

72857  
Control System Solution

Q.2 A]

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

dynamic error - Coefficients are

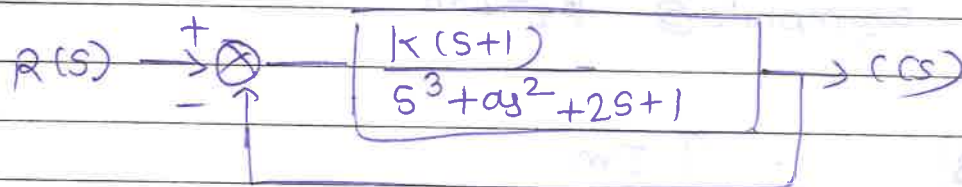
$$k_0 = \lim_{s \rightarrow 0} \left[ \frac{0.1s^2 + s}{0.1s^2 + s + 10} \right] = 0$$

$$k_1 = \lim_{s \rightarrow 0} \frac{d}{ds} \left[ \frac{0.1s^2 + s}{0.1s^2 + s + 10} \right] = 0.1$$

$$k_2 = \lim_{s \rightarrow 0} \frac{d^2}{ds^2} \left[ \frac{0.1s^2 + s}{0.1s^2 + s + 10} \right] = 0$$

Q.2 B]

$$k_{max} = 2 \quad \& \quad \alpha = 0.75$$



$$s^3 + as^2 + (k+2)s + (k+1) = 0 \quad \text{--- char. eqn}$$

from Routh's array we get  $a > \frac{k+1}{k+2}$

So s/m will marginally stable,

$$k_{max} = 2 \quad \& \quad \alpha = 0.75$$

Q.3 A]

$$G(s)H(s) = \frac{C}{s(s+C)}$$

i]  $M_p = 40\%$

$$0.4 = e^{-\frac{\pi \zeta}{\sqrt{1-\zeta^2}}}$$

$$\zeta^2 = 0.078 \quad \therefore \zeta = \pm 0.28$$

Since  $\zeta \geq 0 \quad \therefore \zeta = 0.28$

$$\zeta = \frac{\sqrt{C}}{2} \quad C = 0.3136, \quad \omega_n = \sqrt{C} = 0.56$$

ii]  $\omega_r = \omega_n \sqrt{1-2\zeta^2} = 0.514 \text{ rad/sec}$

$$M_r = \frac{1}{2\zeta \sqrt{1-\zeta^2}} = 1.86$$

→ path b-c-d maps on origin.  
 → path d-e (mirror image of path a-b)

