5.5c) poles: $-1 \pm 3i, 0$

zeros: $-1 \pm \sqrt{7}\,i$

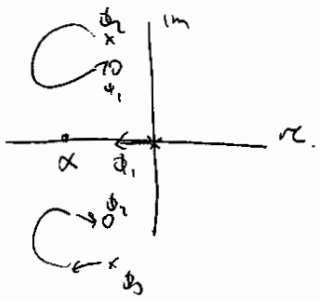
$\alpha = \frac{p-z}{n-m} = -2$

$\theta = \frac{1}{1}\pi = 180$

$\phi_1 = \tan^{-1}\sqrt{7} - \tan^{-1}\sqrt{7} + 180 - \tan^{-1}(3) + \tan^{-1}(3)$

$-180^\circ - 180^\circ - 0$

$= -180^\circ$



$\phi_2 = -90 - 90 + \tan^{-1}(3) + 90 - 180 = 161.6$

$\phi_3 = 90 - 90 - \tan^{-1}(3) - 90 + 180 = -161.6$

$\phi_1 = 90 - 90 - \tan^{-1}(\sqrt{7}) + 270 = 200.7$

$\phi_4 = 90 + 90 + \tan^{-1}(\sqrt{7}) + 90 = 159.3$

$s^3 + 2s^2 + 10s + 1ks^2 + 2ks + 8k$

$\rightarrow s^3 + (2+1k)s^2 + (10+2k)s + 8k$

3	1	$10+2k$
2	$2+k$	$8k$
1	$\frac{2k^2+14k+20}{2+k}$	0
0	$8k$	

$\rightarrow k^2 + 7k + 10 = 0$ No solution

b $\frac{dc}{ds} - a\frac{dj}{ds} = 0 \rightarrow$ matlab/wolframalpha

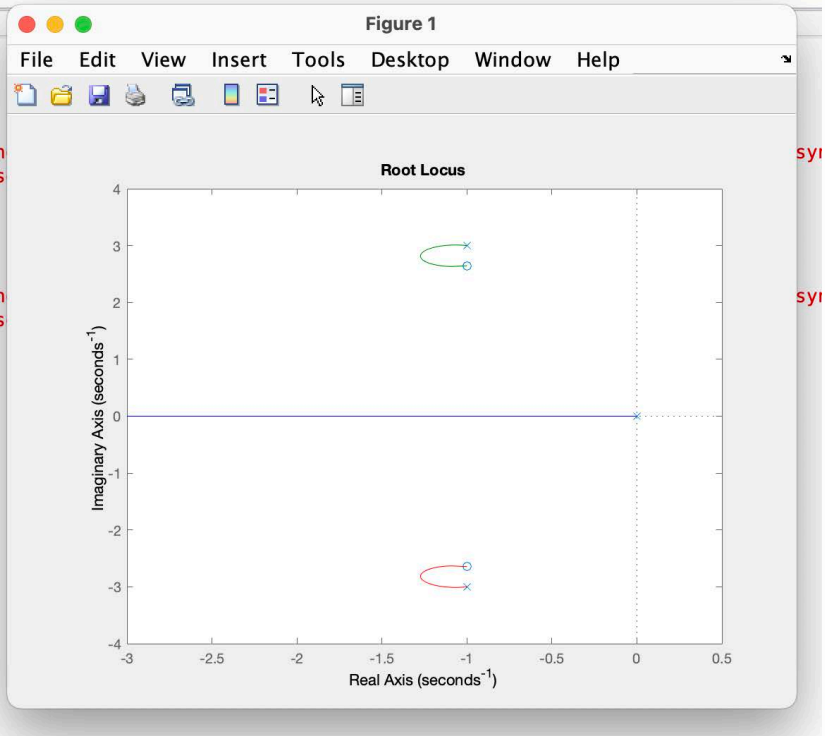
$s^4 + 9s^3 + 10s^2 + 32s + 80 = 0$

$X = \pm 2i\sqrt{2}, \pm 2i\sqrt{6}$

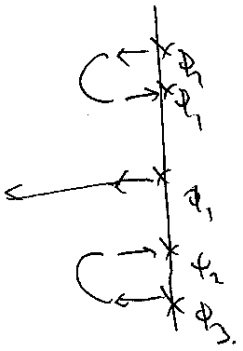
no solution

Command Window

```
>> s = tf('s');
>> sysL = (s^2+2s+8)/(s*(s^2+2s+10))
 sysL = (s^2+2s+8)/(s*(s^2+2s+10))
                ↑
Error: Invalid expression. Check for missin
matrices, use brackets instead of parenthes

>> sysL = (s^2+2*s+8)/(s*(s^2+2s+10))
 sysL = (s^2+2*s+8)/(s*(s^2+2s+10))
                              ↑
Error: Invalid expression. Check for missin
matrices, use brackets instead of parenthes

>> sysL = (s^2+2*s+8)/(s*(s^2+2*s+10))

sysL =

    s^2 + 2 s + 8
  ------------------
  s^3 + 2 s^2 + 10 s

Continuous-time transfer function.

>> rlocus(sysL)

>> %5.5c
>>
```



