ECE 461/661 - Test #3: Name _____

November 21, 2018

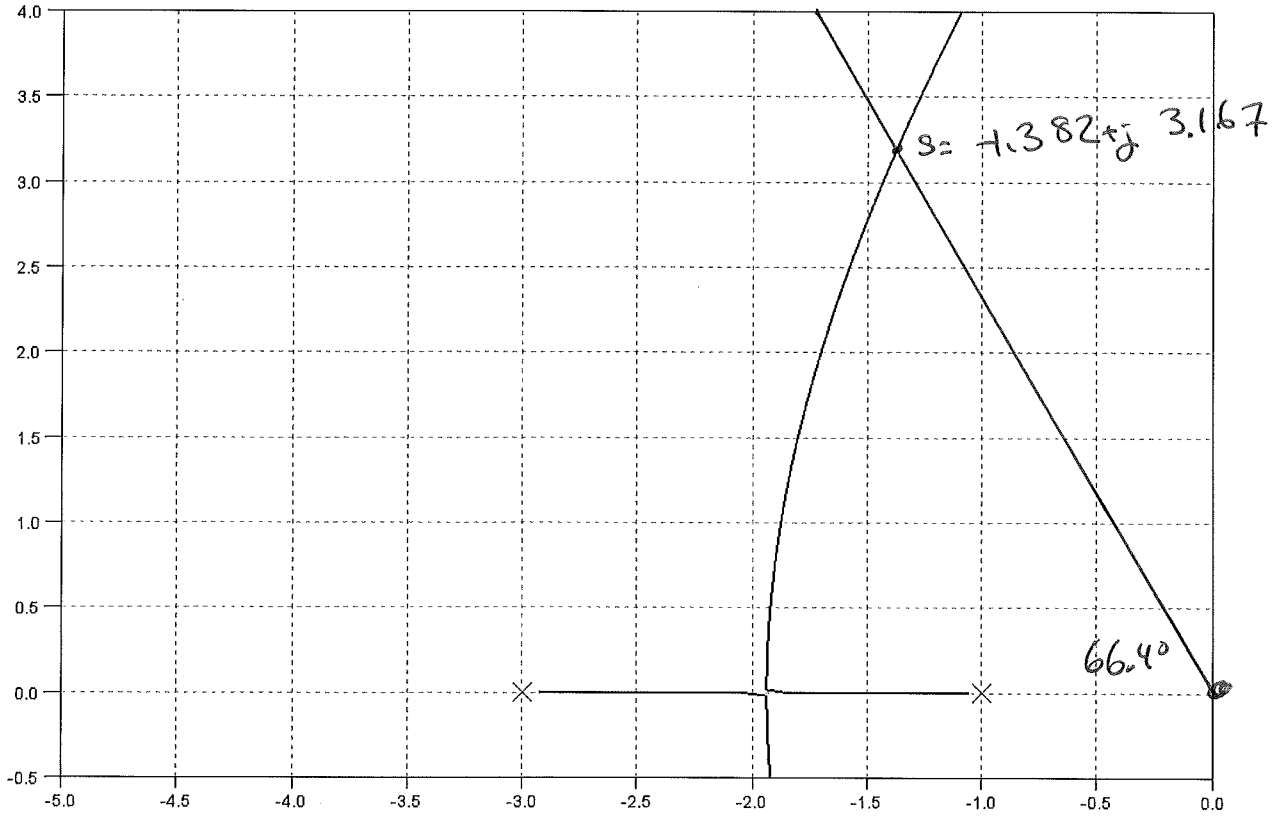
1) The root locus for

$$G(s) = \left(\frac{100}{(s+1)(s+3)(s+10)}\right)$$

is shown below. Determine the gain, k, which results in a damping ratio of 0.4. For the value of k, determine the following:

k for a damping ratio of 0.4	1.041
For this value of k, what will be the closed-loop system's...	
Dominant Pole(s)	$-1.382 \pm j\,3.167$
Closed-Loop DC gain	.776
2% Settling Time	$\frac{4}{1.382} = 2.984$ sec

