ECE 3510 Exam 2 given: Spring 22 (Some of the space between problems has been removed.)

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

1. You want to build a device which will show a significant ringing effect at 50Hz. The ringing should last 5 seconds before its amplitude decays to 37% of the original value. The ringing should start when a power switch is closed. Where should the poles of this system be located. Be as specific as you can be.

2. 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 =

   b) Voltage =

   c) Ground =

   d) Resistor =

   e) Inductor =

   f) Capacitor =

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

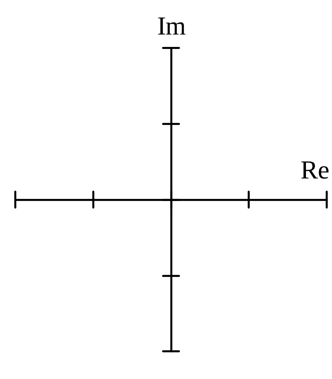
   h) Name two things represented by transformers. You may include items that rotate.

      1.

      2.

3. 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.

      1

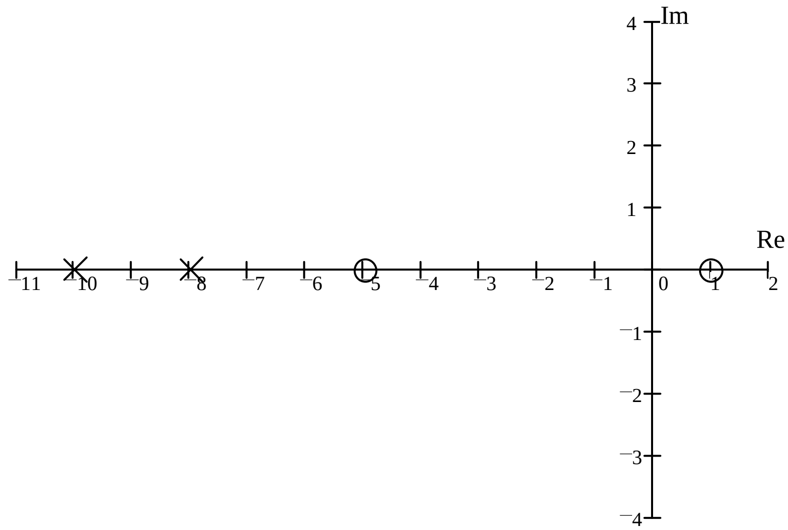
      2

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

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.

4. (13 pts)

