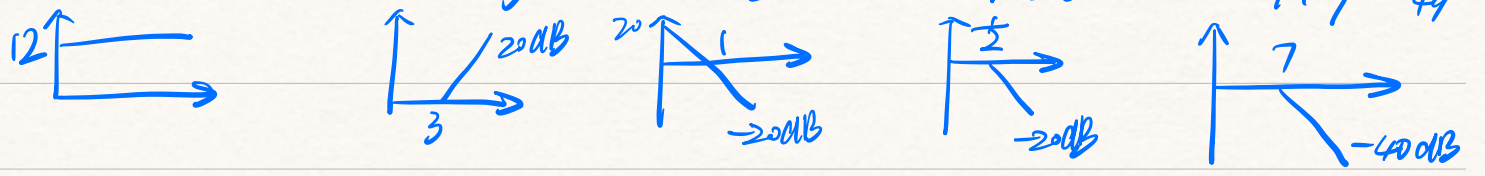
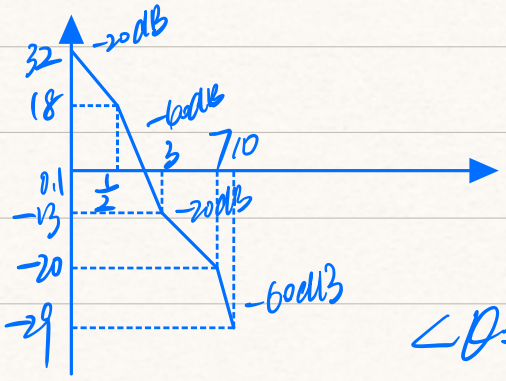
E 9.1

$$G(s)=\frac{4\left(1+\frac{s}{3}\right)}{s(1+2s)\left(1+\frac{s}{7}+\frac{s^2}{49}\right)}$$

$G_1=4$ $\quad G_2=1+\frac{s}{3}$ $\quad G_3=\frac{1}{s}$ $\quad G_4=\frac{1}{1+2s}$ $\quad G_5=\frac{1}{1+\frac{s}{7}+\frac{s^2}{49}}$





$$G(j\omega)=\frac{4\left(1+\frac{1}{3}j\omega\right)}{j\omega(1+2j\omega)\left(1-\frac{\omega^2}{49}+\frac{j\omega}{7}\right)}$$

$$\angle\theta=\arctan\frac{\omega}{3}-\frac{\pi}{2}-\arctan 2\omega-\arctan\frac{\frac{\omega}{7}}{1-\frac{\omega^2}{49}}$$

$$|G(j\omega)|=\frac{4\sqrt{1+\frac{1}{9}\omega^2}}{\omega\sqrt{1+4\omega^2}\sqrt{\left(1-\frac{\omega^2}{49}\right)^2+\frac{\omega^2}{49}}}$$

$$\frac{-13-0}{g_3-g\omega_0}=-40 \qquad \omega_0=1.2$$

$$\angle\theta=-146^\circ$$

$$\gamma=180^\circ-146^\circ=34^\circ$$

$$\angle\theta=-180^\circ$$

$$\omega=5.7$$

$$h=\frac{1}{|G(j\omega)|}=6.09$$

$$h(dB)=20\lg h=16.5\ dB$$

Eg.2

$$G(s)=\frac{6.14\left(1+\frac{s}{5}\right)}{s\left(1+\frac{s}{2}\right)\left(1+\frac{s}{10}\right)}$$

$$\frac{6.14\left(1+\frac{\omega_0}{5}\right)}{\omega_0\left(1+\frac{\omega_0}{2}\right)\left(1+\frac{\omega_0}{10}\right)}=1$$

$$\omega_0=3.6$$

$$\angle\theta=\arctan\frac{\omega}{5}-\frac{\pi}{2}-\arctan\frac{\omega}{2}-\arctan\frac{\omega}{10}$$

$$\angle\theta\big|_{\omega_0=3.6}=-135^\circ$$

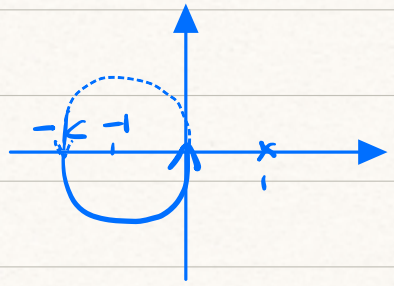
$$\gamma=180^\circ+\angle\theta=45^\circ$$