e) zeros: $\pm j$ poles $0, 2j, -2j$



$\alpha = 0$

$\theta = -\pi = 180°$

$\phi_1 = 0 - 90 = 180°$

$\phi_2 = -90 - 360 = 180$

$\phi_3 = -180 = 180°$

$\#\phi = -90 + 270 - 180°$

$\phi_2 = 90 - 90 - 90 = 180°$

$L(s) \rightarrow \quad \theta(s) = \theta_0 \cdot s^3 + ks^2 + 4s + k$

$b\frac{dq}{ds} - q\frac{db}{ds} = 0$ → matlab / mathematica

3	1	4
	k	k
	4	0
	k	

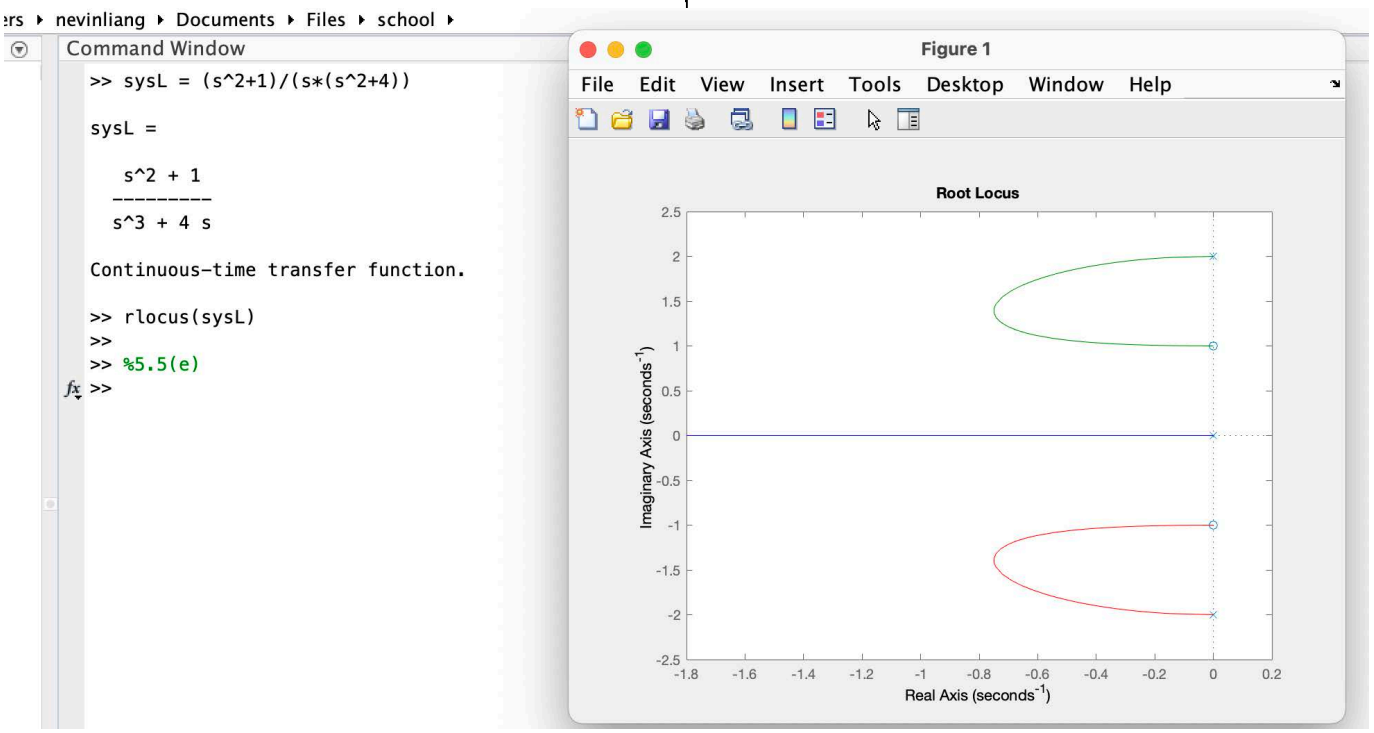
$\frac{-6-4k}{k} = 3 \rightarrow [3]$

$k = 0$

$s^4 + s^2 + 4 = 0$.