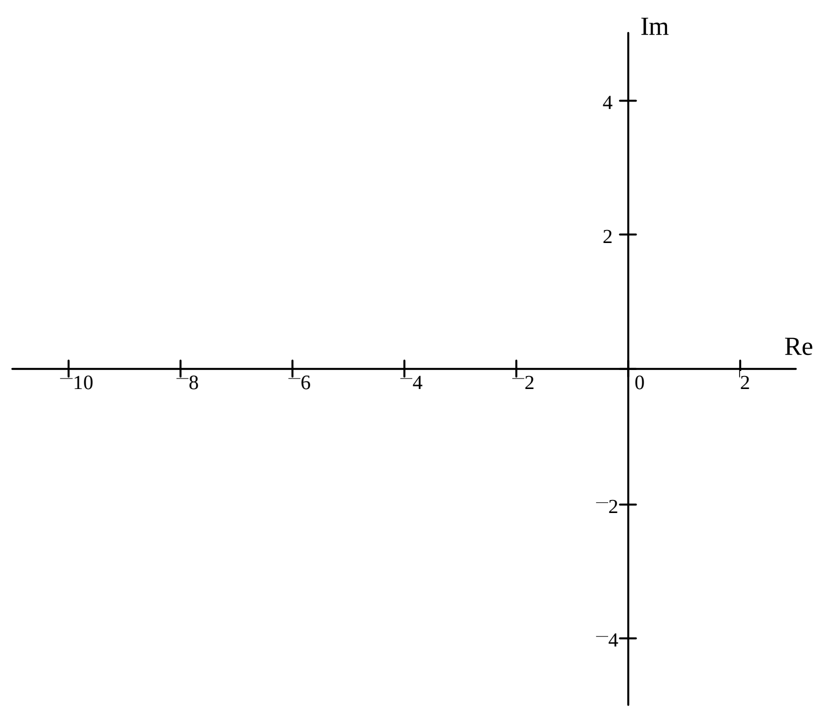
a) sketch



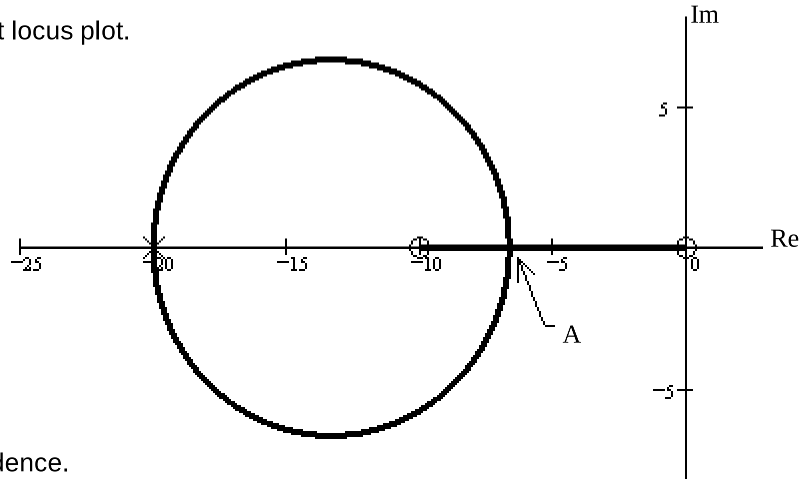
b) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$.

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

5. (11 pts) $G(s) = \dfrac{1}{\left(s^2 + 2\cdot s + 10\right)\cdot(s+4)\cdot(s+6)}$



1. (10 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.

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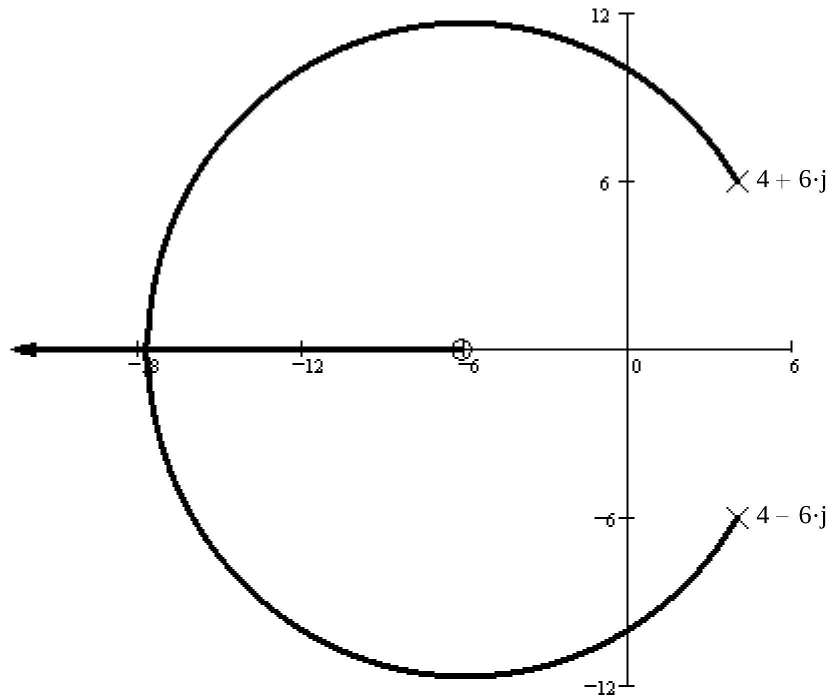
2. (14 pts) For the root locus is shown.

a) Does the root locus cross the $j\omega$ axis at 10? 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 10.
Give the range of gain k for which the system is closed-loop stable.

