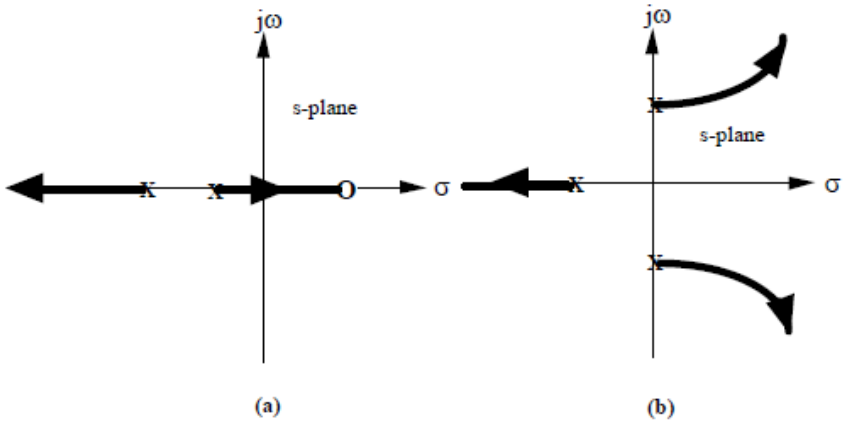
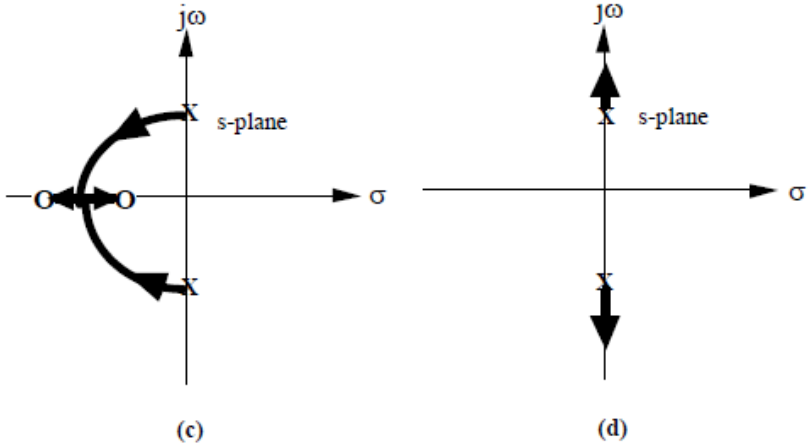
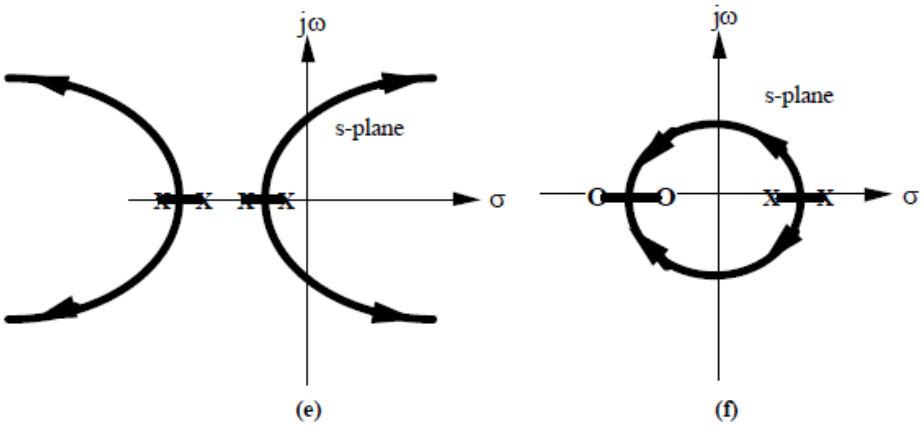
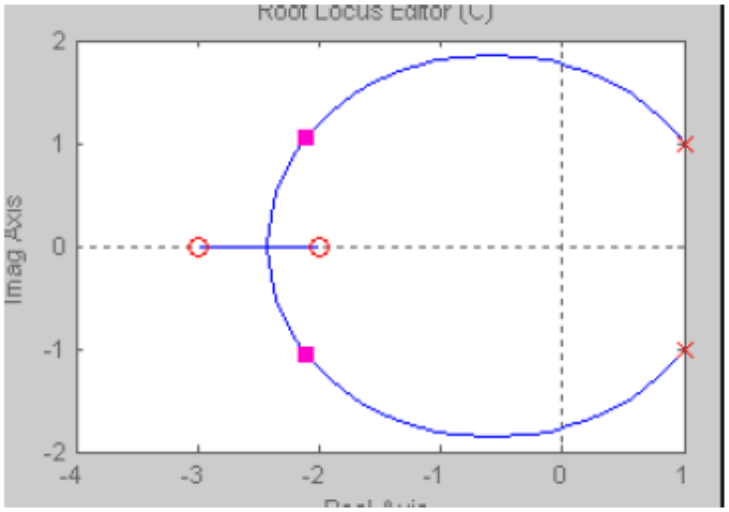
2.


