velocity, V_{M2}, 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.