Eg.7

$$G(s)=\frac{k}{s-1}$$

$$G(j\omega)=\frac{k}{j\omega-1}=\frac{-k}{1-j\omega}$$

$$|G(j\omega)|=\frac{k}{\sqrt{\omega^2+1}}$$



$$\angle\theta=-180^\circ-\arctan(-\omega)=-180^\circ+\arctan\omega$$

ω	0	1	5	10	$+\infty$
$\lvert G(j\omega)\rvert$	k	$\frac{k}{\sqrt{2}}$	$\frac{k}{\sqrt{26}}$	$\frac{k}{\sqrt{101}}$	0
$\angle\theta$	-180°	-135°	-101°	-96°	-90°

$-k<-1$ 即 $k>1$ 时，$Z=N+P$，$P=1$，$N=-1$，$Z=0$，稳定

$-k>-1$ 即 $k<1$ 时，$P=1$，$N=0$，$Z=1$，不稳定

Eg.9

$$G(s)=\frac{5}{s(s+1)(s+2)}$$

$$G(j\omega)=\frac{5}{j\omega(j\omega+1)(j\omega+2)}$$

$$\frac{5}{\omega(\omega+1)(\omega+2)} = 1$$

$$\omega^3 + 3\omega^2 + 2\omega - 5 = 0$$

$$\omega = 0.9$$

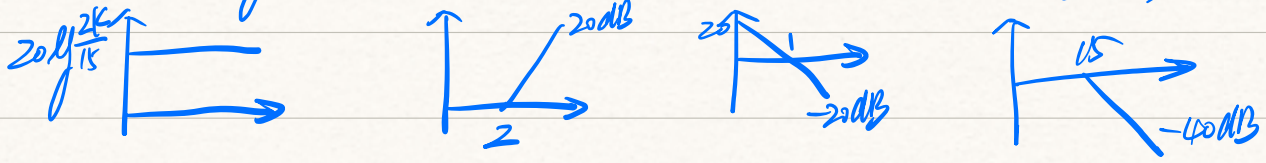
$$\angle\theta = -\frac{\pi}{2} - \arctan\omega - \arctan\frac{\omega}{2}$$

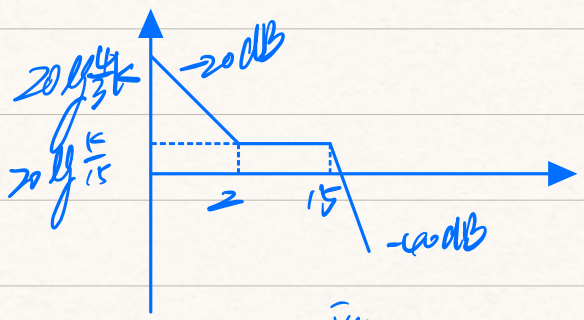
$$\angle\theta|_{\omega=0.9} = -156^\circ$$

$$\varphi = 180^\circ - 156^\circ = 24^\circ$$

E9.17 $$G(s) = \frac{K(s+2)}{s^3+2s^2+15s} = \frac{2K\left(\frac{s}{2}+1\right)}{15s\left(\frac{s^2}{15}+\frac{2s}{15}+1\right)}$$

$$G_1 = 20\lg\frac{2}{15}K \quad G_2 = \frac{s}{2}+1 \quad G_3 = \frac{1}{s} \quad G_4 = \frac{1}{\frac{s^2}{15}+\frac{2s}{15}+1}$$





$$G(j\omega) = \frac{2K\left(\frac{j\omega}{2}+1\right)}{15j\omega\left(1-\frac{\omega^2}{15}+\frac{2}{15}j\omega\right)}$$

$$\angle\theta = \arctan\frac{\omega}{2} - \frac{\pi}{2} - \arctan\frac{\frac{2}{15}\omega}{1-\frac{\omega^2}{15}}$$

