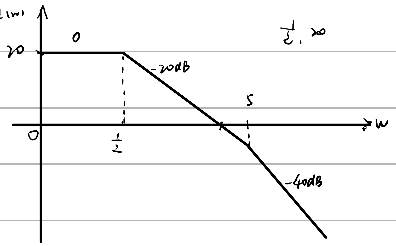
5.14 解：① $G_1(s)=\frac{50}{(2s+1)(s+5)}=\frac{10}{(2s+1)(\frac{1}{5}s+1)}$

转折频率 $w_1=\frac{1}{2}$　$w_2=5$

| 环节 | 斜率 | 累积斜率 |
|---|---|---|
| 10 | 0 | 0 |
| $\frac{1}{2s+1}$ | -20dB/dec | -20dB/dec |
| $\frac{1}{\frac{1}{5}s+1}$ | -20dB/dec | -40dB/dec |

作出伯德图




$A(w)=\frac{50}{\sqrt{4w^2+1}\sqrt{w^2+25}}$　当 $A(w_g)=1$ 时　$w_g=3.91$ rad/s

$\varphi(w)=-\arctan 2w-\arctan 0.2w$　　$\varphi(w_c)=\varphi(3.91)=-121°$

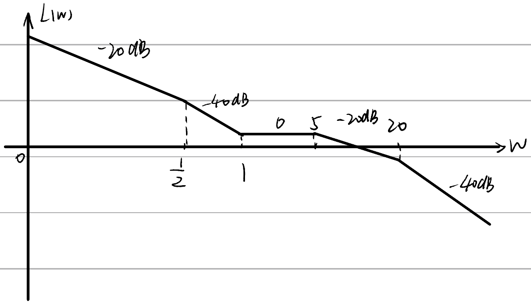
故相位裕度 $\gamma=180°+\varphi(w_c)=59°$

由于存在59°的相位裕度，故是稳定的.

③ $G_3(s)=\frac{40(s^2+s+1)}{s(2s+1)(0.2s+1)(0.05s+1)}$

| 环节 | 转折w | 斜率 | 累积斜率 |
|---|---|---|---|
| 40 | / | 0 | 0 |
| $\frac{1}{s}$ | / | -20dB | -20dB |
| $\frac{1}{2s+1}$ | $\frac{1}{2}$ | -20dB | -40dB |
| $s^2+s+1$ | 1 | 40dB | 0 |
| $\frac{1}{0.2s+1}$ | 5 | -20dB | -20dB |
| $\frac{1}{0.05s+1}$ | 20 | -20dB | -40dB |

故幅度特性为




利用斜线近似 $L(w_g)=0$ 时 $w_g = 42.3$

$\varphi(w) = \arctan\frac{w}{1-w^2} - \frac{\pi}{2} - \arctan 2w - \arctan 0.2w - \arctan 0.05w$

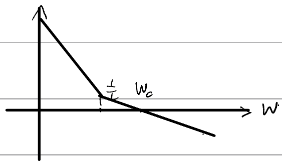
$\varphi(w_c) = -148.7^\circ$　　$\gamma = 180^\circ + \varphi(w_c) = 31.3^\circ$

存在31.3°的相位裕度 因此稳定

5.15 解: $G(s) = \frac{\tau s+1}{s^2}$　　$G(jw) = \frac{\tau jw+1}{-w^2}$

$A(w) = \frac{\sqrt{1+(\tau w)^2}}{w^2}$　　$\varphi(w) = \arctan \tau w - 180^\circ$

| 环节 | 转折频率 | 斜率 | 累计斜率 |
|---|---|---|---|
| $\frac{1}{s^2}$ | — | -40dB | -40dB |
| $\tau s+1$ | $\frac{1}{\tau}$ | 20dB | -20dB |




作出伯德图、要存在45°的相位裕度　$\varphi(w_c) = -180^\circ + 45^\circ = -135^\circ$

故 $\arctan w_c\tau = 45^\circ$　　$w_c\tau = 1$

当 $A(w)=1$ 时　$\frac{\sqrt{1+(w\tau)^2}}{w^2} = 1$　　$1+(w_c\tau)^2 = w_c^4$

$w_c = \sqrt[4]{2}$　　则 $\tau = \frac{1}{\sqrt[4]{2}} \approx 0.84$