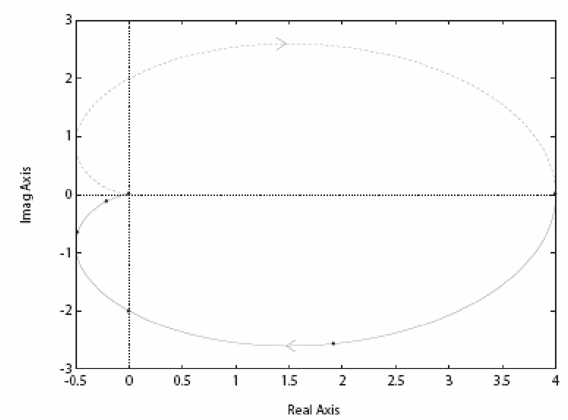
Nyquist

$E8.1$



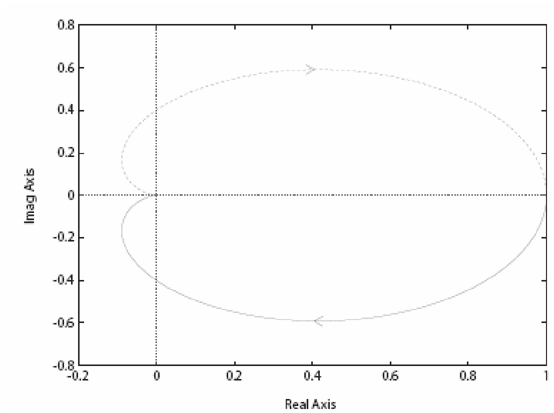
$P8.1/9.1$

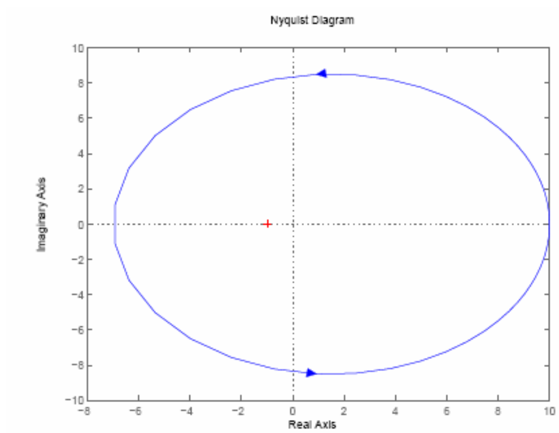
$a)\quad N=0\quad P=0\quad Z=0$

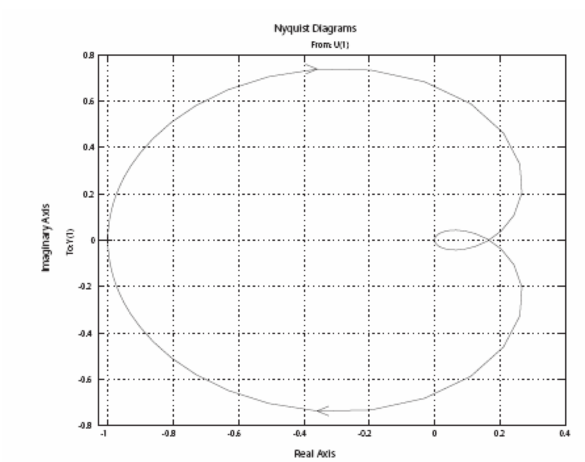
$b)\quad N=0\quad P=0\quad Z=0$

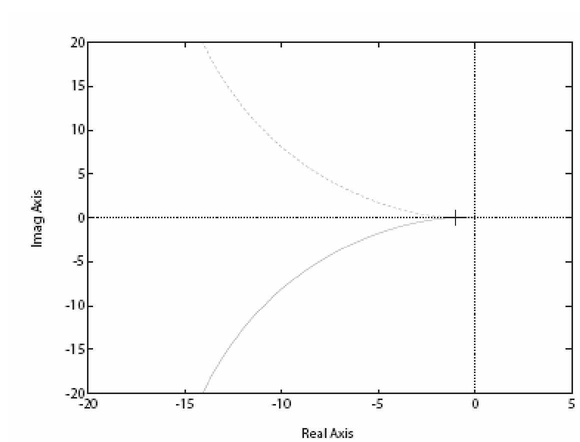
$c)\quad N=0\quad P=0\quad Z=0$

$d)\quad N=2\quad P=0\quad Z=2$

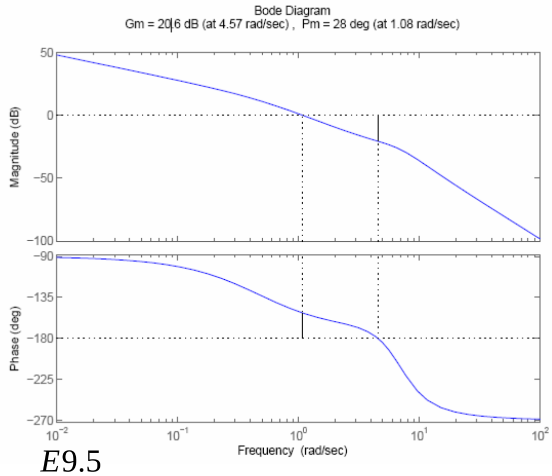








$E9.1$



$E9.5$

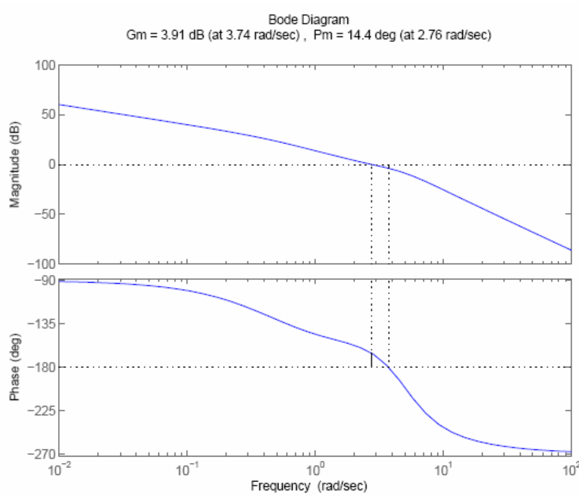
$a)\quad GM = 5dB \quad PM = 10°$

$b)\quad 10dB$

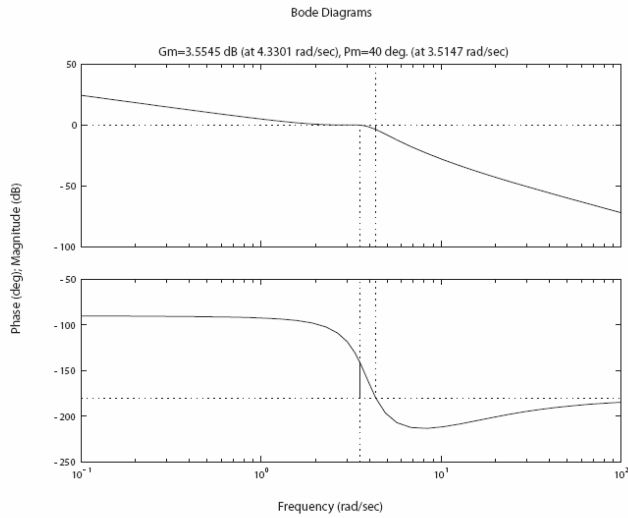
$E9.7 \quad K > 2$

$E9.9 \quad PM = 5°$

$E9.11$



$E9.17 \quad K = 10.82$



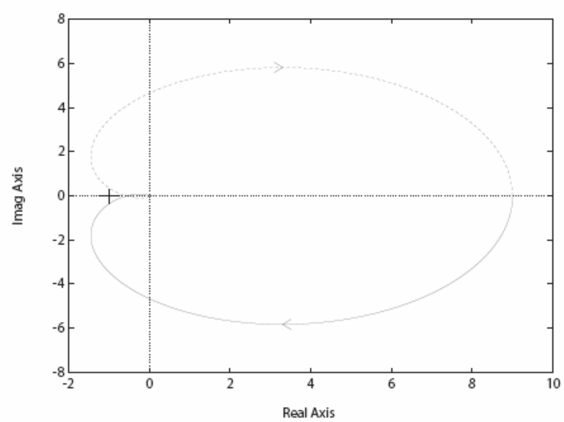
$E9.22 \quad PM = 20° \quad K = 11.1$

$E9.27$

$K = 122.62 \quad PM = 40° \quad GM = 10.94dB$

$P9.5$

$K > 9 \quad GM = 5dB \quad PM = 18°$



P9.4 (a) $P = 0, N = 2$, therefore $Z = 2$. The system has two roots in the right hand s-plane.

(b) In this case, $N = +1 - 1 = 0$, so $Z = 0$. Therefore the system is stable.

P9.5 (a) The loop transfer function is

$$L(s) = G_c(s)G(s)H(s) = \frac{K}{(s+1)(3s+1)(0.4s+1)} \ .$$

The steady-state error is

$$e_{ss} = \frac{|R|}{1+K} \ .$$

We require $e_{ss} = 0.1|R|$, so $K > 9$.

(b) Use $K = 9$. The Nyquist plot is shown in Figure P9.5. We determine that $P = 0$ and $N = 0$. Therefore, $Z = 0$ and the system is stable.

