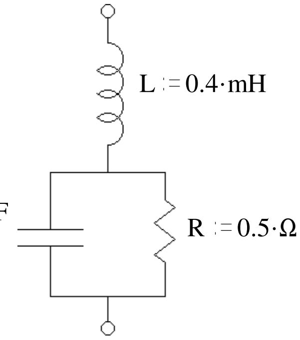
ECE 3510 Exam 2 given: Spring 06

(The space between problems has been removed.)

1. (13 pts) Find $\mathbf{Zeq}(j\omega)$ Reduce your answer to a simple complex number.



$$\omega := 2000\cdot\frac{rad}{sec}$$

$$\mathbf{Z}_{\mathbf{eq}}(j\omega) = ?$$

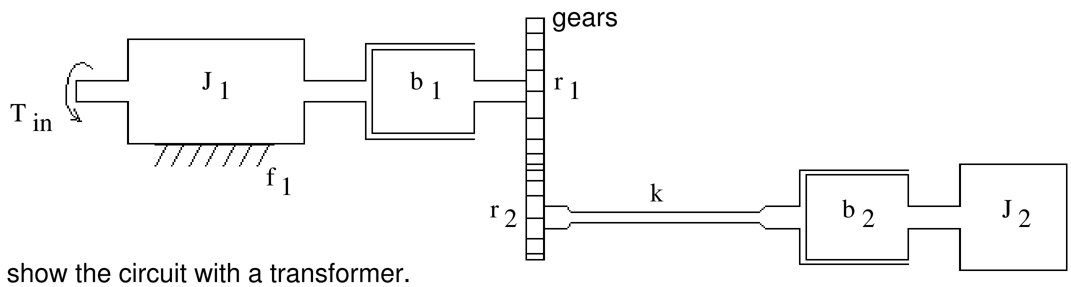
2. (12 pts) Find the steady-state (sinusoidal) magnitude and phase of the following transfer function.

$|H(j\cdot\omega)| = ?$ $\qquad \underline{/\,H(j\omega)} = ?$ $\qquad$ The phase angle may be reported as $\tan^{-1}\left(\frac{b}{a}\right)$

$$\omega := 10\cdot\frac{rad}{sec} \qquad H(s) = \frac{\frac{40}{sec}\cdot s - \frac{300}{sec^2}}{s^2 + \frac{90}{sec^2}}$$

3. (6 pts) Express the following signal in the time domain, as a sum of cosine and sine with no phase angles: $\quad Y(s) = 3 + 0.5\cdot j \qquad \omega := 10\cdot\frac{rad}{sec}$

4. (13 pts) Find the equivalent electric circuit for the mechanical system shown. T_{in} is the input.



a) show the circuit with a transformer.

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

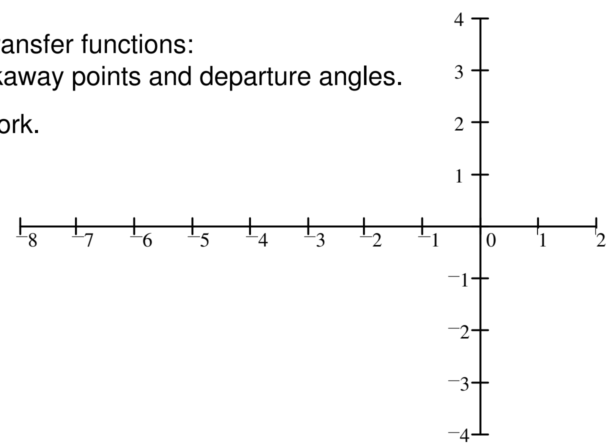
5. (6 pts) The transfer functions of C(s) and P(s) are given below. In each case determine if the steady-state tracking error will go to zero and whether disturbances will be completely rejected. You may assume closed-loop stability. Give reasons for your answers.

