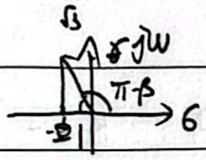
5.1

$G(s) = \frac{k}{s(0.5s+1)} = \frac{2k}{s(s+2)}$, $H(s)=1$. $\frac{C}{R} = \frac{G}{1+GH} = \frac{2k}{s^2+2s+2k}$

① $k=2$, $\frac{C}{R} = \frac{4}{s^2+2s+4} = \frac{4}{(s+1)^2+(\sqrt{3})^2} = \frac{4}{(s+1+\sqrt{3}i)(s+1-\sqrt{3}i)}$

$\therefore s_{1,2} = -1 \pm \sqrt{3}i = -\sigma \pm \omega_d i$, $\sigma = \xi \omega_n$, $\omega_d = \sqrt{1-\xi^2}\,\omega_n$, $\omega_n = 2$

$\therefore \xi = \frac{1}{2}$, $\sigma = -1$ $\omega_d = \sqrt{3}$



$t_r = \frac{\pi-\beta}{\omega_d}$. $\beta = \frac{\pi}{3}$ $\therefore t_r = \frac{2\sqrt{3}}{9}\pi\ s$

$M_p = \exp[-\pi \cdot \frac{\sigma}{\omega_d}] = e^{-\frac{\pi}{\sqrt{3}}}$

$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\sqrt{3}}$

② $k=8$. $\frac{C}{R} = \frac{16}{s^2+2s+16} = \frac{16}{(s+1)^2-(\sqrt{15}i)^2} = \frac{16}{(s+1+\sqrt{15}i)(s+1-\sqrt{15}i)}$

$s_{1,2} = -1 \pm \sqrt{15}i$, $\sigma = 1$, $\omega_d = \sqrt{15}$, $\omega_n = 4$, $\xi = \frac{1}{4}$

$\therefore t_r = \frac{\pi-\beta}{\omega_d}$, $\tan\beta = \sqrt{15} \Rightarrow \beta = 75.5^\circ = 1.32\,rad$.

$= \frac{\pi - 1.32}{\sqrt{15}} = 0.47\ s$

$M_p = \exp[-\pi \frac{1}{\sqrt{15}}] = e^{-\frac{\pi}{\sqrt{15}}}$.

$t_p = \frac{\pi}{\omega_d} = \frac{\pi}{\sqrt{15}}$

③ k对动态性能影响.

$t_r = \frac{\pi-\beta}{\omega_d}$, $\omega_d = \sqrt{2k-1}$, $\beta = \arctan\sqrt{2k-1}$ $\therefore t_r$ 随k单减

$M_p = e^{-\pi/\sqrt{2k-1}}$, M_p 随k单增.

$t_p = \frac{\pi}{\sqrt{2k-1}}$ 随k单减

5.2.

$G(s) = \frac{2k}{s(s+1)(s+4)}$. $H(s)=1$. $\frac{C}{R} = \frac{2k}{s^3+5s^2+4s+2k}$.

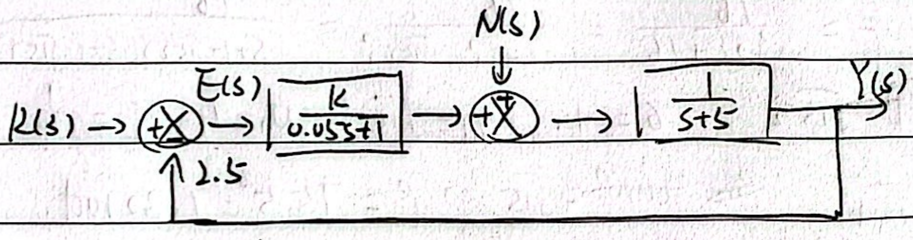
$\therefore$
$s^3 \quad 1 \quad 4$
$s^2 \quad 5 \quad 2k \qquad a_1 = \frac{20-2k}{5}.\quad a_2 = 0 \qquad$ 且 $5>0$
$s^1 \quad a_1 \quad a_2 \qquad a_3 = \frac{2a_1k - 5a_2}{a_1} = 2k \qquad \therefore a_1, a_3 > 0$
$s^0 \quad a_3 \quad a_4$

$\therefore \quad k \in (0, 10)$

$N=1$, I型系统. $k_p = G(0) = \infty$. $k_v = \cancel{2k}\, sG(0) = \frac{k}{2}$

$k_a = s^2 G(0) = 0$

5.3.