$K_p = 3.471$

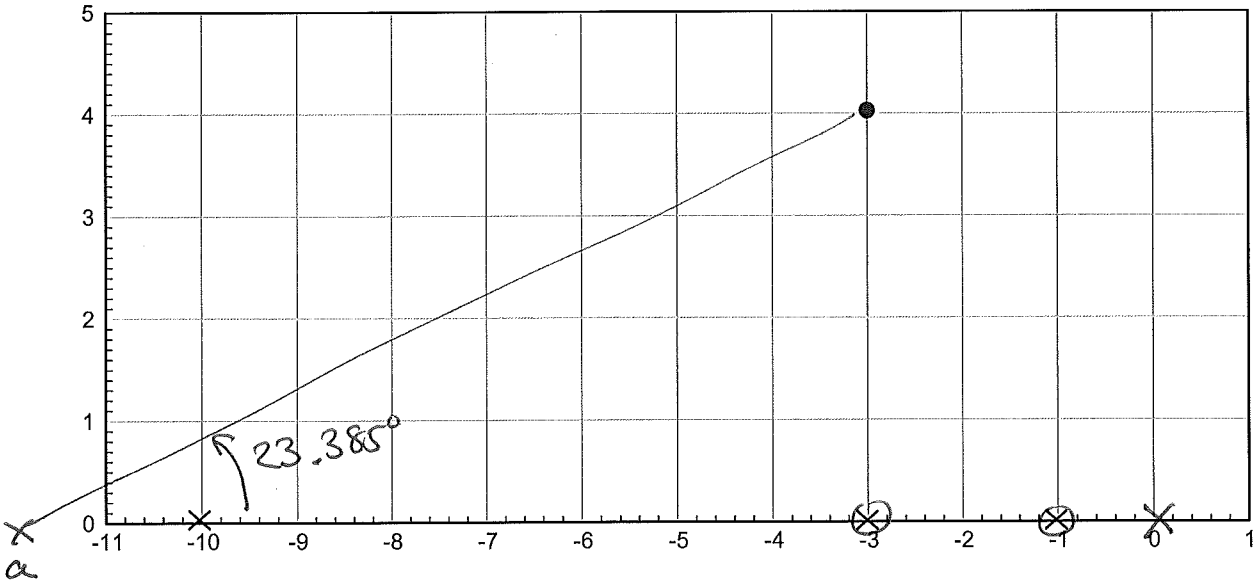


2) Assume the transfer function for a system is:

$$G(s) = \left(\frac{100}{(s+1)(s+3)(s+10)}\right)$$

Design a **continuous-time** compensator,K(s), so that the closed-loop system has

- No error for a step input, and
- Closed-loop dominant poles at **s = -3 + j4**



$$K(s) = \frac{(s+1)(s+3)}{s(s+a)}$$

$$\left.\frac{100}{s(s+10)}\right|_{s=-3+j4} = \angle -156.6°$$

↑ off by 23.385°

$$a = \frac{4}{\tan(23.385°)} + 3 = 12.25$$

$$GK = \left.\frac{100}{s(s+10)(s+12.25)}\right|_{s=-3+j4} = .246\angle 180°$$

$$K = \frac{1}{.246} = 4.063$$

$$K(s) = 4.063\,\frac{(s+1)(s+3)}{s(s+12.25)}$$

3) Assume the transfer function for a system is:

$$G(s) = \left(\frac{100}{(s+1)(s+3)(s+10)}\right)$$

Design a **discrete-time** compensator,K(z), so that the closed-loop system has

- No error for a step input, and
- Closed-loop dominant poles at **s = -3 + j4**
- A sampling rate of 100ms (T = 0.1)

Closed-Loop Dominant Poles in in the z-plane	K(z)
$.682 + j.288$	$3.574 \dfrac{(z-.9048)(z-.741)}{(z-1)(z-.023)}$

$$\frac{100}{(s+1)(s+3)(s+10)}\Big|_s \cdot e^{-sT/2} \cdot K(z) = 1\angle 180^\circ$$