$$\angle q(j\omega)H(j\omega) = -180^\circ$$

at  $\omega = \infty$  ;  $|q(j\omega)H(j\omega)| = 0$

$$\angle q(j\omega)H(j\omega) = 0$$

at  $\omega = 0$  ;  $|q(j\omega)H(j\omega)| = 25$

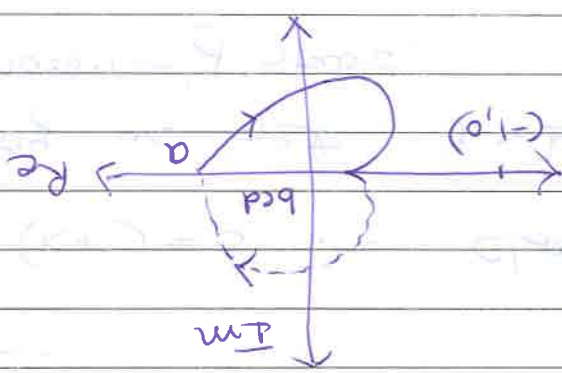
→ path a-b

path d-e  $S = -j\omega$

path b-c-d  $S = \lim_{R \rightarrow \infty} R e^{j\theta}$

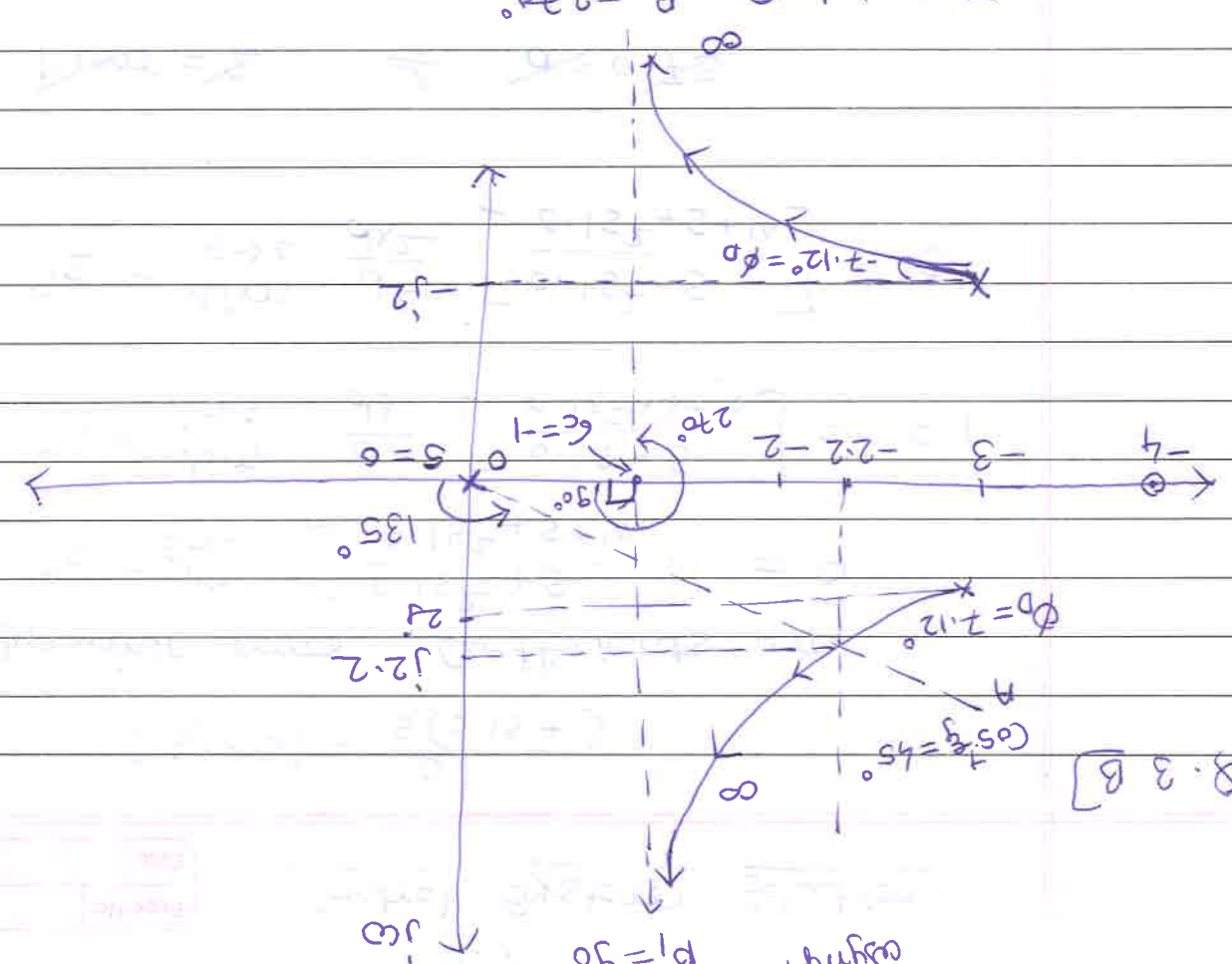
→ Nyquist paths are path a-b =  $S = j\omega$

S/m is stable  
 $(N = P - Z \therefore Z = P - N)$   
 $(Z = 0)$



Q. 4. B

asymptote @  $\theta_2 = 270^\circ$



Q. 3 B

asymptote @  $\theta_1 = 90^\circ$

Q. 6. A]  $G(s)H(s) = \frac{K}{s(s+2)(s+4)}$

→ magnitude plot table:

Factor	Slope	Start pt.	End pt.
1. $1/j\omega$	$-20 \text{ dB/sec}$	0.1	2
2. $\frac{1}{(1 + \frac{j\omega}{2})}$	$-40 \text{ dB/sec}$	2	4
3. $\frac{1}{(1 + \frac{j\omega}{4})}$	$-60 \text{ dB/sec}$	4	$\infty$

→ phase angle table

$$\phi_{\text{resultant}}(\omega) = -90^\circ - \tan^{-1}\left(\frac{\omega}{2}\right) - \tan^{-1}\left(\frac{\omega}{4}\right)$$

1) to get gain margin of 20 dB, we need to shift the mag. curve by 8 dB in downward direction

$$20 \log K_1 = -8 \text{ dB} \quad K_1 = 0.398$$

$$\text{but } K_1 = \frac{K}{8} \quad K = 3.18$$

2) to get phase margin of  $60^\circ$  we need to shift the mag. curve by 4 dB in downward direction

$$20 \log K_1 = -4 \text{ dB} \quad K_1 = 0.6$$

$$K_1 = \frac{K}{8} \quad K = 5.04$$



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$$u' = \frac{v}{c} \quad K = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

at rest in the rest frame

of length  $L_0$  moving with velocity  $v$  in the  $x$  direction. The length of the rod in the rest frame is  $L$ .

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

at rest in the rest frame

of length  $L_0$  moving with velocity  $v$  in the  $x$  direction. The length of the rod in the rest frame is  $L$ .

at rest in the rest frame

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

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at rest in the rest frame of length  $L_0$  moving with velocity  $v$  in the  $x$  direction. The length of the rod in the rest frame is  $L$ .

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}}$$