1) $k=40$, $N(s)=\frac{1}{s}$, $R(s)=0$, 求 ~~稳~~ $y_{ss}(\infty)$ 和 e_{ss}

$Y(s) = \frac{1}{s+5}\cdot\frac{800}{s+20}E(s) + \frac{1}{s+5}\cdot\frac{1}{s}$, $E(s) = -2.5Y(s)$.

$\therefore Y(s) = \frac{\frac{1}{s}(s+20)}{2000+(s+20)(s+5)}$. $y(\infty) = \lim\limits_{s\to 0} sY(s) = \frac{1}{105}$

$e_{ss} = 0 - y(\infty) = -\frac{1}{105}$ $\quad \cancel{e_{ss} = \lim\limits_{s\to 0}}$

2) $k=40$, $R(s)=\frac{1}{s}$, $N(s)=0$, 求 $y_{ss}(\infty)$ 和 e_{ss}

$\cancel{Y(s)=}\ G(s) = \frac{800}{s+20}\cdot\frac{1}{s+5}$. $H(s) = 2.5$.

$Y(s) = \frac{1}{s}\cdot\frac{G(s)}{1+G(s)H(s)} = \frac{800}{2000+(s+20)(s+5)}\cdot\frac{1}{s}$. $y(\infty) = \frac{8}{21}$

$e_{ss} = 1 - y(\infty) = \frac{13}{21}$

~~3)~~

3) $G(s)=\frac{20K}{s+20}\cdot\frac{1}{s}\cdot\frac{1}{s+5}$, $H(s)=2.5$ 对R(s)来说

$Y(s)=\frac{1}{s}\cdot\frac{20K}{s(s+20)(s+5)+50K}$ => $y(\infty)=0.4$, $e_{ss}=0.6$ 减小了.
与K无关.

对N(s)来说, $G(s)=\frac{1}{s+5}$, $H(s)=2.5\,\frac{20K}{s+20}\cdot\frac{1}{s}$

$Y(s)=\frac{s(s+20)}{s(s+20)(s+5)+50K}\cdot\frac{1}{s}$ => $y(\infty)=0$, $e_{ss}=0$, 减小了.

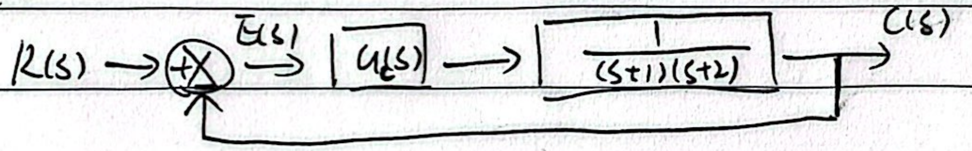
4) 对R(s)来说结果不变.

对N(s)来说, $G(s)=\frac{1}{s(s+5)}$, $H(s)=\frac{50K}{s+20}$

$Y(s)=\frac{s+20}{s(s+5)(s+20)+50K}\cdot\frac{1}{s}$ => $y(\infty)=\frac{2}{5K}$, $e_{ss}=-\frac{2}{5K}$

$K=40$时, $e_{ss}=-0.01$, 变大了.

5.4.



1) $G_c(s)=K_p$. $G(s)=\frac{G_c(s)}{(s+1)(s+2)}$, $H(s)=1$.

$\frac{C}{R}=\frac{K_p}{s^2+3s+2+K_p}$

s^2 1 $2+K_p$
s^1 3 0
s^0 $2+K_p$

令 $2+K_p>0$ => ~~$K_p<-2$~~. $K_p>-2$. 此时稳定.

$R(s)=\frac{1}{s}$ => $C(s)=\frac{1}{s}\,\frac{K_p}{s^2+3s+2+K_p}$

$C_{ss}(\infty)=\lim_{s\to 0} sC(s)=\frac{K_p}{2+K_p}$, $e_{ss}=1-C_{ss}=\frac{2}{2+K_p}$.

2) $G_c(s)=3(1+2s)$. $R(s)=\frac{1}{s}$ 求 e_{ss}.

$\frac{E}{R}=\frac{R-C}{R}=1-\frac{C}{R}=1-\frac{G}{1+GH}=1-\frac{G}{1+G}=\frac{1}{1+G}$

$G(s)=\frac{G_c(s)}{(s+1)(s+2)}=\frac{3(2s+1)}{(s+1)(s+2)}$ $E=\frac{1}{s}\,\cancel{\frac{3(2s+1)}{(s+1)(s+2)}}\cdot\frac{1}{1+\frac{3(2s+1)}{(s+1)(s+2)}}$

$e(\infty)=\lim_{s\to 0} sE(s)=\cancel{3}\cdot\frac{2}{5}$.