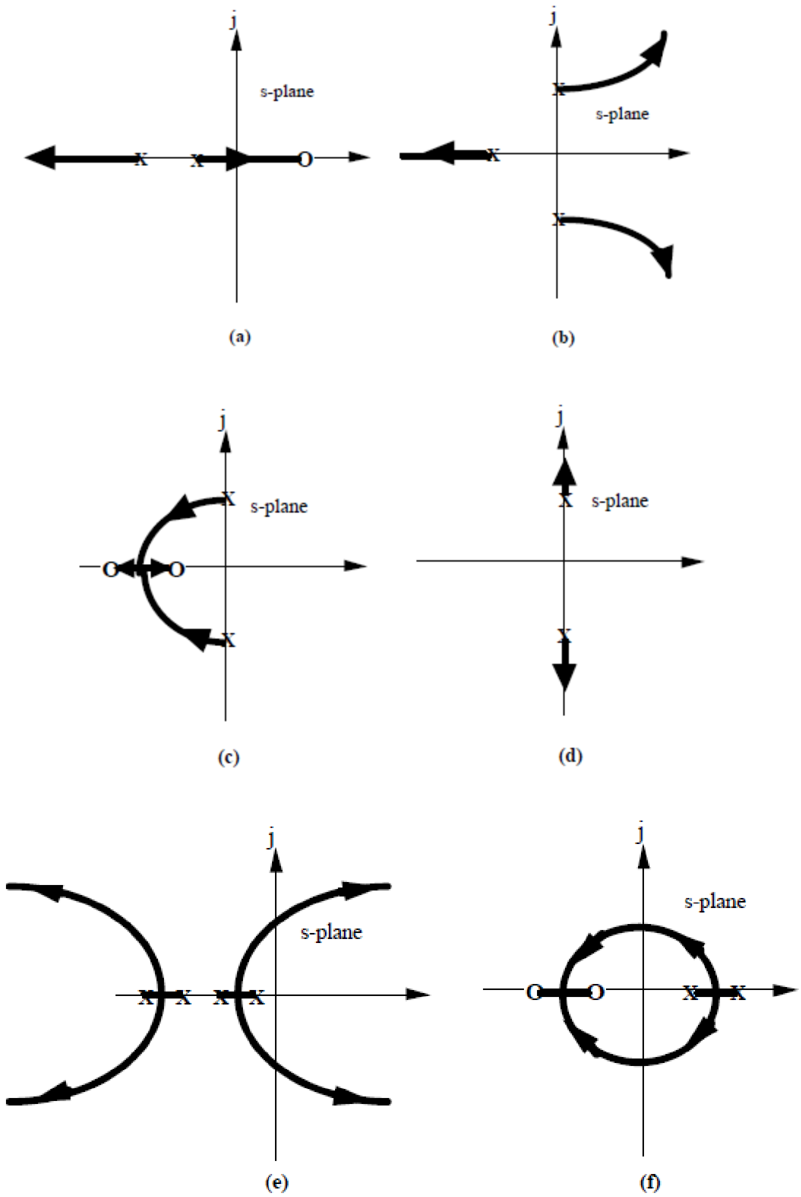
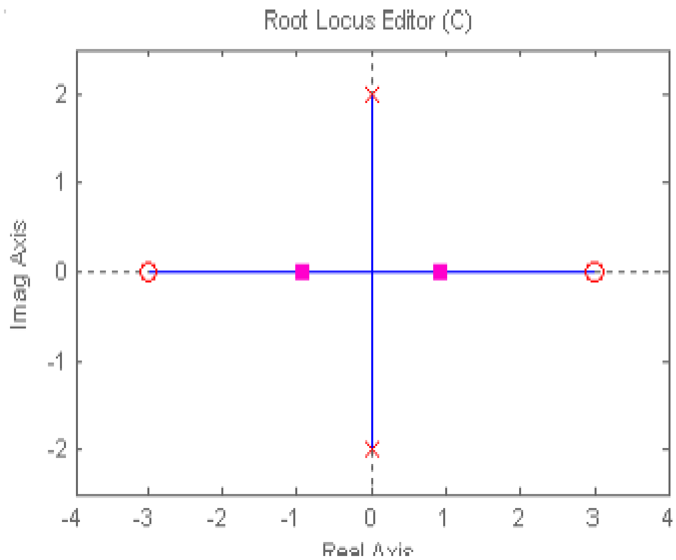
Chapter 8 Solutions, Problems 2, 11, 23, 30, 34, 41, 71 6

2.



11.