$$\angle\theta = -150^\circ$$

$$\arctan\frac{2\omega}{15-\omega^2} - \arctan\frac{\omega}{2} = 60^\circ$$

$$\arctan\frac{\frac{2\omega}{15-\omega^2} - \frac{\omega}{2}}{1+\frac{\omega^2}{15-\omega^2}} = \arctan\frac{\omega^3+4\omega^2-15\omega}{30} = 60^\circ$$

$$\omega = 3.7$$

$$\frac{2k\left(\frac{5.7}{2}+1\right)}{15\times 3.7\left(1-\frac{3.7^2}{15}+\frac{2}{15}\times 3.7\right)} = 1$$

$$k = 5.7$$

$$G(s) = \frac{5.7(s+2)}{s^3+2s^2+15s}$$

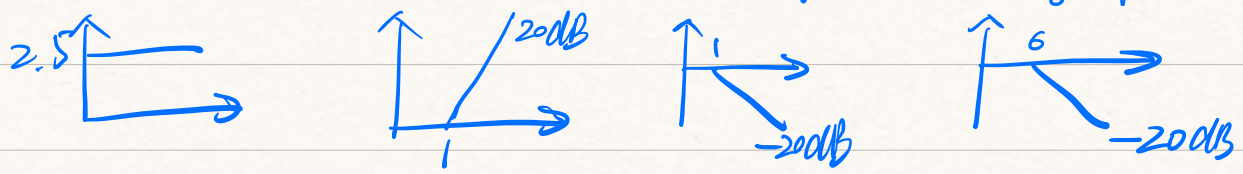
$$\frac{E(s)}{R(s)} = \frac{1}{1+G}, \quad R(s) = \frac{A}{s^2}$$

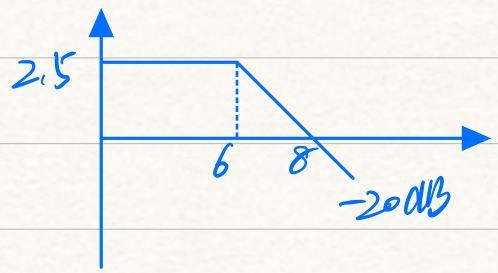
$$e_{ss} = \lim_{s\to 0} s\cdot\frac{A}{s^2}\cdot\frac{1}{1+\frac{5.7(s+2)}{s^3+2s^2+15s}} = \frac{15A}{11.4}$$

Eg.22 $\quad G(s) = \frac{K(s+1)}{(s-1)(s-6)}$

(a) $\quad G(s) = \frac{8(s+1)}{(s-1)(s-6)} = \frac{4(s+1)}{3(s-1)(\frac{s}{6}-1)}$

$G_1 = 2.5 \quad G_2 = s+1 \quad G_3 = \frac{1}{s-1} \quad G_4 = \frac{1}{\frac{s}{6}-1}$





$$G(j\omega) = \frac{8(j\omega+1)}{(j\omega-1)(j\omega-6)}$$

$$\angle\theta = \arctan\omega - [180^\circ - \arctan\omega) - (180^\circ - \arctan\frac{\omega}{6})$$

$$= 2\arctan\omega + \arctan\frac{\omega}{6} - 360^\circ$$

$$\angle\theta|_{\omega=8} = -141^\circ$$

$$\gamma = 180^\circ - 141^\circ = 39^\circ$$

(b) $\quad \angle\theta = -135^\circ$

$$2\arctan\omega + \arctan\frac{\omega}{6} - 360^\circ = -135^\circ$$

$$2\arctan\omega + \arctan\frac{\omega}{3} = 225^\circ$$

$$\arctan\frac{13\omega-\omega^2}{6-8\omega^2} = 225^\circ = 225^\circ - 180^\circ = 45^\circ$$