			0 steady-state err.?	Reject disturbance?
a)	$C(s) = \frac{s+1}{s^3 + 7\cdot s^2 + 12\cdot s}$	$P(s) = \frac{s+1}{s+3}$	yes no	yes no
		Why?	______________________	______________________
b)	$C(s) = \frac{s+4}{s^2 + 3\cdot s + 2}$	$P(s) = \frac{s+1}{s^2 + 3\cdot s}$	yes no	yes no
		Why?	______________________	______________________

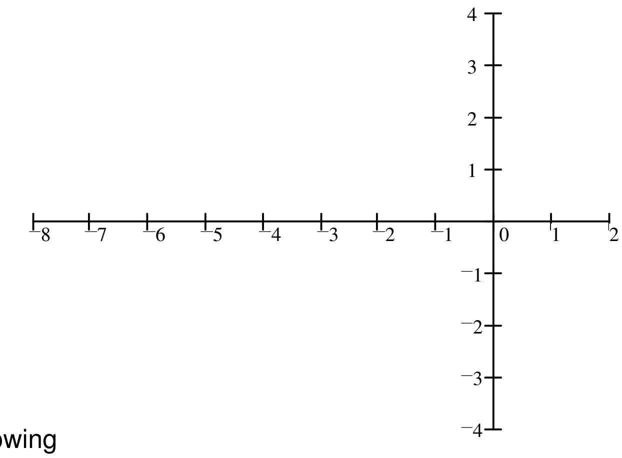
6. (12 pts) Sketch the root-locus plots for the following open-loop transfer functions:
Use only the main rules, that is, don't sweat the details like breakaway points and departure angles.

If you calculate anything (like a centroid) be sure to show your work.

a) $G(s) = \frac{(s-1)\cdot(s+3)}{(s+1)^2\cdot(s+5)}$



b) $G(s) = \dfrac{1}{s \cdot (s+2) \cdot (s+4)}$

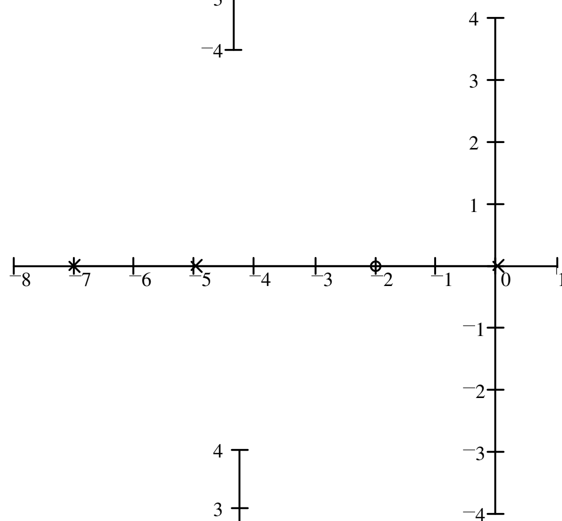


7. (20 pts) Sketch the root-locus plots for the following open-loop transfer functions:

   Use only the main rules, that is, don't sweat the details like breakaway points and departure angles.

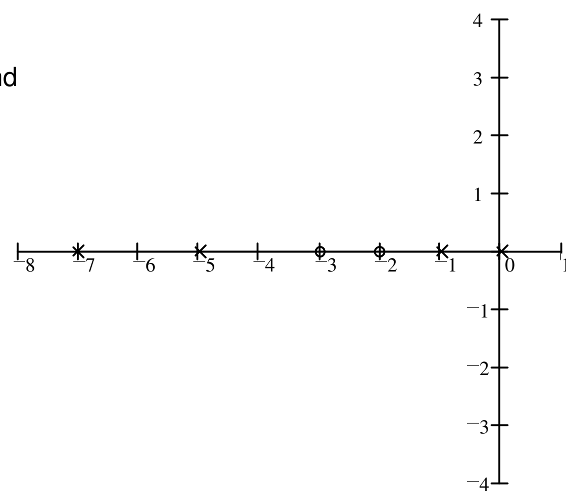
   If you calculate anything (like a centroid) be sure to show your work.