no solution

matlab



5.7 c)

zeros: $-3, -3$

poles: $0, 0, -10, -3 \pm 4i$

$\alpha = \frac{-10+0}{3} = \frac{-10}{3}$

$\theta = \frac{2l-1}{n-m}\pi = \frac{-\pi}{3} = \frac{\pi}{3}, \pi$

$D(s) = s^5 + 16s^4 + 85s^3 + (250+k)s^2 + 6ks + 9k$

s^5	1	85	6k
s^4	16	250+k	9k
s^3	k-110	-71k	0
s^2	$\frac{16(-176)-(250+k)(k-110)}{k-110}$	9k	
s^1	$\frac{(k-111)9k-(-71k)(k-110)}{a}$		
s^0	9k		

$Q_{1,1} = \frac{1}{2}(300 - 270 - 90 + 90 - 180 - 180)$

$= -90$

$\theta_{1,2} = 90°$

$\phi_2 = -90 + 53.13 + 90 + 66.8 - 180$

$= -7.2$

θ_3 = same as negative -7.2

$\theta_4 = 0 - 72.11 - 71.1 - 90 = -180°$

$\psi_1 = \frac{1}{2}(90 + 90) = 90$

$\psi_2 = \frac{1}{2}(90 + 90) = 90$

$\frac{bds}{ds} - \frac{adj}{ds}$: real roots $(0, 7)$

matlab

matlab.

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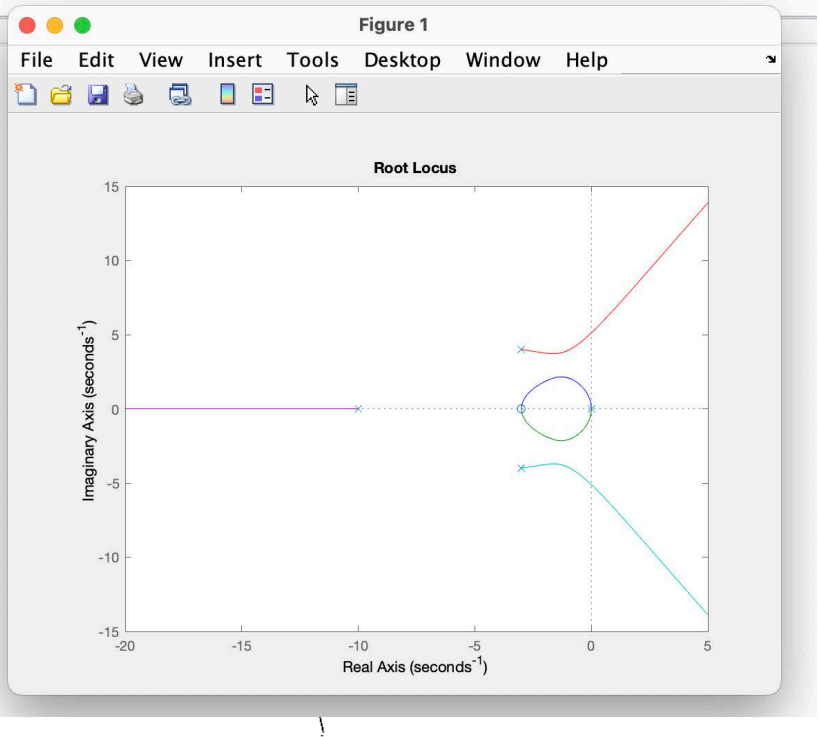
Command Window

```
>> s = tf('s');
>> sysL = (s+3)^2/(s^2*(s+10)*(s^2+6*x+25))
Unrecognized function or variable 'x'.

>> sysL = (s+3)^2/(s^2*(s+10)*(s^2+6*s+25))

sysL =

          s^2 + 6 s + 9
  ------------------------------
  s^5 + 16 s^4 + 85 s^3 + 250 s^2

Continuous-time transfer function.

>> rlocus(sysL)
>> %problem 5.7c
>>
```



(c) zeros: $-1 \pm i$

poles: $0, 0, -2, -3$

$\alpha = \frac{p-z}{n-m} = -1.5$

$\theta = \frac{1}{2}\pi, \frac{3\pi}{2}$

$\phi_{1,1} = \frac{1}{2}(135-135-360-180) = 90^\circ$

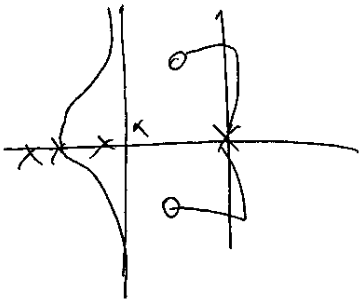
$\phi_{1,2} = \frac{1}{2} \cdot 540 = 270$