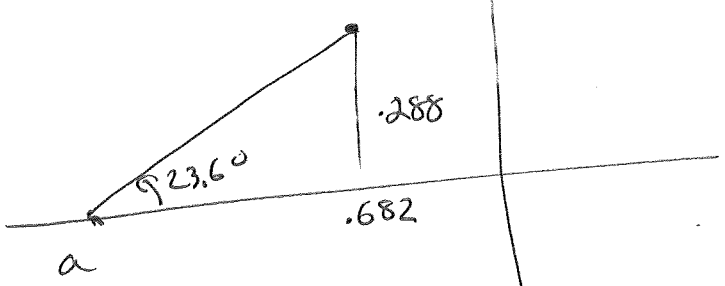
$$K(z) = \frac{(z-.9048)(z-.741)}{(z-1)}$$

$$\frac{100}{(s+1)(s+3)(s+10)} \cdot e^{-sT/2} \cdot \frac{(z-.9048)(z-.741)}{(z-1)}\Big|_{s=-3+j4}$$

$$(.693\angle 123^\circ)(1.162\angle -11.4^\circ)(.25\angle 91^\circ) -$$

$$= .201\angle -156^\circ$$

Lo by 23.6°



$$a = -\frac{.288}{\tan(23.6^\circ)} + .682 = .023$$

$$K(z) = \frac{(z-.9048)(z-.741)}{(z-1)(z-.023)}$$

$G \cdot K \cdot D = .280\angle 180^\circ$ $\quad K = 1/.280$

4a) Determine G(z): a discrete-time transfer function with approximately the same step response as G(s). Assume a sampling rate of 100ms (T = 0.1)

$$G(s) = \left(\frac{100}{(s+1)(s+3)(s+10)}\right)$$

DC gain = 3.333

$$\left.\frac{.0520}{(z-.9048)(z-.7408)(z-.3679)}\right|_{z=1} = 3.333$$

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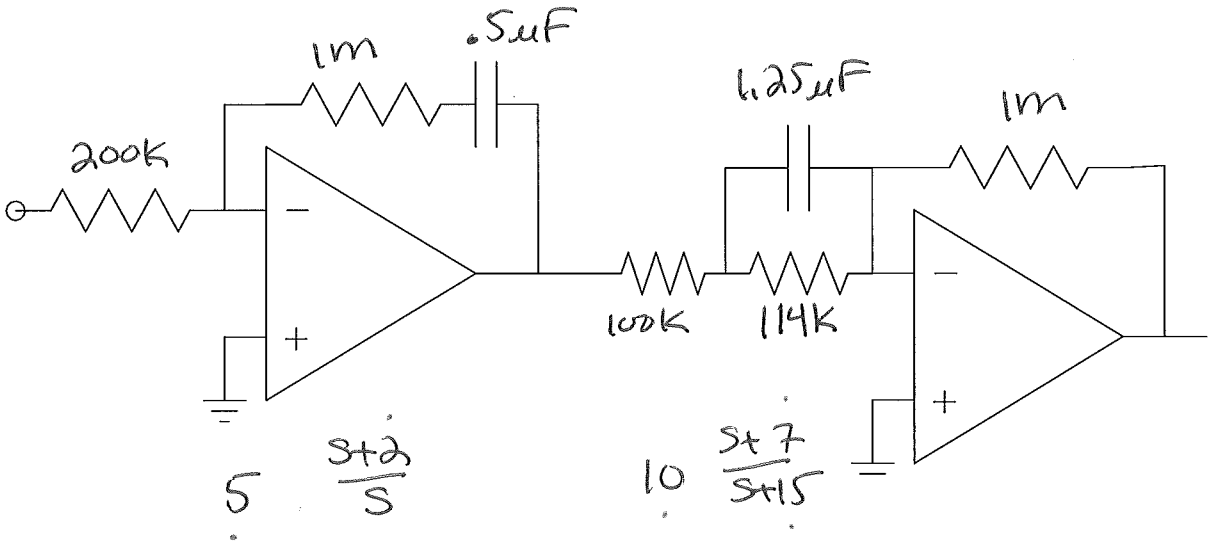
4b) Design a circuit to implement K(s)

$$K(s) = \left(\frac{50(s+2)(s+7)}{s(s+15)}\right)$$



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Industrial Hemp Bonus! There are 10 essential amino acids that we must have in our food: our body cannot make them (8) or has extreme difficulty making (2). How many of these 10 essential amino acids are in hemp seeds?

all 10