

Question 01/A

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$$T(s) = \frac{Y_5(s)}{Y_1(s)}$$

first path: $Y_1 \rightarrow Y_2 \xrightarrow{G_1} Y_3 \xrightarrow{G_2} Y_4 \xrightarrow{G_5} Y_5$

$$P_1 = G_1 G_2 G_5$$

second path: $Y_1 \rightarrow Y_2 \xrightarrow{G_4} Y_6 \xrightarrow{G_5} Y_5$

$$P_2 = G_4 G_5$$

⊗ single loop gain $L_1 = -G_2 H_1$ $L_2 = -G_3 H_2$

$$L_3 = -G_1 G_2 G_3 H_3 \quad L_4 = -H_4$$

$$L_5 = -G_4 G_5 H_3$$

⊗ non touching loop (L_1, L_4) (L_2, L_4) (L_3, L_4) (L_1, L_5)

$$\text{so } \Delta = 1 - (L_1 + L_2 + L_3 + L_4 + L_5) + (L_1 L_4 + L_2 L_4 + L_3 L_4 + L_1 L_5)$$

$$= 1 + G_2 H_1 + G_3 H_2 + G_1 G_2 G_3 H_3 + H_4 + G_4 G_3 H_3 + G_2 H_1 H_4 + G_3 H_2 H_4 + G_1 G_2 G_3 H_3 H_4 + G_2 G_4 G_5 H_1 H_3$$

loop not touching in first path L_4 $\Delta_1 = 1 - L_4 = \boxed{1 + H_4}$

" " " " second " L_1 $\Delta_2 = 1 - L_1 = \boxed{1 + G_2 H_1}$

①

Continue Question 1/A1

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$$T(s) = \frac{Y(s)}{U(s)} = \frac{P_1 \Delta_1 + P_2 \Delta_2}{\Delta} =$$

$$\frac{G_1 G_2 G_3 (1 + H_4) + G_4 G_5 (1 + G_2 H_1)}{1 + G_2 H_1 + G_3 H_2 + G_1 G_2 G_3 H_3 + H_4 + G_4 G_3 H_3 + G_2 H_1 H_4 + G_3 H_2 H_4 + G_1 G_2 G_3 H_3 H_4 + G_2 G_4 G_5 H_1 H_3}$$

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②

Question 01/b/

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the equation is

$$1 + \left(\frac{K}{s+2}\right) \left(\frac{1}{(0.5s+1)(s+1)}\right) \left(\frac{1}{0.005s+1}\right) = 0$$

$$\textcircled{1} \Rightarrow s^4 + 205s^3 + 1008s^2 + 1604s + 800 + 400K = 0$$

by using rooth;

s^4	1	1008	$800 + 400K$
s^3	205	1604	
s^2	$\frac{205036}{205}$	$800 + 400K$	
s^1	$\frac{73814436 - 4202500K}{51259}$		
s^0	$800 + 400K$		

for stable system first column must be positive.

$$\Rightarrow 800 + 400K > 0 \quad \& \quad 0 < \frac{73814436 - 4202500K}{51259}$$

$$\Rightarrow K > -2$$

$$K < 17.564$$

$$\therefore -2 < K < 17.564$$

$$\text{So maximum Value} = 17.564$$

(3)

(b) half maximum Value of K

$$= \frac{17.564}{2} = \boxed{8.782} \text{ --- (2)}$$

Now we will Put half maximum Value of K on ~~equation~~ equation (1)

$$s^4 + 205s^3 + 1008s^2 + 1604s + 800 + 400(8.782) = 0$$

by ~~Complex~~ Complex calculator the root is:

$$\boxed{s = -4.324}$$

$$\boxed{s = -200}$$

$$\boxed{s = -0.338 \pm j2.207}$$

(c) Complex root is:

$$s = -0.338 \pm j2.207$$

Corresponding charac. equation is:

$$(s + 0.338 + j2.207)(s + 0.338 - j2.207) = 0$$

$$\Rightarrow s^2 + 0.676s + 4.985 = 0 \text{ --- (3)}$$

Now we will compare equation (3) with $s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$

$$\Rightarrow 2\zeta\omega_n = 0.676$$

$$\sqrt{\omega_n^2} = \sqrt{4.985} = \boxed{2.2327 \frac{\text{rad}}{\mu\text{s}}}$$

$$\zeta = \frac{0.676}{2 \times 2.2327} \Rightarrow 0.15$$

(4)

$$\text{Over shoot} = e^{-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}} \times 100\% = \boxed{62.08\%}$$



