# ECE 3510 Exam 2 given: Spring 11

(The space between problems has been removed.)

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

1. (6 pts) You want to build a device which will show a significant ringing effect at 100Hz. The ringing should last between 10 and 20 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. (10pts) For the past couple of weeks we have been drawing root-locus plots. Be specific and clear in your answers below.

   a) Each locus (line) starts at:      b) The __________ is __________ at this point.

   c) Each locus (line) ends at:      d) The __________ is __________ at this point.

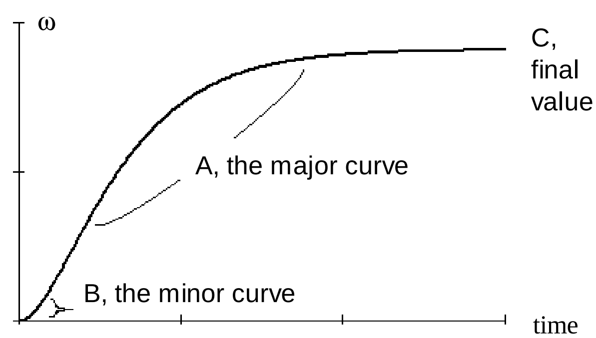
   e) how many locus lines are there?      f) What do the lines actually represent?

3. (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 major curve

   B, the minor curve

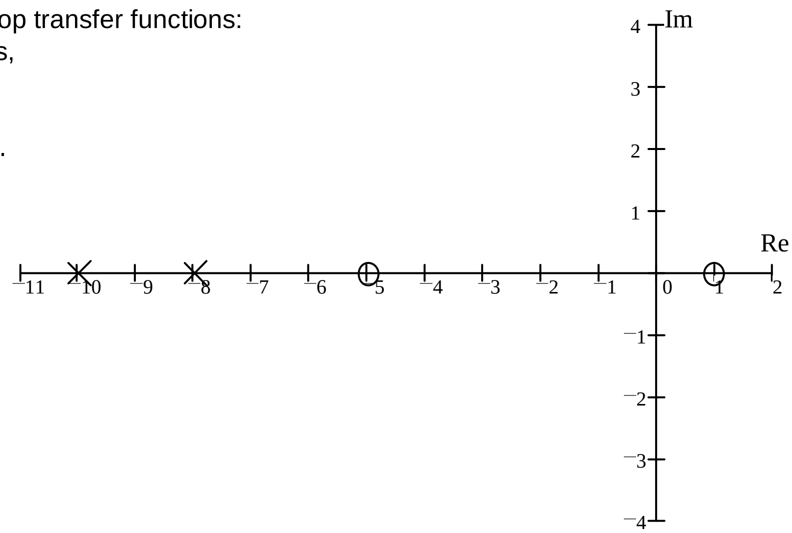
   C, final value



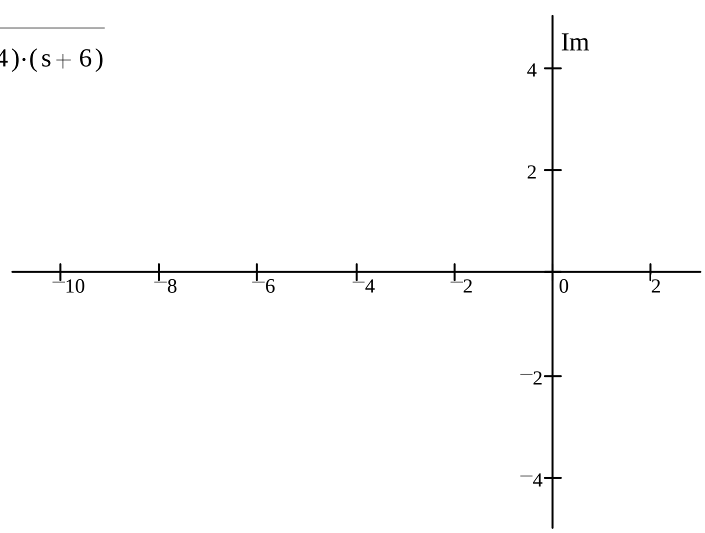

Sketch the root-locus plots for the following open-loop transfer functions:
Use only the rules you were told to memorize, that is, you may estimate details like breakaway points and departure angles from complex poles. Show your work where needed (like calculation of the centroid). Draw things like the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

4(11 pts) a) sketch

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




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



# Open-book part



1. (10 pts) The controller and plant transfer functions shown below are part of a standard unity feedback system.

