ECE 3510 Exam 2 given: Spring 08

(The space between problems has been removed.)

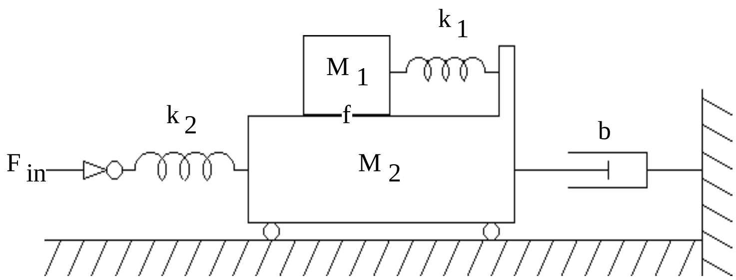
1. (6 pts) List Three advantages of state space over classical frequency-domain techniques.

2. (4 pts) The output of a system is given by:

$$Y(s) = \frac{b_2 \cdot s^2 + b_1 \cdot s + b_0}{s^2 + a_1 \cdot s + a_0} \cdot X(s) \quad + \quad \frac{s \cdot y(0) + \dot{y}(0) + a_1 \cdot y(0) - b_2 \cdot s \cdot x(0) - b_2 \cdot s \cdot \dot{x}(0) - b_1 \cdot s \cdot x(0)}{s^2 + a_1 \cdot s + a_0}$$

List the variables that which together fully describe the *state* of the system at time $t = 0$ (the initial state).

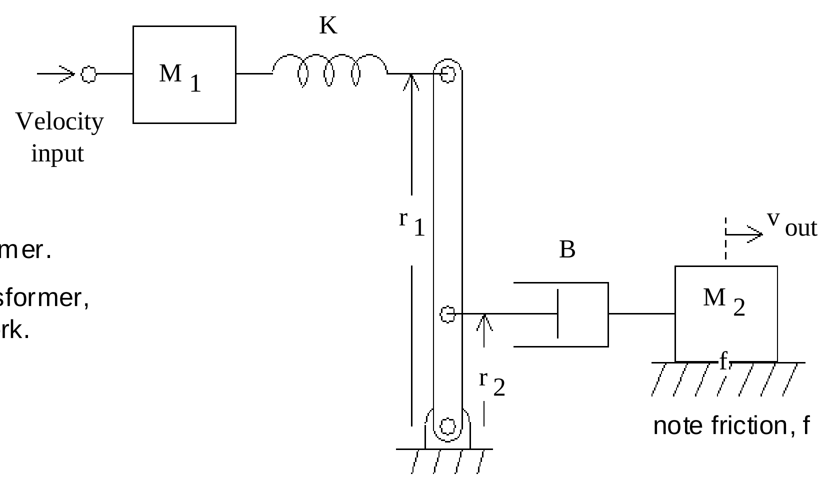
3. (13 pts) Find the equivalent electric circuit for the mechanical system shown. F_{in} is an input force.



4. (17 pts) Find the equivalent electric circuit for the mechanical system shown.

   a) Show the circuit with a transformer.

   b) Show the circuit without a transformer, just like you did in the homework.



5. (12 pts) The transfer functions of C(s) and P(s) (Controller and Plant) are given below. In each case determine if the DC steady-state tracking error will go to zero and whether DC disturbances will be completely rejected. You may assume closed-loop stability. Give reasons for your answers.

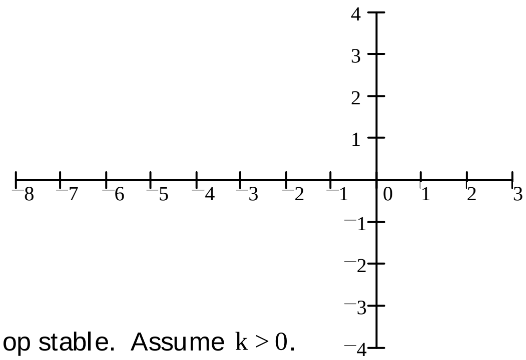
			<u>0 steady-state err.?</u>	<u>Reject disturbance?</u>
a)	$C(s) = \frac{s+2}{s^3 + 8 \cdot s^2 + 20 \cdot s}$	$P(s) = \frac{s+4}{s+6}$	yes no	yes no
		Why?		
b)	$C(s) = \frac{s+4}{s^2 + 4 \cdot s + 3}$	$P(s) = \frac{s+2}{s^2 + 3 \cdot s}$	yes no	yes no
		Why?		
c)	$C(s) = \frac{s+2}{s \cdot (s+3) \cdot (s+5)}$	$P(s) = \frac{s}{s+3}$	yes no	yes no
		Why?		
d)	$C(s) = \frac{s+2}{(s+3) \cdot (s+5)}$	$P(s) = \frac{1}{s+3}$	yes no	yes no
		Why?		