$\phi_2 = 45-45-180-180 = 0$

$\phi_3 = -2.185+2.185-180 = 180^\circ$

$\psi_1 = -90-135-126.9+90+ \ldots = -71.6^\circ$

$\psi_2 = 90+135-\tan^{-1}(1)+90 = -71.6^\circ$

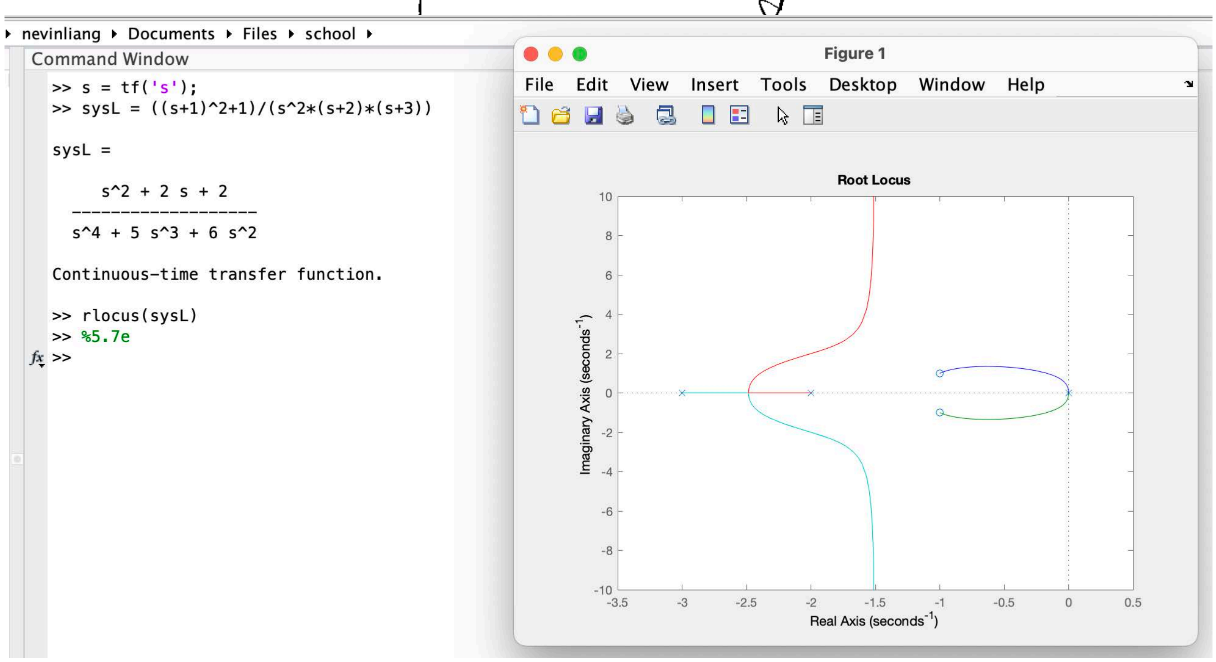


$P(s) = s^5 + ks^4 + 5ks^3 + 6ks^2 + 2s + 2$

4	k	$6k+1$	2
3	$5k$	2	0
2	$\frac{6+10k}{?}$	2	0
1	$\frac{6+10k}{5+10k}$	0	
0	2		

$b\frac{da}{ds} - a\frac{db}{ds} = $ roots $-2.4848, 0$ → matlab.

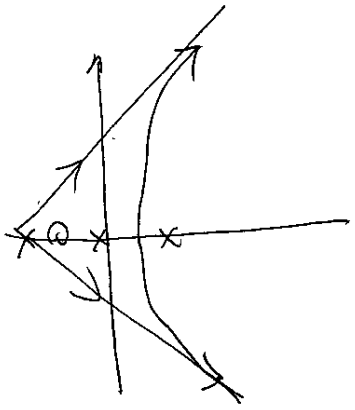
matlab



5.8)

Zeros: -2

Poles: 0, 1, -6, -6



$\alpha = \frac{-9}{3} = -3$

$\theta = \frac{\pi}{3}, \frac{-\pi}{3}, \pi$

$\phi_1 = 180 - 54 - 180 = 180$

$\phi_2 = 180 - 60 - 60 = 0$

$\phi_{3,1} = \frac{1}{2}(0) = 0$

$\phi_{3,1} = \begin{cases} -180 \\ 180 \end{cases}$

$D(s) = s^4 + (5+2)s^3 + (12+5+2)s^2 + (5+2k)s + 2k$

4	1	24	2k
3	11	k-36	0
2	249	$\frac{396-k}{11}$	2k
1	a	0	
0	2k		

b $\frac{da}{as} - \frac{adb}{as}$ = roots $\boxed{-6, 2.488}$

```
>> sysL = (s+2)/(s*(s-1)*(s+6)^2)

sysL =

             s + 2
  ----------------------------
  s^4 + 11 s^3 + 24 s^2 - 36 s

Continuous-time transfer function.

>> rlocus(sysL)
>> %5.8
>>
```