Question 2/A

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$$K_m = 30$$

$$R_f = 1 \Omega$$

$$K_t = K_b = 1$$

$$d = 0.1$$

$$b = 1$$

$$\frac{1}{s(s+1)} = \frac{1}{s(0.1s+1)} = \frac{10}{s(s+10)}$$

$$\frac{K_m}{R_f} = \frac{30}{1} = 30 \quad K_t = 1$$

$$\Phi(s) = K_i K \cdot \frac{K_m}{R_f} \cdot \frac{1}{s(s+10)}$$

$$1 + K_t \cdot K \cdot \frac{K_m}{R_f} \cdot \frac{1}{s(s+10)}$$

$$\Phi(s) = (K_i)(K)(30) \frac{1}{s(0.1s+1)}$$

$$1 + (K_t)(K)(30) \frac{1}{s(0.1s+1)}$$

~~22 K_t = K_b = 1~~

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Question 2/A

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$$K_m = 30$$

$$R_f = 1 \Omega$$

$$K_t = K_b = 1$$

$$d = 0.1$$

$$b = 1$$

$$\frac{1}{s(js+b)} = \frac{1}{s(0.1s+1)} = \frac{10}{s(s+10)}$$

$$\frac{K_m}{R_f} = \frac{30}{1} = 30 \quad K_t = 1$$

$$\Theta(s) = K_i K \cdot \frac{K_m}{R_f} \cdot \frac{1}{s(js+b)}$$

$$1 + K_t \cdot K \cdot \frac{K_m}{R_f} \cdot \frac{1}{s(js+b)}$$

$$\Theta(s) = (K_i)(K)(30) \cdot \frac{1}{s(0.1s+1)}$$

$$1 + (K_t)(K)(30) \cdot \frac{1}{s(0.1s+1)}$$

~~Answer is not~~

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Continue Question 2/

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⑥

$$T_d = \frac{1}{s} \cdot \Theta_i(t) = 0$$

$$\frac{\Theta(s)}{T_d(s)} = \frac{G_d(s)}{1 + G(s)H(s)}$$

$$G_d(s) = \frac{1}{s(0.1s + 1)}$$

$$= \frac{1}{s(0.1s + 1)}$$

$$\frac{\Theta(s)}{T_d(s)} = \frac{1}{s(0.1s + 1)} \cdot \frac{1}{1 + \frac{30k}{s(0.1s + 1)}}$$

$$= \frac{1}{s(0.1s + 1) + 30k} \quad (k = 20)$$

$$\frac{\Theta(s)}{T_d(s)} = \frac{1}{0.1s^2 + s + 6000}$$

$$T_d(s) = \frac{1}{s}$$

$$\therefore \frac{1}{s(0.1s^2 + s + 6000)}$$

$$\Theta_s = \lim_{s \rightarrow 0} s \Theta(s) = \frac{1}{600} = 0.00167$$

⑦

Continue Question 2 /
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(C) $r(t) = t$, $T_d(s) = 0$

$$R(s) = \frac{1}{s^2}$$

$$E(s) = \frac{R(s)}{1 + G(s)H(s)} = \frac{1/s^2}{1 + 30k \cdot \frac{s(0.1s + 1)}{s(0.1s + 1) + 30k}}$$

$$= \frac{1}{s^2} \cdot \frac{s(0.1s + 1)}{s(0.1s + 1) + 30k}$$

$$e_{ss} = \lim_{s \rightarrow 0} sE(s) = \lim_{s \rightarrow 0} \frac{0.1s^2 + s}{s(0.1s + 1) + 30k} = \frac{s}{30k}$$

$$\text{Type (1)} = KV = \lim_{s \rightarrow 0} sG(s) = 30k \Rightarrow e_{ss} = \frac{1}{KV}$$