jω
s-plane
σ
X
X
O
(a)
jω
X
s-plane
σ
X
X
(b)


jω
X
s-plane
σ
O
O
X
(c)
jω
X
s-plane
σ
X
(d)

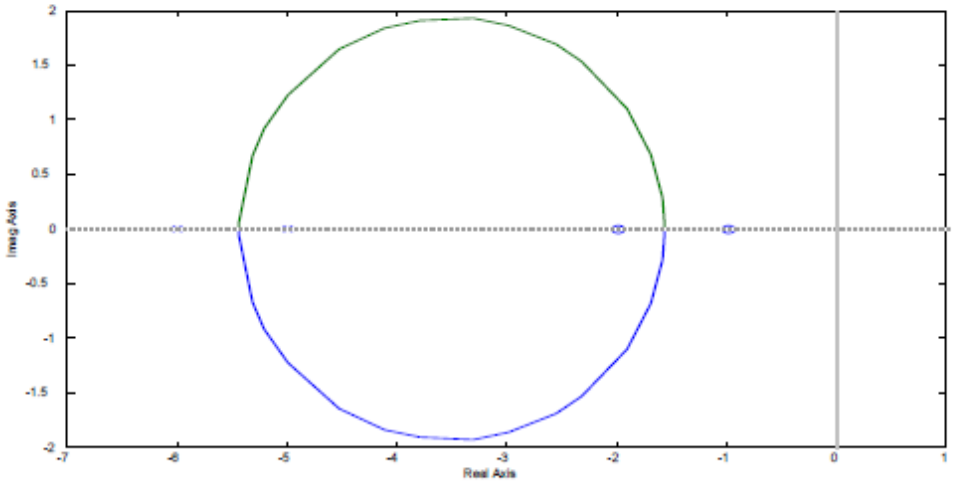

jω
s-plane
σ
X
X
X
X
(e)
jω
s-plane
σ
O
O
X
X
(f)

6.




Breakaway: $\sigma = -2.43$ for $K = 52.1$

7.



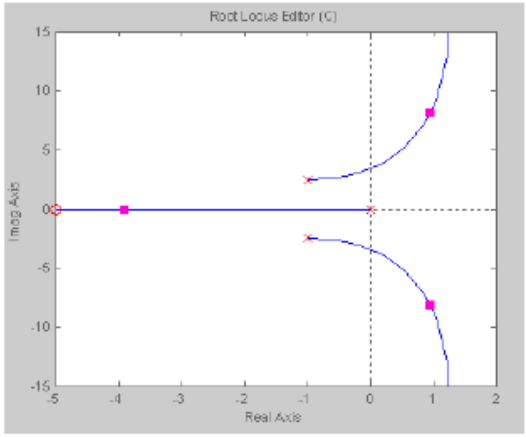

Break-in: $\sigma = -1.5608$ for $K = 61.986$; Breakaway: $\sigma = -5.437$ for $K = 0.01613$.

