ECE 461 - Test #3: Name _____

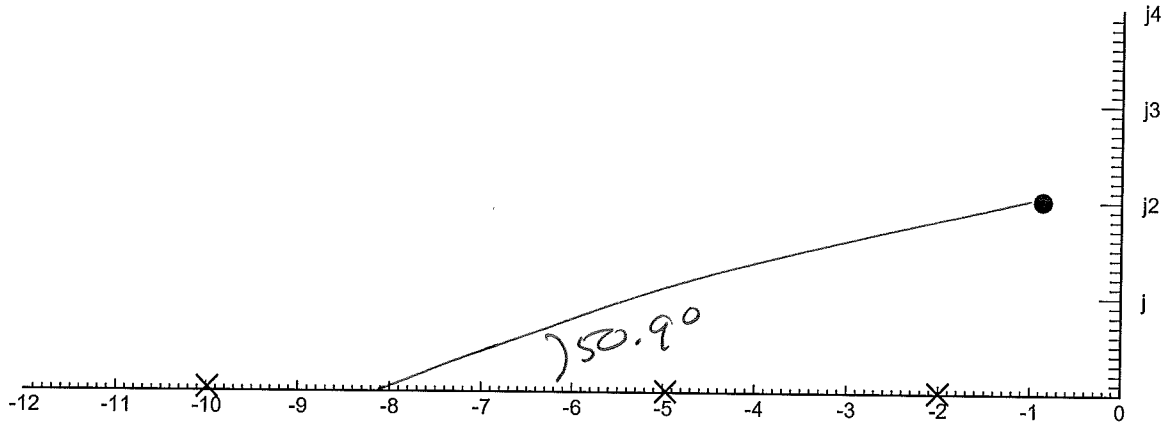
Compensator Design in the s and z plane - November 25th, 2015

1) Design a compensator, K(s), which results in

- A stable closed-loop system,
- With no error for a step input , and
- Closed-loop dominant poles at s = -1 + j2

Assume

$$G(s) = \left(\frac{100}{(s+2)(s+5)(s+10)}\right)$$



$$K(s) = \frac{(s+2)(s+5)\cdot 0.5312}{s(s+2.628)}$$

$$a = \frac{2}{\tan(50.9°)} + 1 = 2.6250$$

OL

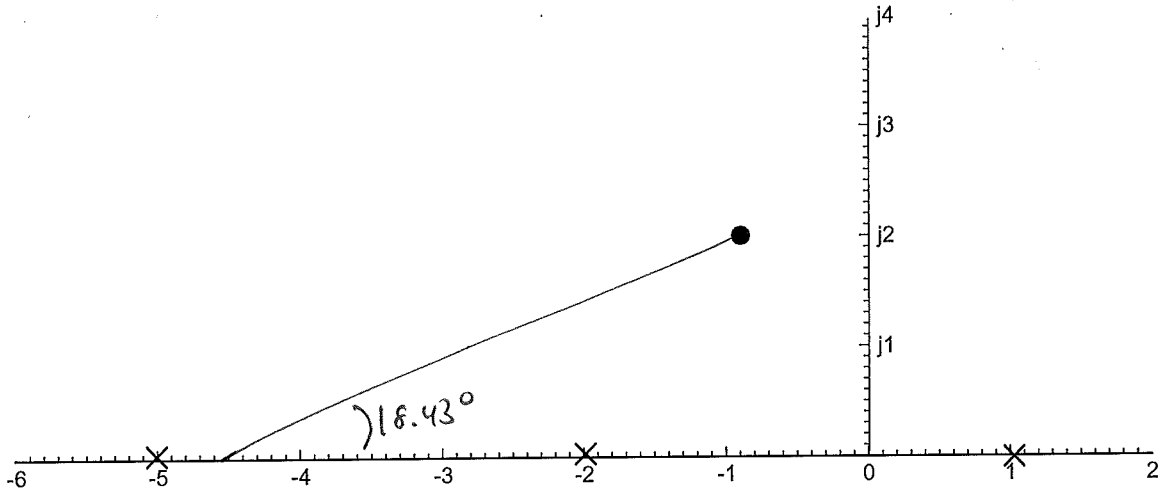
$$0.3236\,\frac{(s+2)(s+5)(s+10)}{s(s+4.2361)^2}$$