$$= \frac{1}{30k}$$

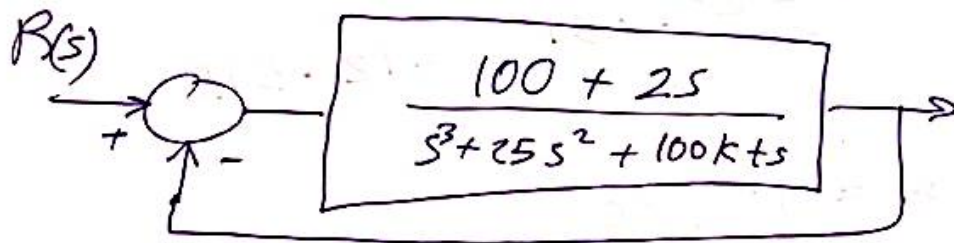
$$e_{ss} = \frac{1}{600}$$

(E)

Question 03/

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$$\frac{100}{s^2 + (s + 25)} = \frac{100}{s^2(s + 25) + 100ks}$$



$$\text{The close loop } T(s) = \frac{100 + 25s}{s^3 + 25s^2 + 100ks + 100 + 25s}$$

$$= \frac{100 + 25s}{s^3 + 25s^2 + 100ks + 100 + 25s}$$

∴ closed loop characteristics:

$$1 + KG(s)H(s) = s^3 + 25s^2 + 100ks + 100 + 25s$$

$$= 1 + \frac{100ks}{s^3 + 25s^2 + 25s + 100}$$

①

Continue Question 3/

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$n = \text{number of poles} = 3, -25, 07, 0, 0.39 \pm j-1.99$
 $m = \text{Zeros} = 1, 0$

$$\alpha = 3 - 1 = 2$$

$$\sigma_m = \frac{-25 - 0.39}{2} = -12.515$$

$$\theta_m = r \frac{180^\circ}{\alpha} = \pm 90$$

$$\text{break point} = \frac{2}{2s} \left[\frac{100s}{s^3 + 25s^2 + 25} \right] = 0$$