**8.**

Convert the denominator to the following form: $D(s) = 1 + \dfrac{20K(s+5)}{s^3 + 2s^2 + 7s}$ and thus identify

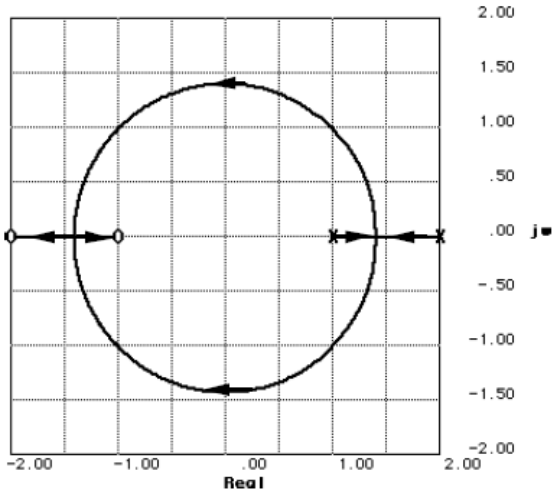
$$G(s) = \frac{20K(s+5)}{s^3 + 2s^2 + 7s} = \frac{20K(s+5)}{s(s^2 + 2s + 7)}.$$

Plotting the root locus yields




**13.**

**System 1:**




(a)

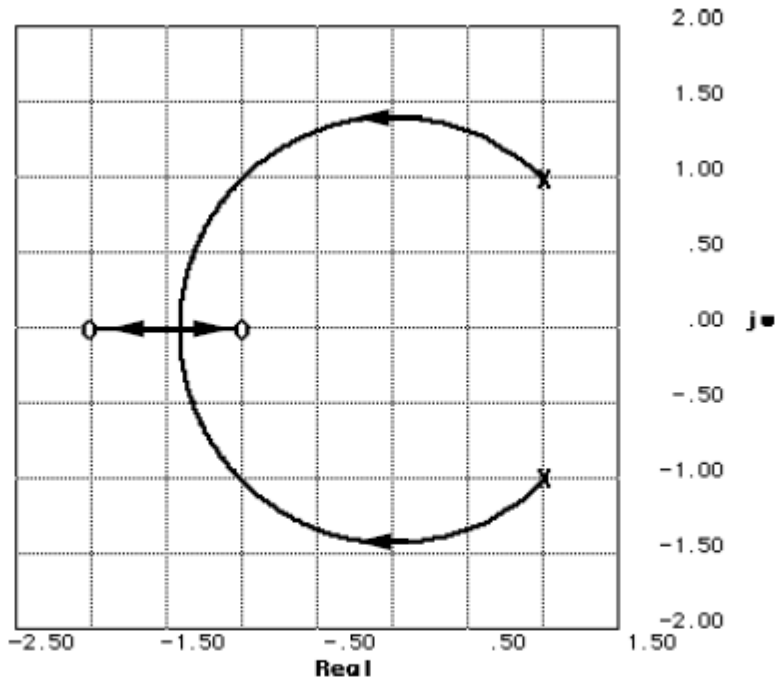
**a.** Breakaway: σ = 1.41 for K = 0.03; Break-in: σ = -1.41 for K = 33.97.

**b.** Imaginary axis crossing at j1.41 for K = 1. Thus stable for K > 1.

**c.** At break-in point, poles are multiple. Thus, K = 33.97.

**d.** Searching along $135^0$ line for $180^0$, K = 5 at $1.414 \angle 135^0$.

**System 2:**




(b)

**a.** Break-in: $\sigma = -1.41$ for $K = 28.14$.

**b.** Imaginary axis crossing at $j1.41$ for $K = 0.67$. Thus stable for $K > 0.67$.

**c.** At break-in point, poles are multiple. Thus, $K = 28.14$.

**d.** Searching along $135^0$ line for $180^0$, $K = 4$ at $1.414 \angle 135^0$.