6. (12 pts) Characteristic equation of a feedback system is shown below.
   Use the Routh-Hurwitz method to determine the value range of k that will produce a stable system.

$$0 = 9 \cdot s^3 + 6 \cdot s^2 + 10 \cdot s + k \cdot s + 4 + k$$

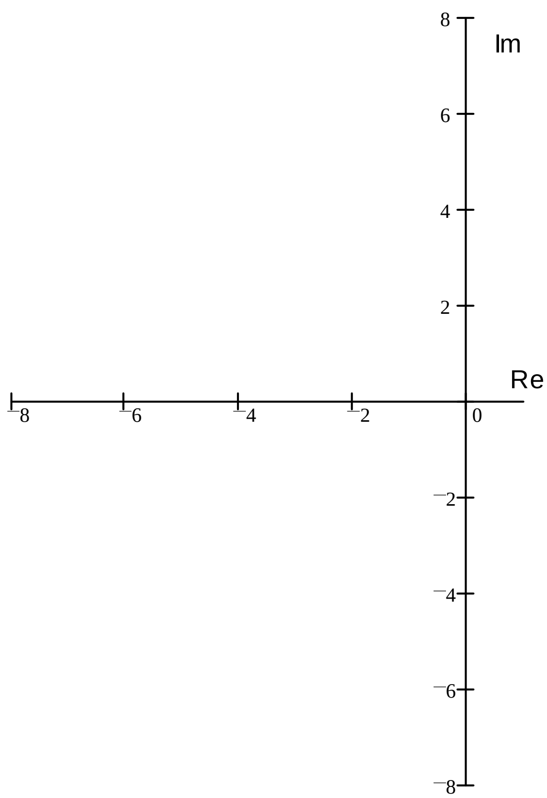
7 - 9 Sketch the root-locus plots for the following open-loop transfer functions:
Use only the main rules, that is, the first page of my root locus notes. You may estimate details like breakaway points and departure angles from complex poles. Show your work where needed (like calculation of the centroid).

7. (12 pts) a) $G(s) = \dfrac{(s-1)\cdot(s+4)}{(s+2)^2\cdot(s+5)}$



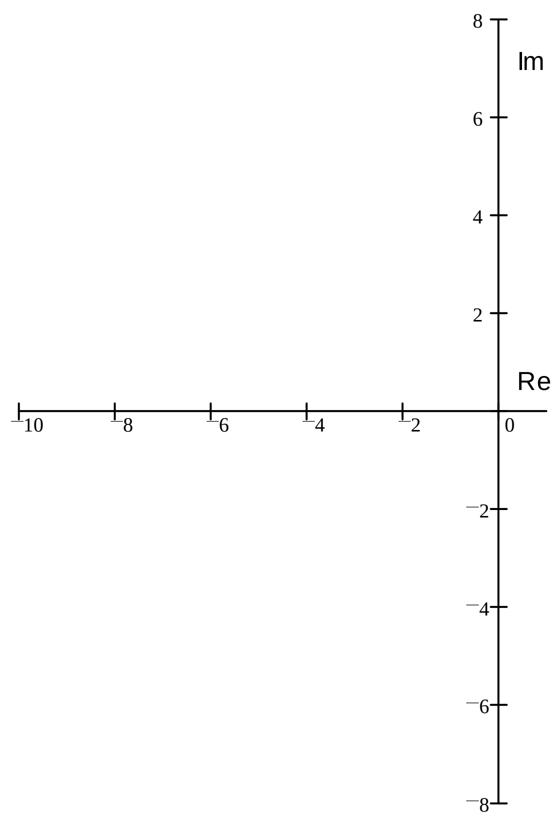
   b) Find the range of gain (k) for which the system is closed-loop stable. Assume $k > 0$.

