Q1 $y_{ss} = \lim_{s\to 0} s \cdot G(s) \cdot \frac{1}{s} = 2$

Q2 1) Type 1

2) $e_{ss} = \lim_{s\to 0} s\left(\frac{1}{s} - G(s)\frac{1}{s}\right) = -\infty$ $\quad e_{ss} = \lim_{s\to 0} \frac{sR(s)}{1+G(s)H(s)} = \frac{s\left(\frac{1}{s}\right)}{1+\frac{10}{s(s+5)}} = 0$

~~3) Since steady state error is $-\infty$, output blows upto ∞, so it~~

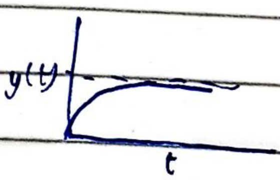
~~3) Since error in steady state in closed loop is 0,~~

3) $T(s) = \frac{G(s)}{1+G(s)} = \frac{10}{s^2+5s+10} \Rightarrow \zeta = \frac{5}{2\sqrt{10}} < 1 \Rightarrow$ underdamped $\Rightarrow$ OVERSHOOT

Q3 1) $\frac{4}{a} < 1.2 \to a > 10/3$ $\quad \frac{1}{1+K} = 0.1 \to K = 9$

2) $G_{new}(s) = \frac{9}{s+\frac{10}{3}}$

3) Shape: smooth exponential rise:



$t_s = 1.20 \to$ faster than Q1

$\lim_{t\to\infty} y(t) = 2.7 \to$ higher than Q1

Q4 1) $G(s) = \dfrac{3}{s+1}$ $\quad C(s) = K(s+z)$

$$T(s) = \frac{3K(s+z)}{s(1+3K) + (1+3Kz)}$$

zero should lie in LHP

$\therefore \boxed{z>0}$ ①

$$\text{gain} = \lim_{s\to 0} T(s) = \frac{3kz}{1+3kz} \quad ①$$

$$y_{ss} = 0.8 \Rightarrow e_{ss} = 0.2 = \frac{1}{1+\text{gain}} \Rightarrow \text{gain} = 4$$

$$\frac{3k\,z}{1+3kz} = 4 \rightarrow kz =$$

$$\text{Gain} = \lim_{s\to 0} G(s)\,C(s) = \lim_{s\to 0} \frac{3K(s+z)}{s+1} = 3Kz$$

$$e_{ss} = 0.2 = \frac{1}{1+\text{Gain}} \Rightarrow \text{gain} = 4 \Rightarrow \boxed{Kz = \frac{4}{3}} \quad ②$$

$$M_p = e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}} < 0.1 \Rightarrow \text{approx range of } \boxed{\zeta : [0.6, 1)} \quad ③$$

$$t_s = \frac{4}{\zeta\omega_n} < 2 \Rightarrow \boxed{\zeta\omega_n > 2} \quad ④$$

Let $z = 1 \Rightarrow K = \dfrac{4}{3}$, $\zeta \in [0.6, 1)$

2) $$T(s) = \frac{C(s)G(s)}{1+C(s)G(s)} \rightarrow T(s) = \frac{0.8(s+1)}{s+1}$$

3) · Adding zero lying in LHP increases overshoot.

· $y_{ss} = \dfrac{1}{1+\frac{1}{K_p}}$, $K_p = 3Kz$ $\Rightarrow$ Increasing K increases y_{ss}.

· Added zero and increased K speeds up the response

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Q5 1) OLTF = $C(s)G(s) = \frac{4}{s+1}$ ⇒ Type 0 system

2) ∞

3) $e_{ss}^{ramp} = \lim_{s\to 0} s\left(\frac{1}{s^2} - T(s)\frac{1}{s^2}\right) = \lim_{s\to 0} \frac{1-T(s)}{s}$

$T(s) = \frac{G(s)C(s)}{1+C(s)G(s)} = \frac{0.8(s+1)}{s+1}$ ⇒ $e_{ss}^{ramp} = \infty$