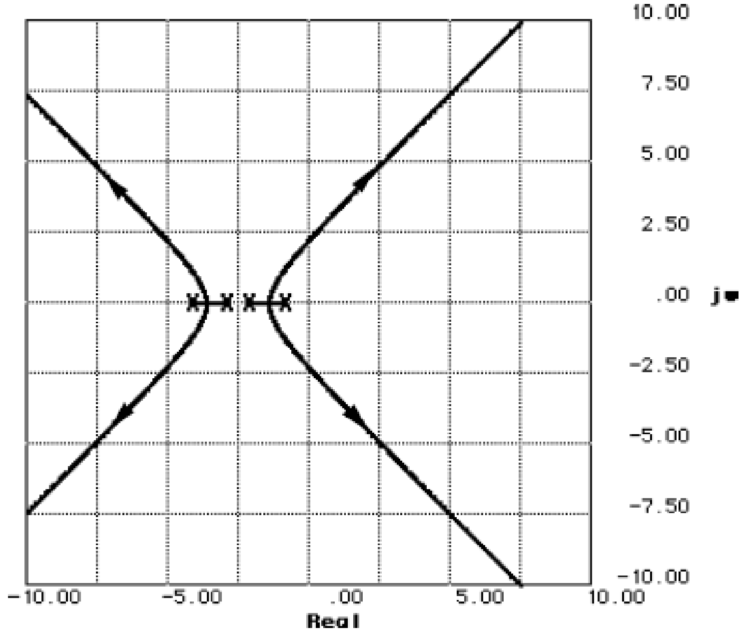


Closed-loop poles will be in the right-half-plane for $K > \dfrac{(2)(2)}{(3)(3)} = \dfrac{4}{9}$ (gain at the origin).

Therefore, stable for $K < 4/9$; unstable for $K > 4/9$.

Note that it is only marginally stable for K<4/9 since the closed-loop poles will be on the imaginary axis.

23.



a. Asymptotes: $\sigma_{int} = \frac{(-1 -2 -3 -4) - (0)}{4} = -\frac{5}{2}$; Angle $= \frac{(2k+1)\pi}{4} = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$

b. Breakaway: -1.38 for K = 1 and -3.62 for K = 1

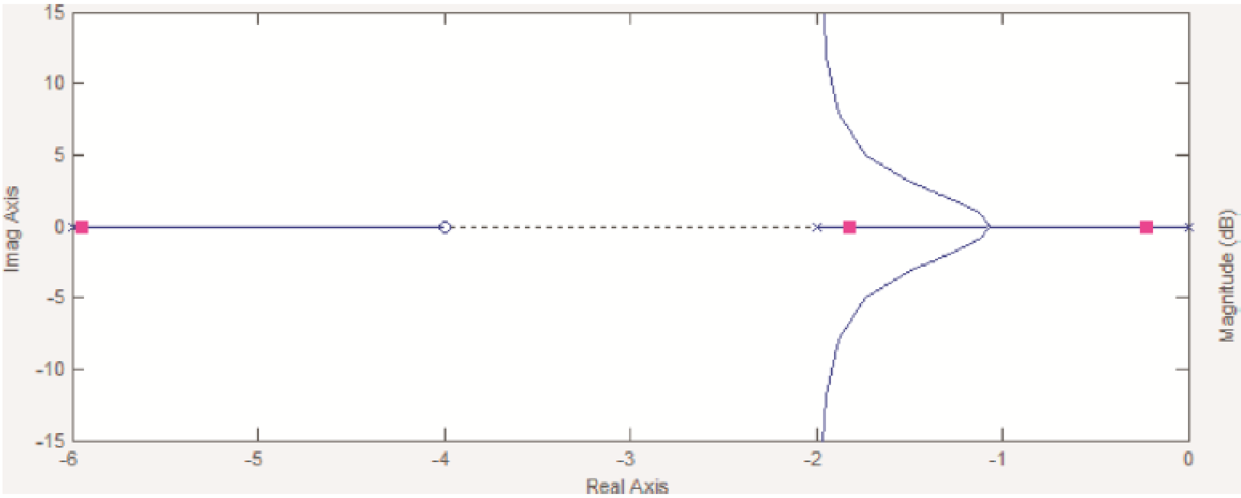
c. Root locus crosses the imaginary axis at $\pm j2.24$ for K = 126. Thus, stability for K < 126.

d. Search 0.7 damping ratio line (134.427 degrees) for 180^0. Point is $1.4171\angle 134.427^o$ = $-0.992 \pm j1.012$ for K = 10.32.

e. Without the zero, the angles to the point $\pm j5.5$ add up to -265.074^o. Therefore the contribution of the zero must be $265.074 - 180 = 85.074^o$. Hence, $\tan 85.074^o = \frac{5.5}{z_c}$, where $-z_c$ is the location of the zero. Thus, $z_c = 0.474$.