$$\frac{13\omega-\omega^2}{6-8\omega^2} = 1$$

$$7\omega^2 + 13\omega - 6 = 0$$

$$\omega = 0.4$$

$$\left.\frac{k(\omega+1)}{(\omega-1)(\omega-6)}\right|_{\omega=0.4} = 1$$

$$k = 2.4$$

$$k < 2.4$$

$$\frac{k}{s\left[(s-1.9j+0.5)\right]\left[(s+1.9j+0.5\right]}$$

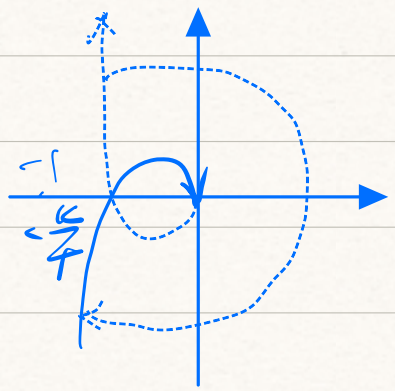
$$(s+0.5-1.9j)(s+0.5+1.9j)$$

$$-\frac{\pi}{2} - \arctan\frac{\omega-1.9}{0.5} - \arctan\frac{\omega+1.9}{0.5}$$

P9.2 (a) $GH(s) = \dfrac{k}{s(s^2+s+4)}$

$$GH(j\omega) = \frac{k}{j\omega(4-\omega^2+j\omega)}$$

$$|GH(j\omega)| = \frac{k}{\omega\sqrt{(4-\omega^2)^2+\omega^2}}$$



$$\angle\theta = -\frac{\pi}{2} - \arctan\frac{\omega}{4-\omega^2}, \quad \omega < 2$$

$$\angle\theta = -\frac{\pi}{2} - (180^\circ - \arctan\frac{\omega}{\omega^2-4}), \quad \omega > 2$$

$$= -270^\circ + \arctan\frac{\omega}{\omega^2-4}$$

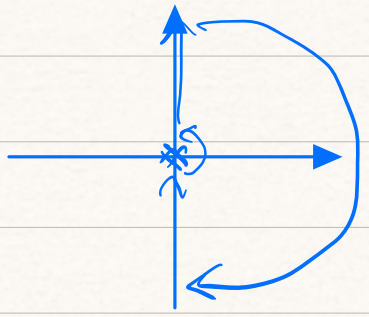
ω	0	1	5	10	$+\infty$
$\lvert GH(j\omega)\rvert$	$+\infty$	$0.3k$	$0.109k$	$0.001k$	0
$\angle\theta$	-180°	-225°	-264°	-270°	

$|GH(2)| = \frac{K}{4}$

$-\frac{K}{4} > -1$ 即 $K<4$，$Z = N+P$，$N=0$，$P=0$，稳定

$-\frac{K}{4} < -1$ 即 $K>4$，$N=2$，$P=0$，$Z=2$，不稳定

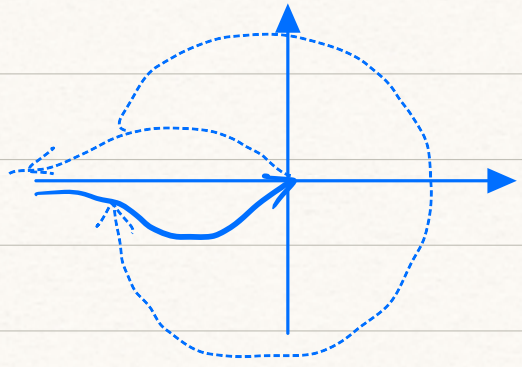
(b) $GH(j\omega) = \frac{K(j\omega+2)}{-\omega^2(j\omega+4)}$



$|GH(j\omega)| = \frac{K\sqrt{\omega^2+4}}{\omega^2\sqrt{\omega^2+16}}$

$\angle\theta = \arctan\frac{\omega}{2} - 180° - \arctan\frac{\omega}{4}$

ω	0	1	5	10	$+\infty$
$\lvert GH(j\omega)\rvert$	$+\infty$	0.5K	0.03K	0.009K	0
$\angle\theta$	$-180°$	$-167°$	$-162°$	$-167°$	$-180°$



P9.4

(a) $Z = N + P$

$N=2$，$P=0$，$Z=2$，不稳定

(b) $Z = N+P$

$N=0$，$P=0$，$Z=0$，稳定