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

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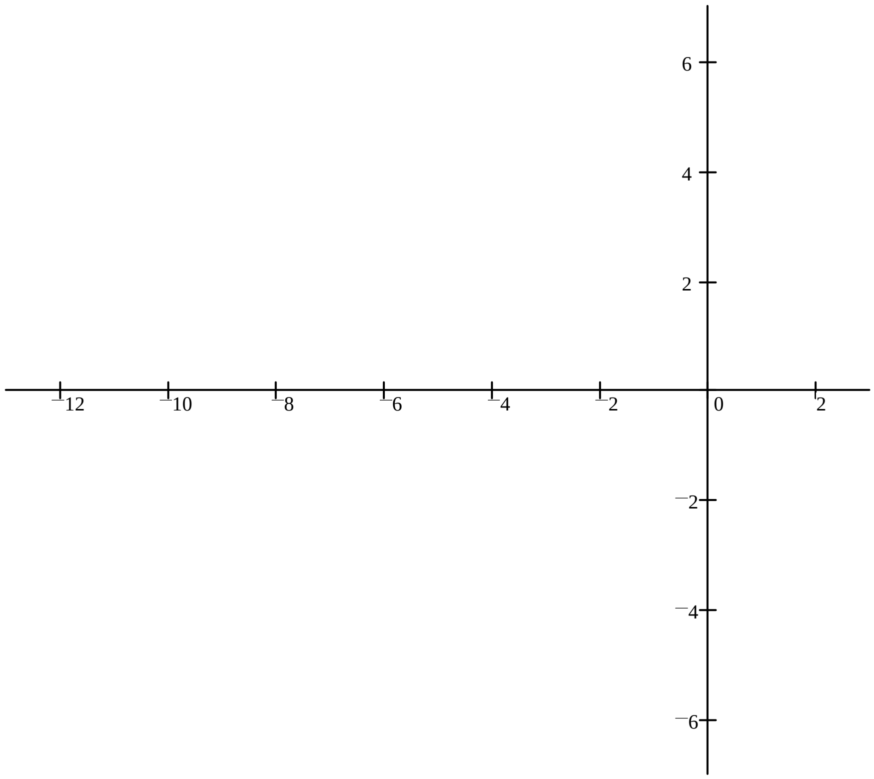
3. (14 pts) a) Sketch the root-locus for the open-loop transfer function below.

$$G(s) = \frac{(s+6)}{(s+1)^2 \cdot \left[(s+5)^2 + 3^2\right]}$$



b) Find the departure angle from the positive complex pole.

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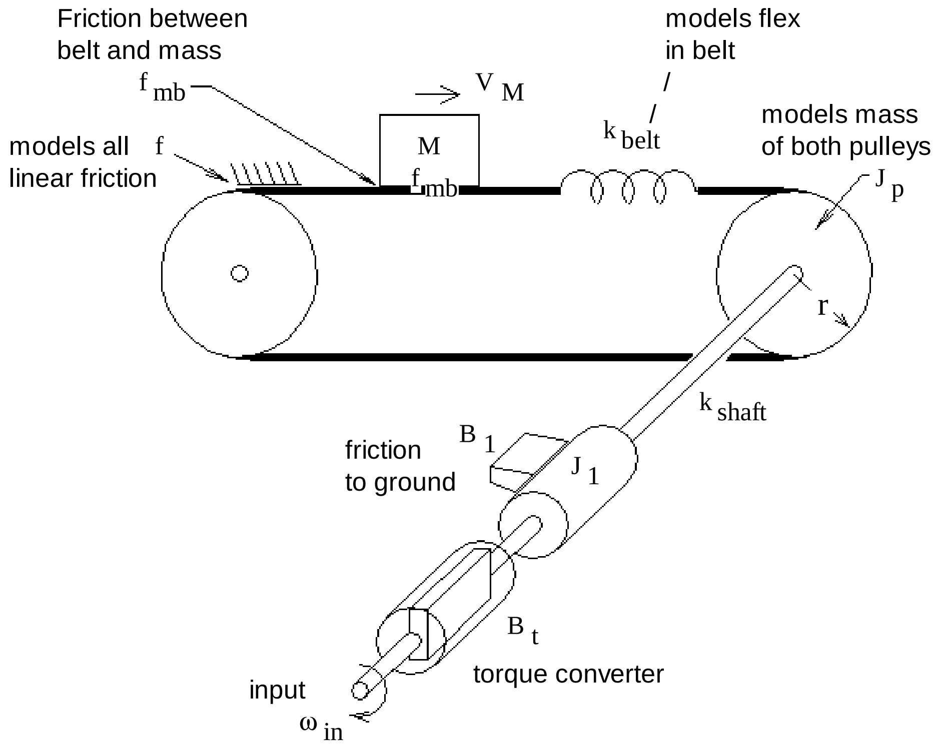
4. (22 pts) Find the equivalent electric circuit for the mechanical system shown. It is a conveyor belt with 2 pulleys. Both pulleys together have a moment of inertia, J_p and radius, r . ω_{in} is an angular velocity input.



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_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.