   a) $G(s) = \dfrac{s+2}{s \cdot (s+5) \cdot (s+7)}$



   b) A compensator is added with a pole at -1 and a zero at -3, how does this change the root locus? (draw again)

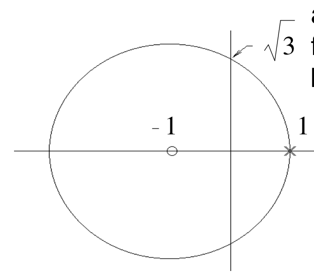
   $G(s) = \dfrac{(s+2) \cdot (s+3)}{s \cdot (s+1) \cdot (s+5) \cdot (s+7)}$



   c) Can the system response be faster with the compensator? yes no

   Why or why not?

8. (18 pts) A root - locus is sketched at right. The open - loop transfer function has one zero at $s = -1$ and two poles at $s = 1$.



assumption for parts b & c

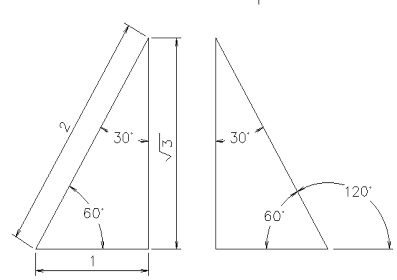
   $G(s) = \dfrac{s+1}{(s-1)^2}$

   a) Find the "break-away" point on the real axis.

   b) Assume that the root-locus crosses the $j\omega$ axis at $\sqrt{3}$ Determine if this is true. Show your work.

   c) Regardless of what you found in part b, continue to assume that the root-locus crosses the $j\omega$ axis at $\sqrt{3}$

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



Some angle relations you may find useful

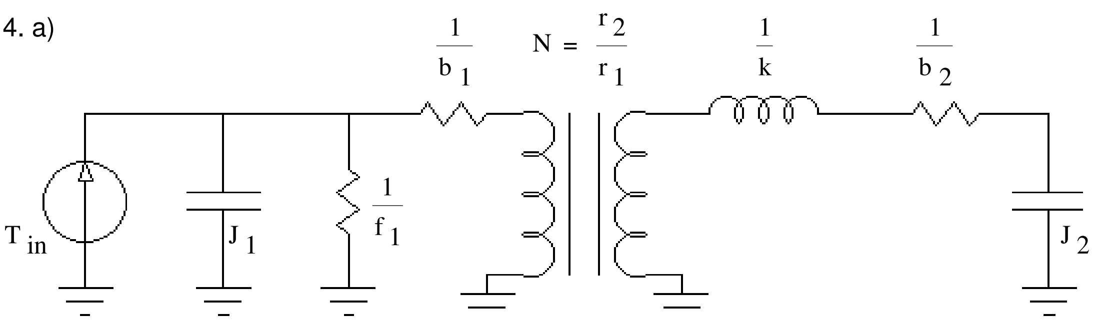
<u>**Answers**</u>

1. $0.25 + 0.55 \cdot j \quad \Omega$

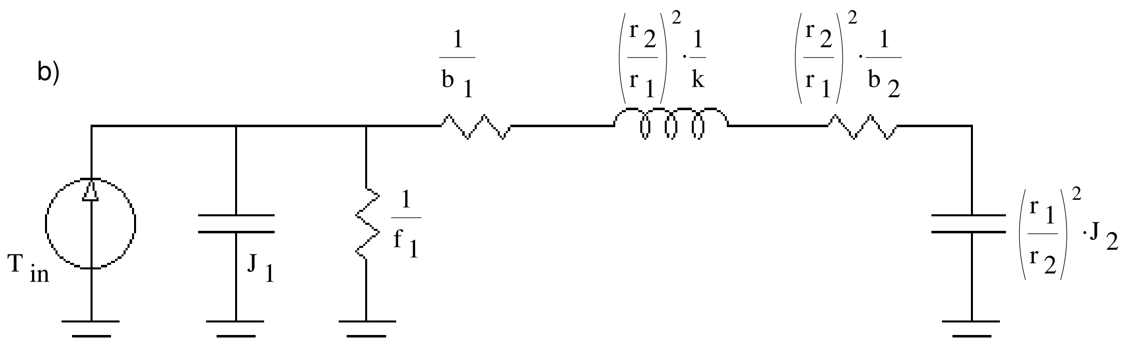
2. $|H(j \cdot \omega)| = 50 \qquad \underline{/\,H(j\omega)} = \tan^{-1}\left(-\frac{4}{3}\right)$