$$= \frac{100 (-2x^3 - 25x^2 + 100)}{(x^3 + 25x^2 + 2x + 100)}$$

$$\text{Break Point} = 1.865 \times$$

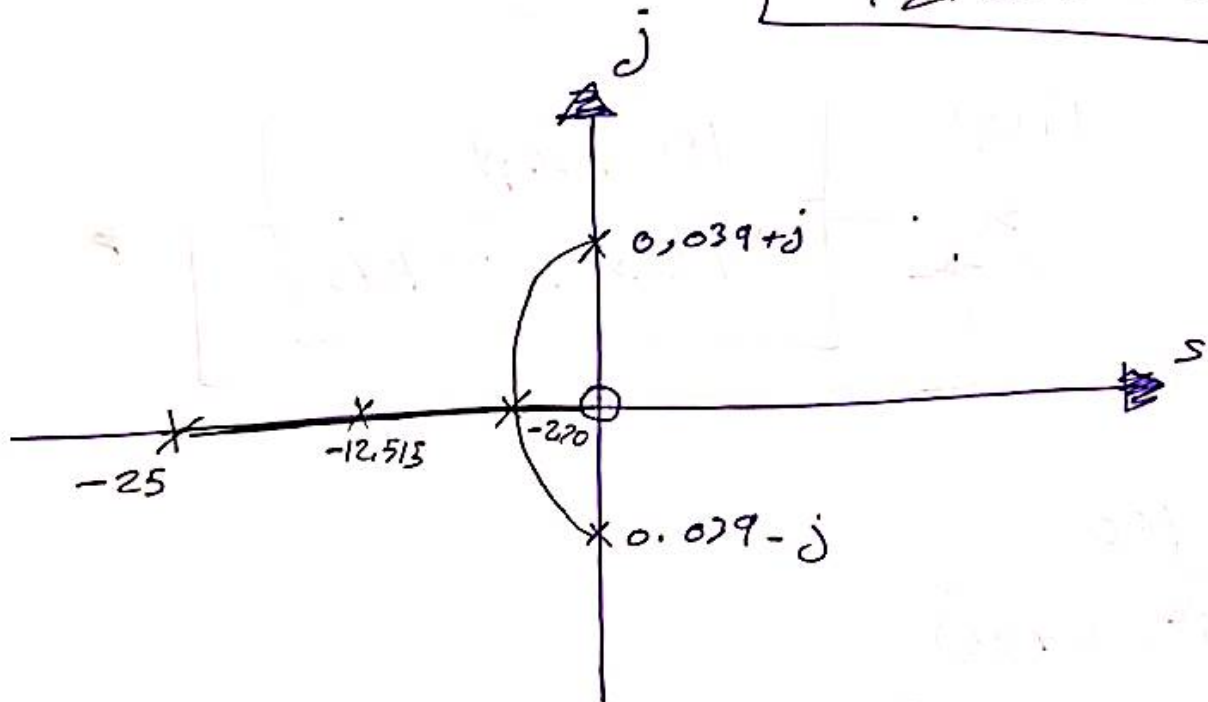
$$-2.203$$

$$-12.161$$

(10)

Continue Question 03/

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Question 4A/

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$$G(s) = \left(\frac{s+k}{s+p} \right) \left(\frac{10}{s+25} \right)$$

$$T(s) = \frac{G(s)}{1+G(s)} = \frac{10(s+k)}{(s+p)(s+25) + (10)(s+k)}$$

$$T(s) = \frac{10(s+k)}{s^2 + (p+25)s + 25p + 10s + 10k}$$

$$T(s) = \frac{10(s+k)}{s^2 + (p+35)s + (25p+10k)}$$

$$M_p = e^{-\pi \xi / \sqrt{1-\xi^2}} \leq 0.25$$

$$\boxed{\xi = 0.405714} \leftarrow \text{by ln}$$

$$T_s = 0.1 \text{ sec}$$

$$T_s = \frac{4}{\xi \omega_n} = 0.1$$

$$\boxed{\omega_n = 99.08}$$

(12)

Continue Question 4A/

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$$\begin{aligned} \rightarrow s^2 + (P + 35)s + (25P + 10K) &= \\ \hookrightarrow s^2 + 2\xi\omega_n s + \omega_n^2 & \end{aligned}$$

$$P = 44.9 \approx \boxed{45}$$

$$K = \boxed{864.184}$$

(13)

Question 4/6/

$$\frac{X(s)}{u(s)} = \frac{2s^2 + 6s + 5}{s^3 + 4s^2 + 5s + 2} = \frac{2s^2 + 6s + 5}{(s+1)^2(s+2)}$$

$$\frac{X(s)}{u(s)} = \frac{A}{(s+1)^2} + \frac{B}{(s+1)} + \frac{C}{(s+2)}$$

$$A = \frac{d}{ds} \left(\frac{(2s^2 + 6s + 5)(s+1)^2}{(s+1)^2(s+2)} \right) = \frac{2x^2 + 8x + 7}{(2+x)^2} \Big|_{s=-1} = \boxed{1}$$

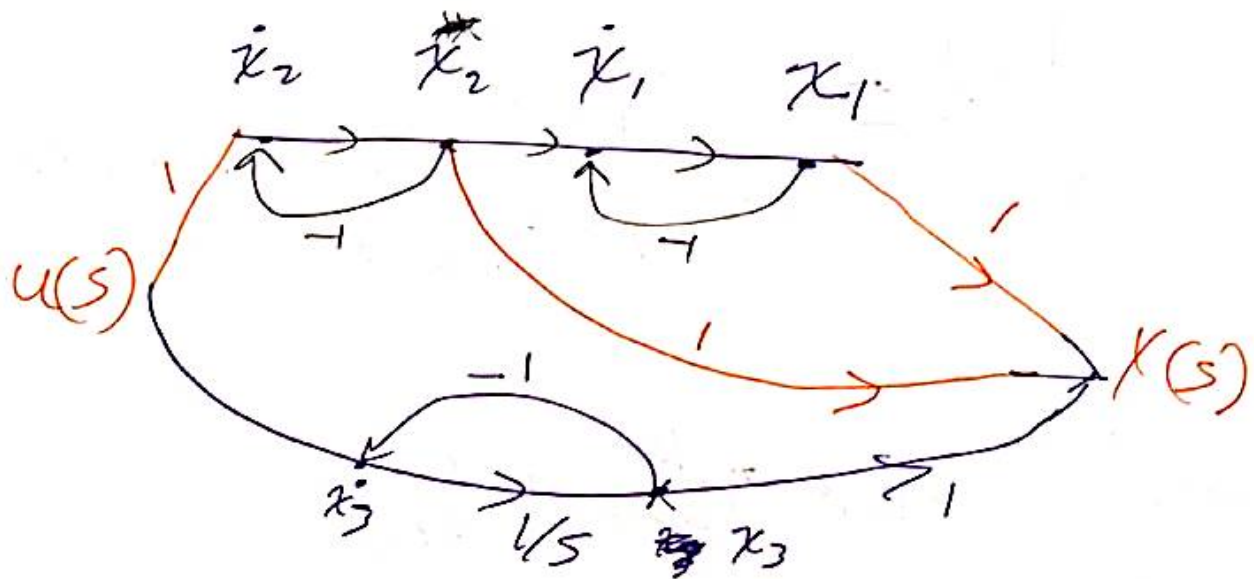
$$B = \frac{2s^2 + 6s + 5}{(s+2)} \Big|_{s=-1} = \boxed{1}$$