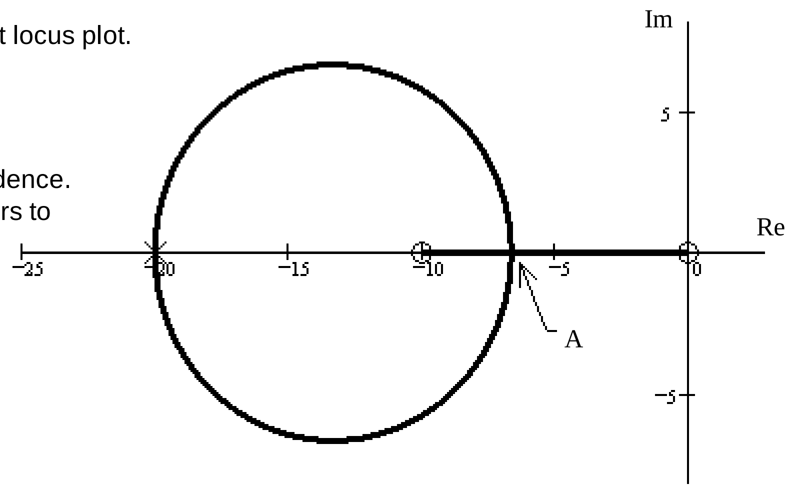
$$C(s) = \frac{1}{s+5} \qquad\qquad P(s) = \frac{2s+3}{s-3}$$

a) As is, without any extra gain in the loop, will the whole feedback system be BIBO stable?
You must justify your answer.

b) If you added gain factor to the controller, so that it is now: $C(s) = \frac{k}{s+5}$ Can you now change the stability of the system?
(That is, make stable if it was unstable, or unstable if it was stable.)
You must justify your answer and find the $k$ value to make the change, if possible.

2. (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 -5 is: Answer without making more calculations.

A) LESS than the gain required to place the closed loop poles at point "A".

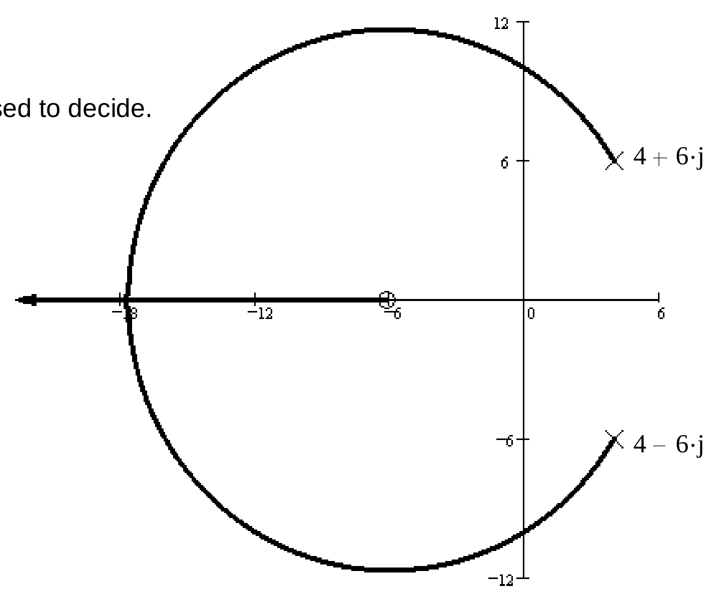
B) THE SAME as the gain required to place the closed loop poles at point "A".

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.

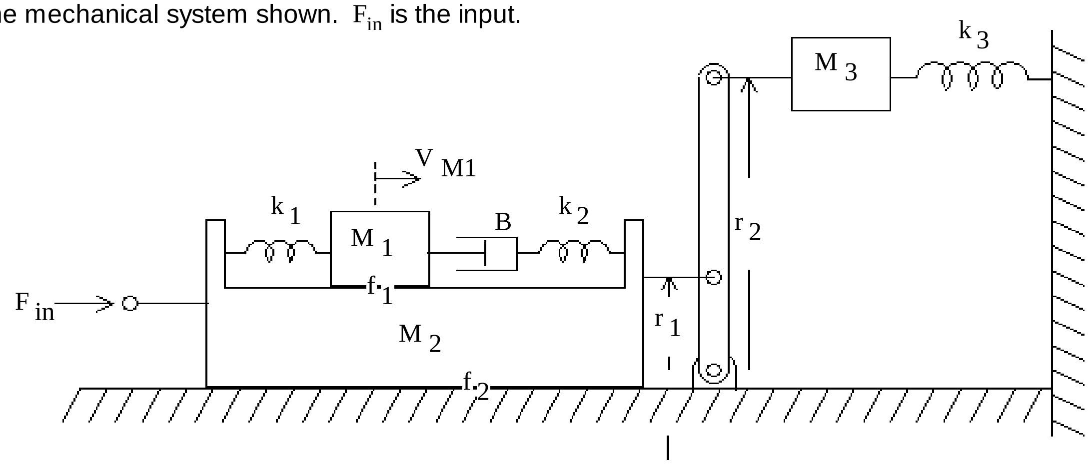
3. (14 pts) A root locus is shown at right.