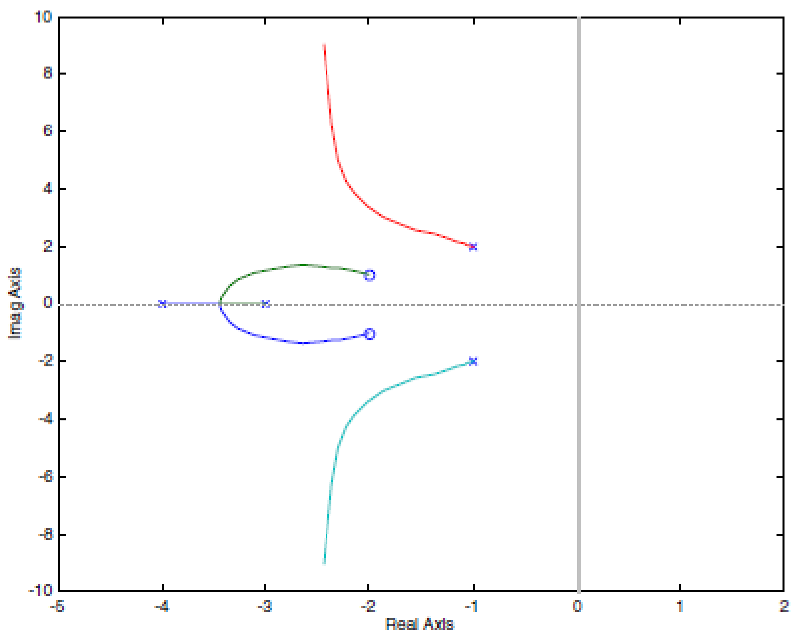
30.

Since the problem stated the settling time at large values of K , assume that the root locus is approximately close to the vertical asymptotes. Hence, $\sigma_a = \frac{-8+\alpha}{2} = -\frac{4}{T_s}$. Since specified $T_s = 2$, $\alpha = 4$. The root locus is shown below



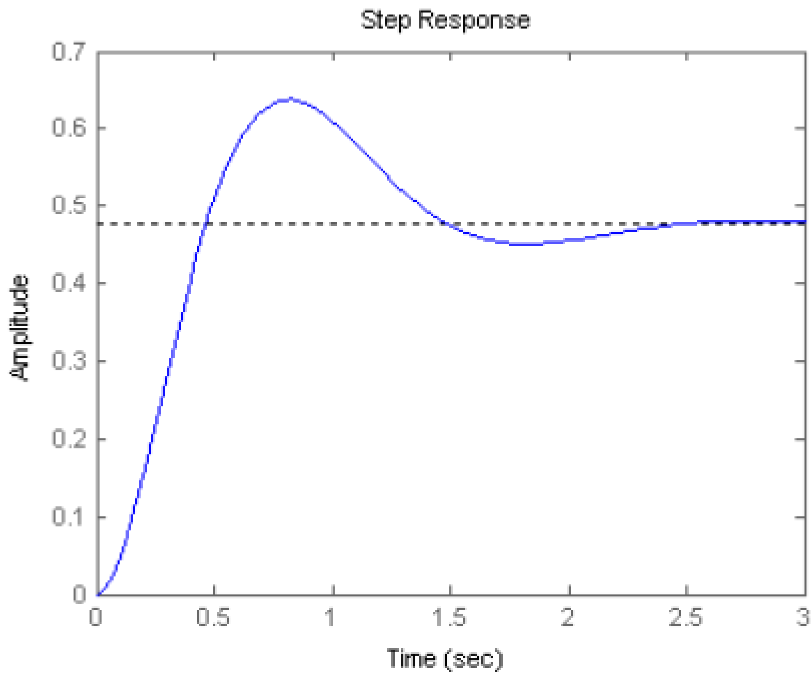
34.

a. For a peak time of 1s, search along the horizontal line, Im = $\pi/T_p = \pi$, to find the point of intersection with the root locus. The intersection occurs at $-2 \pm j\pi$ at a gain of 11.



b.
Program:

```
numg=11*[1 4 5];
deng=conv([1 2 5],poly([-3 -4]));
G=tf(numg,deng);
T=feedback(G,1);
step(T)
```



Peak time approximately 0.8 second instead of 1 second.

41.

a. Search $j\omega$=j5 for 180°and find $-3.41+j5$ with $K=58.5$.

b. $K_a = \dfrac{Kz}{10} = 11.7$

c. A settling time of 0.8 sec yield a real part of -5. Thus if the zero is at the origin $G(s)=\dfrac{K}{s(s+10)}$, which yields complex poles with -5 as the real part. At the design point $-5+j5$, $K=50$.

Additional explanation

a) You are searching along a horizontal line defined by s = -r + 5j. That line intersects the root locus plot at r = 3.41 and K = 58.5. An algebraic way of expressing this problem is:
Delta(s) = Delta(-r + 5j) = 0
Or
$(-r+5j)^3 + 10\,(-r+5j)^2 + K(-r+5j) + 2K = 0$
That represents two equations (the real parts and the imaginary parts each equal zero) for two unknowns K and r.

c) Set the asymptote location to -5. That gives -5 = (-10+z)/2 and is solved by z = 0.