3. $3 \cdot \cos\left(10 \cdot \frac{\text{rad}}{\text{sec}} \cdot t\right) - 0.5 \cdot \sin\left(10 \cdot \frac{\text{rad}}{\text{sec}} \cdot t\right)$

4. a)



b)



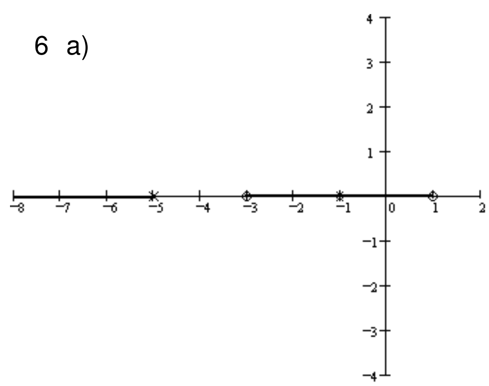
5. a) Yes, $C(s)$ has pole at zero

Yes, $C(s)$ has pole at zero

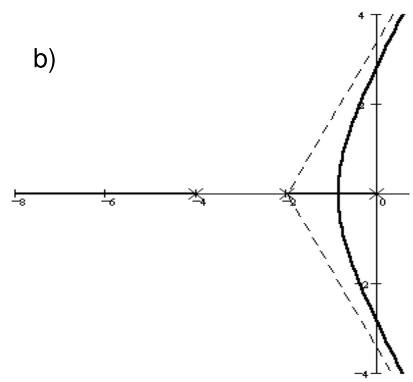
b) Yes $P(s)$ has pole at zero

No, $C(s)$ has no pole at zero

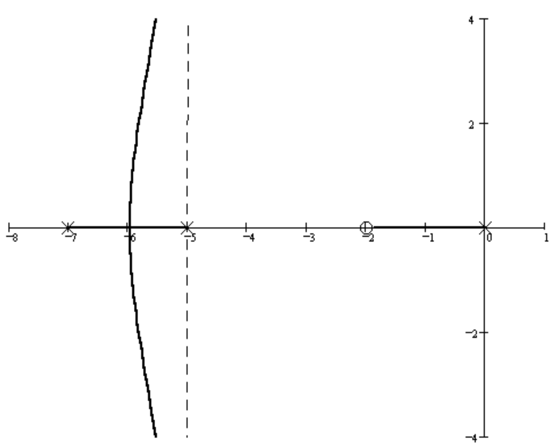
6 a)



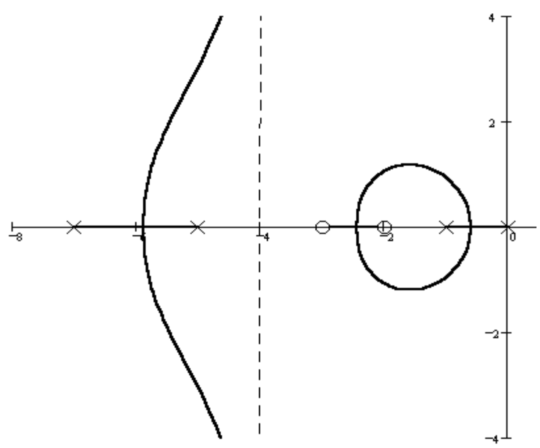
b)



7. a)



b)



8. a) -3 b) Yes c) $k > 2$

c) Yes You can move the pole nearest the jω axis farther from the jω axis.