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.

4. (21 pts) Find the equivalent electric circuit for the mechanical system shown. $F_{in}$ is the input.




line "A"

a) Show the circuit with a transformer. Show the parts in terms of M's, k's, B's, etc., above. Indicate $V_{M1}$ on your drawing.

b) Show the circuit to the right of line "A" without a transformer, just like you did in the homework. Show the parts in terms of M's, k's, B's, etc., above.

**<u>Answers</u>** 1. the poles should be between -0.1 and -0.05 at $\pm$ 628j.

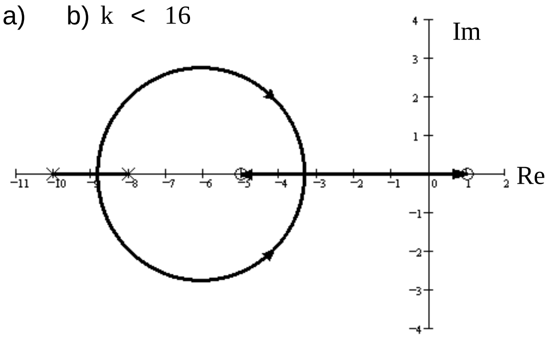
2. a) An open-loop pole b) gain zero c) An open-loop zero or at infinity d) gain infinite

e) The number of closed-loop poles, one per pole. f) The positions of the closed-loop poles

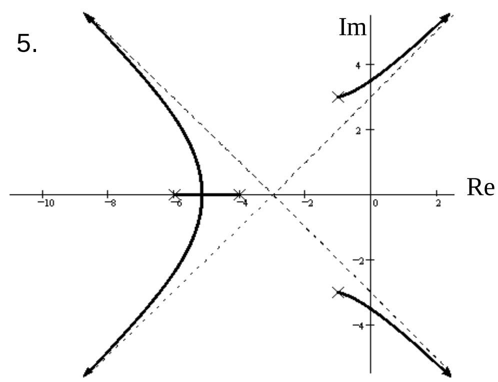
3. A, $J_m$ , The motor's moment of inertia B, $L_a$ , The armature inductance

The mechanical inertia C, $K_V$, The motor's generation constant

4. a) b) $k < 16$




5.



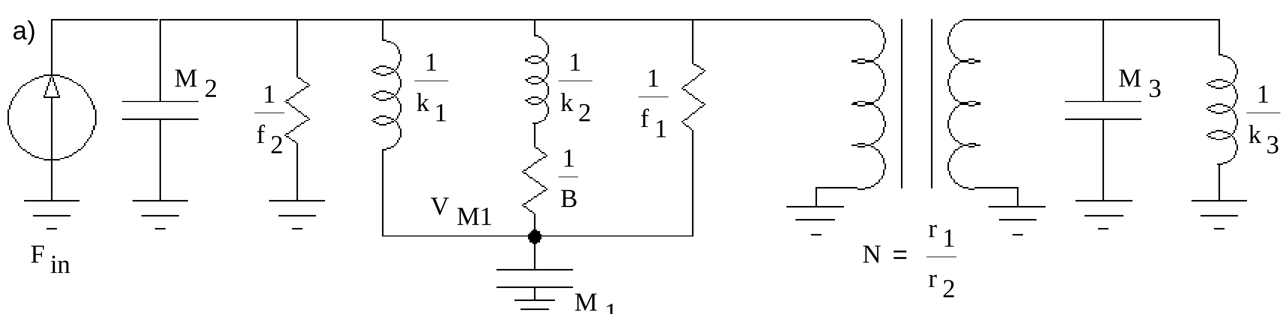

## Open-book part

1. a) NO b) Becomes stable for $k > 5$

2. a) Break-in point b) NO c) C

3. a) YES b) $k > 8$

4. a)




4. b)