8. (11 pts) $G(s) = \dfrac{1}{\left(s^2 + 6\cdot s + 25\right)\cdot(s+6)\cdot(s+8)}$



9. (13 pts)

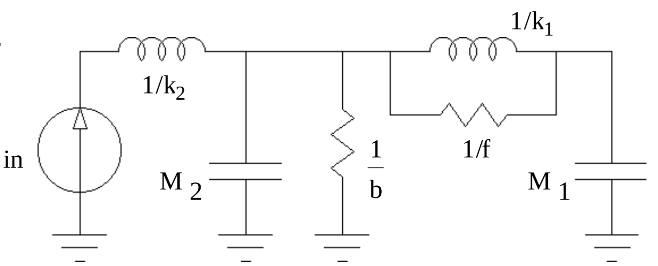
$$G(s) = \frac{(s+5)}{\left[(s+2)^2 + 4^2\right]\cdot\left[(s+5)^2 + 3^2\right]}$$



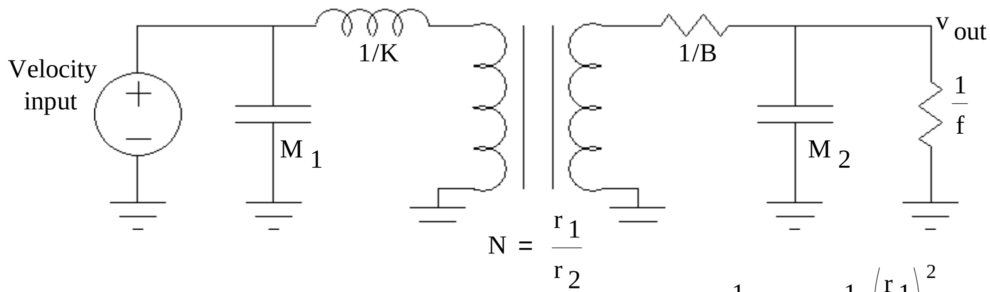
1. Multiple input / multiple output systems
   Can model nonlinear systems
   Can model time varying systems
   Can be used to design optimal control systems
   Can determine controllability and observability

2. $y(0)$, $\dot{y}(0) = \frac{d}{dt}y(0)$, $x(0)$, $\dot{x}(0) = \frac{d}{dt}x(0)$

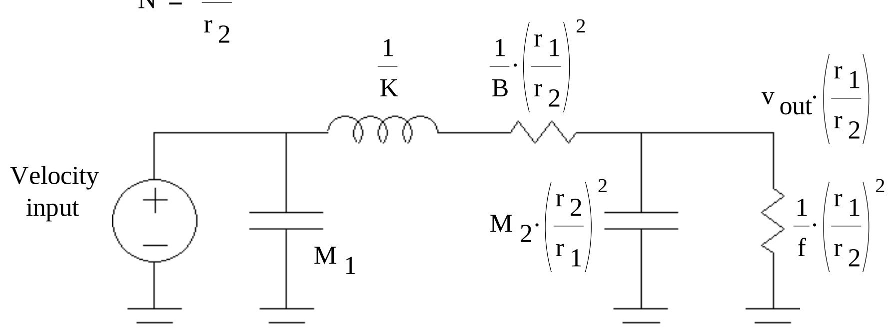
3.



4. a)



b)



5. a) YES $C(s)$ has pole at zero   YES $C(s)$ has pole at zero
   b) YES $P(s)$ has pole at zero   NO $C(s)$ has no pole at zero
   c) NO $P(s)$ has zero at zero   YES $P(s)$ has zero at zero
   d) NO No poles at zero   NO No poles at zero

6.

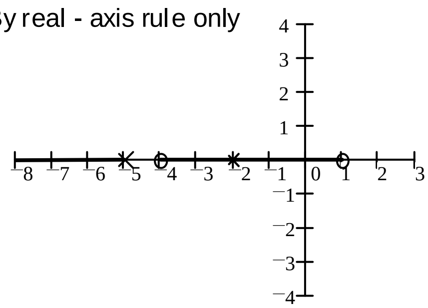
s^3	9	$(10+k)$	0
s^2	6	$(4+k)$	
s^1	$\frac{6\cdot(10+k)-9\cdot(4+k)}{6}$	$\frac{6\cdot0-9\cdot0}{6}=0$	0
s^0	$(4+k)$		

$\frac{6\cdot(10+k)-9\cdot(4+k)}{6} = \frac{24-3\cdot k}{6}$ $k < 8$

$k > -4$

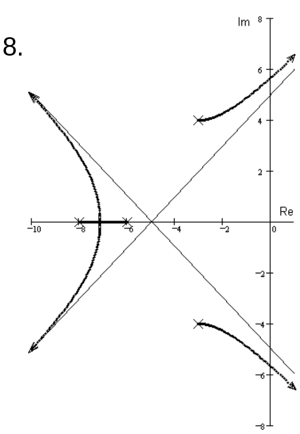
Ans: $-4 < k < 8$

7. By real - axis rule only



b) $k < 5$

8.



9.