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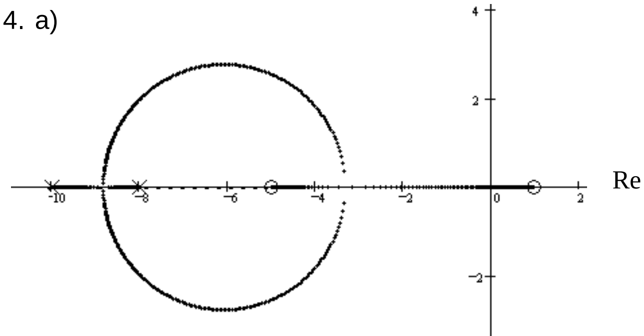
Total ___________ / 100

1. the poles should be at $-0.2 \pm 314j$.

3. a) Force b) Velocity c) Stationary reference of zero velocity d) Friction or damping e) Spring f) Mass
   g) Yes, one side is always hooked to ground
   h) Levers Wheels Belts Gears Electric motors 2 of these

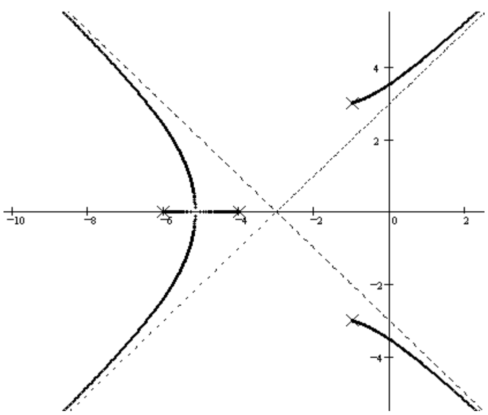
3. a) Stability b) in left-half plane c) fast smooth minimum error Often measured in steady state but also means minimum overshoot, etc.
   d) Any of these: Reject disturbances
   Insensitive to plant variations
   Tolerant of noise
   Or item left out of c) Like overshoot

4. a)

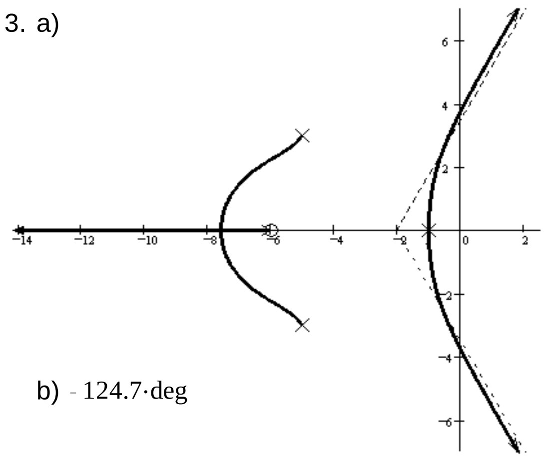


b) $k < 16$

5.

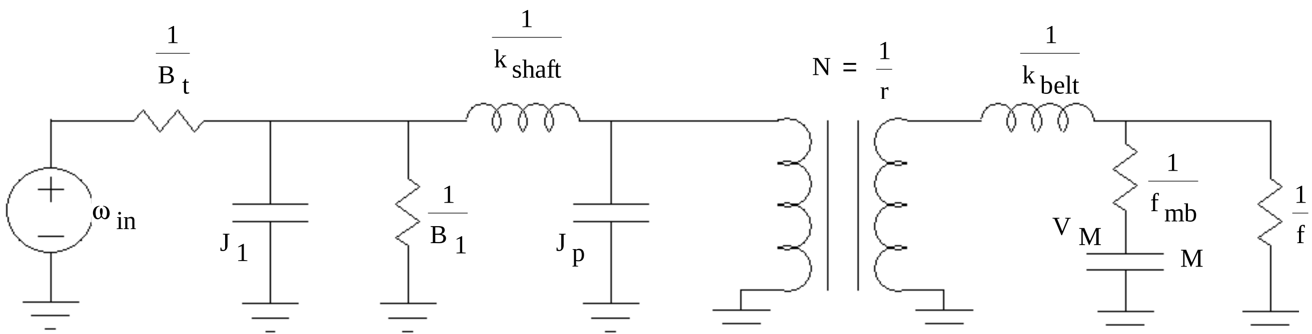


1. a) Break-in point b) NO c) (C
2. a) YES b) $k > 8$
3. a)



b) $-124.7 \cdot deg$

4. a)



b)