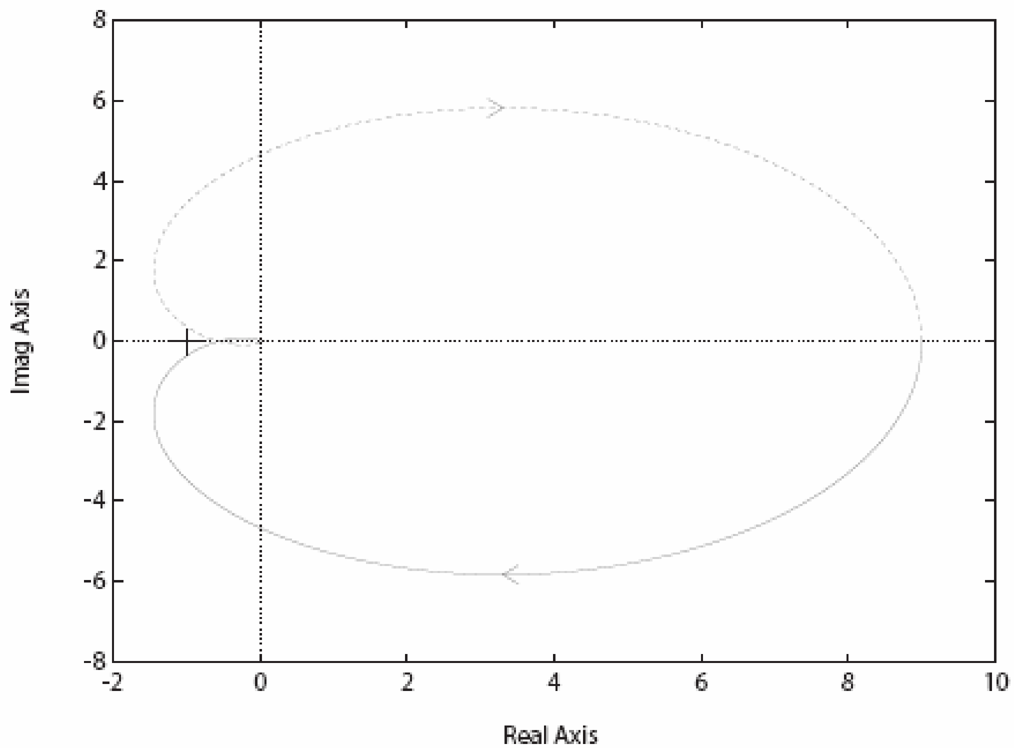


FIGURE P9.5
Nyquist Diagram for $L(s) = G_c(s)G(s)H(s) = \frac{9}{(s+1)(3s+1)(0.4s+1)}$.

(c) The phase and gain margins are $P.M. = 18^o$ and $G.M. = 5$ dB.

P9.7 The loop transfer function is

$$L(s) = G_c(s)G(s)H(s) = \frac{10K_1 s(s+7)}{(s+3)(s^2+0.36)} .$$

(a) The Bode plot is shown in Figure P9.7 for $K_1 = 2$.

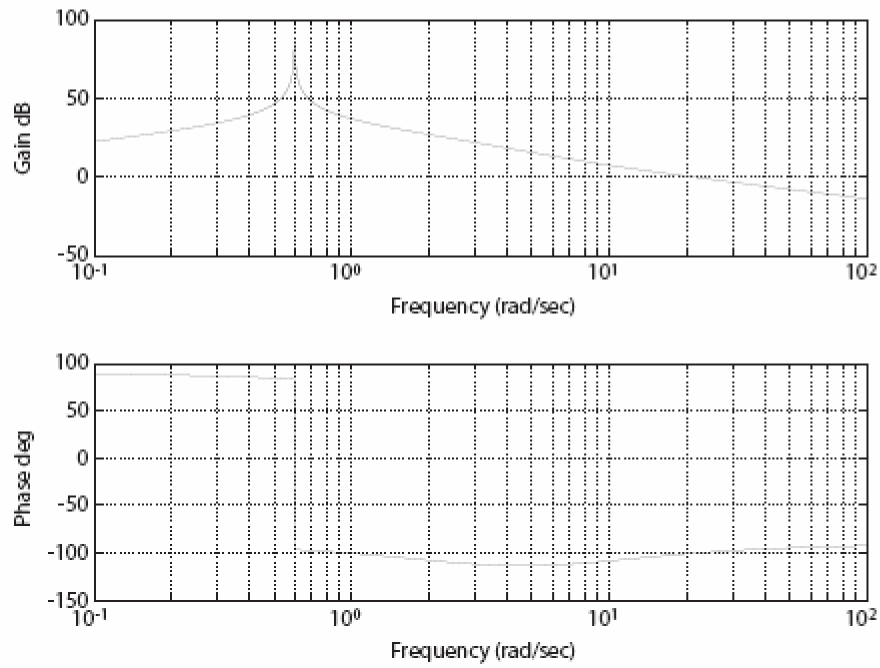


FIGURE P9.7
Bode Diagram for $G_c(s)G(s)H(s) = \frac{10K_1 s(s+7)}{(s+3)(s^2+0.36)}$, where $K_1 = 2$.

(b) The phase margin $P.M. = 80^o$ and the gain margin $G.M. = \infty$, since ϕ never crosses $= -180^o$.

(c) The transfer function from $T_d(s)$ to $\theta(s)$ is

$$\theta(s) = \frac{G(s)}{1 + G_c(s)G(s)H(s)} T_d(s) .$$

Then, for a step disturbance $\theta(\infty) = \lim_{s\to 0} s\theta(s) = G(0) = 10/0.36 = 27.8$, since $H(0) = 0$.