$$C = \frac{2s^2 + 6s + 5}{(s+1)^2} \Big|_{s=-2} = \boxed{1}$$

$$\frac{X(s)}{u(s)} = \frac{1}{(s+1)^2} + \frac{1}{(s+1)} + \frac{1}{(s+2)}$$

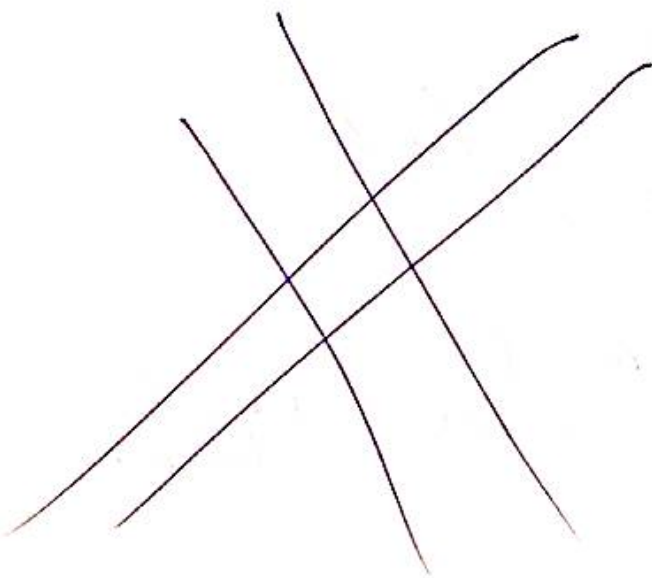
(1.4)

Continue Question 4/6/



$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} -1 & -1 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix} u(s)$$

$$y(s) = [1 \ 1] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$



(5)

Continue Question 2/1/1 | أستاذة المصنف خالد
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a) $K_i = K_f = 1$

$$G(s) = \frac{30K}{s(0.1s+1)} \rightarrow T(s) = \frac{G(s)}{1+G(s)} = \frac{30K}{s(0.1s+1)+30K}$$

$$T(s) = \frac{30K}{0.1s^2 + s + 30K} \quad K=20$$

$$T(s) = \frac{6000}{0.1s^2 + s + 6000}$$

$$\omega_n^2 = 6000 \Rightarrow \boxed{\omega_n = 77.46}$$

$$T_r = \frac{\pi}{\omega_d} = \frac{\pi}{\omega_n \sqrt{1-\xi^2}} = 0.0406s$$

Overshoot $M_p = e^{-\pi\xi/\sqrt{1-\xi^2}} \times 100 = 81.6\%$

$$\Theta(t) = 1 - e^{-\xi\omega_n t} \left(\cos(\omega_d t) + \frac{\xi}{\sqrt{1-\xi^2}} \sin(\omega_d t) \right)$$

$$\Theta(t) = 1 - e^{-5t} \left(\cos(77.186) + 0.0645 \sin(77.186) \right)$$

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