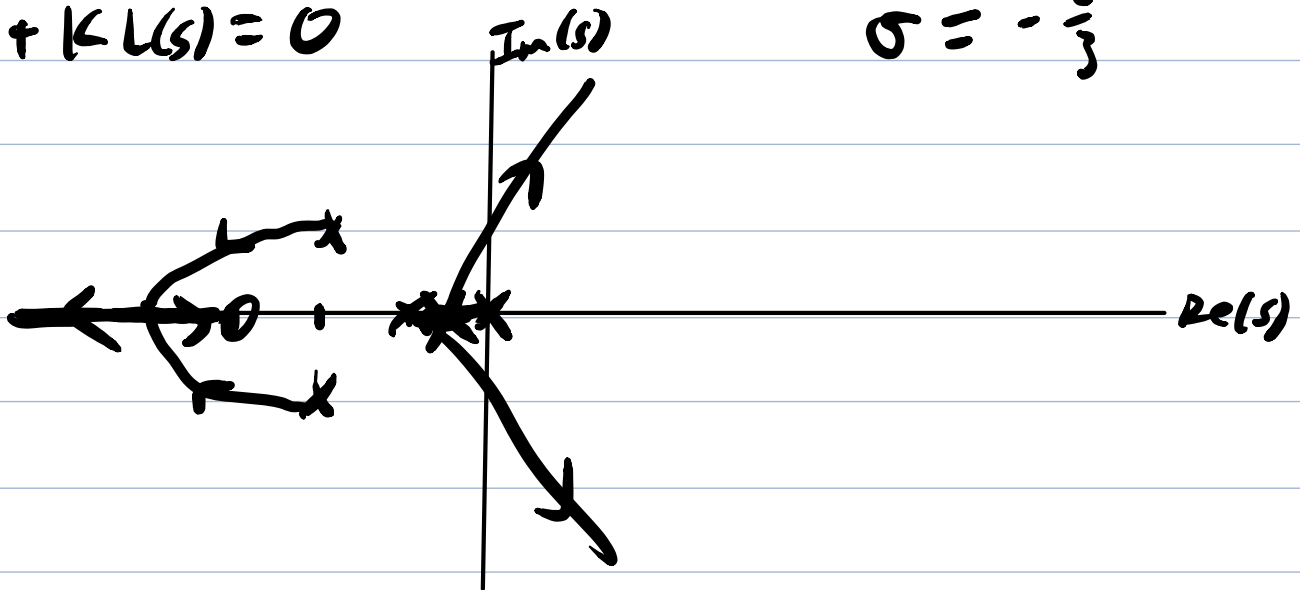## Problem 2 (PS9)

$$L(s) = \frac{s+3}{s(s+1)(s^2+4s+5)}$$

$$s = \frac{-2 \pm \sqrt{-4}}{2} = -2 \pm j$$

$$1 + K L(s) = 0$$

$$\sigma = -\frac{2}{3}$$

$$s(s+1)(s^2+4s+5) + Ks + 3K$$
$$= s^4 + 5s^3 + 9s^2 + (5+K)s + 3K$$

s^4	1	9	3K
s^3	5	5+K	0
s^2	$\frac{40-K}{5}$	3K	
s^1			
s^0	3K		

$$K \leq 40$$
$$(\text{set } K = 40)$$

$$5s^3 + (5+K)s = s(5s^2 + 5 + K)$$
$$\Rightarrow \pm j3$$

$$\begin{bmatrix} 1 & b_1 & 0 & 0 \\ a_1 & b_0 & b_1 & 0 \\ a_0 & 0 & b_0 & b_1 \\ 0 & 0 & 0 & b_0 \end{bmatrix} \begin{bmatrix} f_1 \\ g_2 \\ g_1 \\ g_0 \end{bmatrix} = \begin{bmatrix} d_3 - a_1 \\ d_2 - a_0 \\ d_1 \\ d_0 \end{bmatrix}$$

$$C(s) = \frac{g_2 s^2 + g_1 s + g_0}{s^2 + f_1 s}$$

```
s = tf('s')
P = 10/(s*(s+5)*(s+10))
poles = [-5 + 5i, -5 - 5i]
theta = pi - angle(freqresp(P, poles(1)))
```

```
% pick P arb.
z = 2                    % z = 4.9
X = sym('x')
p = real(double(solve(angle(poles(1) + z) - angle
        (poles(2) + X) - theta, X) ))
```

```
% Select control gain
k0 = 1/norm(freqresp(P, poles(1)))
     * norm(poles(1) + p)/norm(poles(1) + z)
```

```
% verify feedback
```

```
C = KO * (s+z) / (s+p)
G = P*C / (1 + P*C)
step(G)

pzplot(G)

feedback( . )  command
        P*C,  1
```