2) Design a compensator, K(s), which results in

- A stable closed-loop system, and
- Closed-loop dominant poles at s = -1 + j2

It's OK if there is steady-state error for a step input

$$G(s) = \left(\frac{100}{(s-1)(s+2)(s+5)}\right)$$



$$0.8\,\frac{(s+2)}{(s+7)}$$

$$\alpha = \frac{2}{\tan(18.43^\circ)} + 1 = 7$$

3) s to z conversion: Give the transfer for a discrete-time compensator, G(z), which has approximately the same step response as G(s). Assume a sampling rate of 100ms (T = 0.1)

$$G(s) = \left(\frac{100}{(s-1)(s+2)(s+5)}\right)$$

DC gain = -10

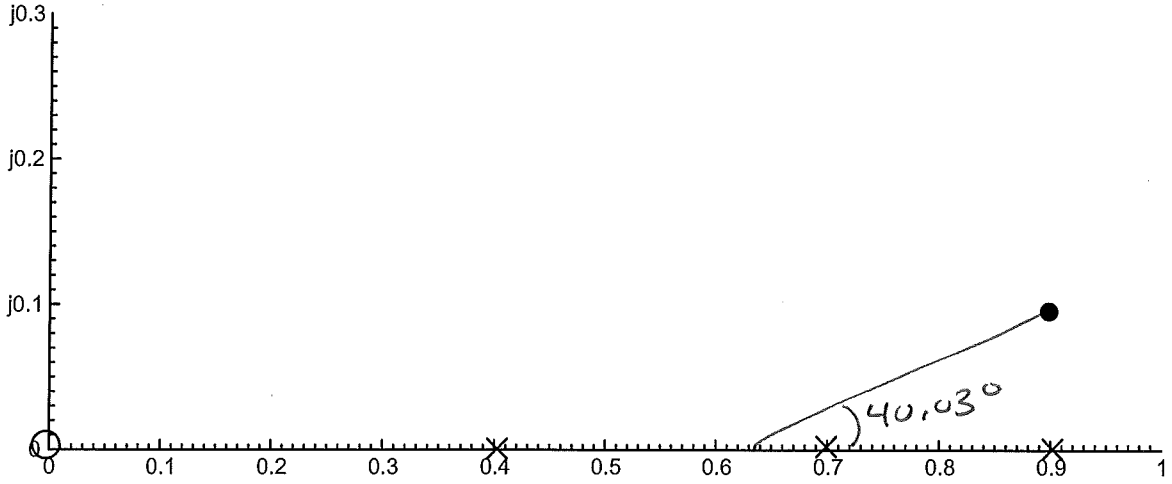
optimal

$$\frac{.0751\ z^2}{(z-1.1052)(z-.8187)(z-.6065)}$$

4) Root Locus in the z-Domain. Determine a compensator, K(z), which results in

- No error for a step input, and
- Closed-loop dominant poles at z = 0.9 + j0.1

$$G(z) = \left(\frac{0.2z}{(z-0.9)(z-0.7)(z-0.4)} \right)$$



$$.0619 \frac{(z-.9)(z-.7)}{(z-1)(z-.7810)}$$

$$GK(.9+j.1) = 1 \angle 180°$$

$$\theta a = .9 - \frac{.1}{\tan(40.03°)} = .7810$$

or

$$.0416 \frac{(z-.9)(z-.7)(z-.4)}{(z-1)(z-.6919)^2}$$

5) Assume a compensator, K(z), is

$$K(z) = \left(\frac{0.06(z-0.7)(z-0.6)}{(z-1)(z-0.5)}\right) = \left(\frac{0.06(z^2-1.3z+0.42)}{z^2-1.5z+0.5}\right)$$

5a) What is the difference equation this filter implements?

$y(k+2) - 1.5\,y(k+1) + 0.5\,y(k) = .06\,(x(k+2) - 1.3\,x(k+1) + 0.42\,x(k))$

5b) Write a program to implement K(z). Assume a sampling rate of 100ms (T = 0.1)

```
while(1) {
    X2 = X1
    X1 = X0
    X0 = A2D_Read()

    Y2 = Y1
    Y1 = Y0
    Y0 = 1.5*y1 - 0.5*y2 + 0.06(X0 - 1.3*X1 + .42*X2)

    wait()
}
```

Bonus! Match the Invention with what it does

d	1st-inator	~~a.~~	Instant clothes dryer that went wrong
a	Dance-Inator	~~b.~~	Kick sand all over the house of former bully
e	Brewinator	~~c.~~	Ruin a dog show
c	Mis-behavinator	d.	Shoots a laser beam into outer space
b	Who's Crying Now-Inator	e.	Attempt to become a certified mad scientist