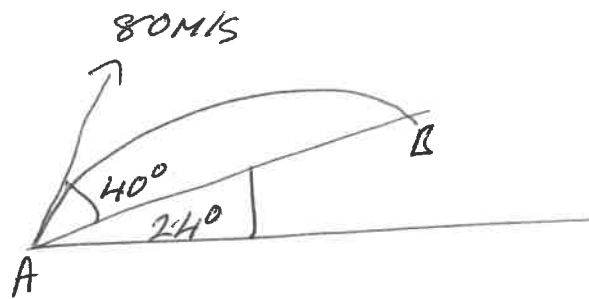


Question

marks

Q₁



RESOLVE SUVAT QUANTITIES.

	HORIZONTAL	⊥ TO PLANE	ALONG PLANE	
U	80 cos(64)	80 sin(40)	80 cos(40)	(1)
V	80 cos(64)			
a	0	-9.81 cos(24)	-9.81 cos(66)	(1)
t	t			
s	s	0		

Applying SUVAT
⊥ TO PLANE

$$s = ut + \frac{1}{2}at^2$$

$$0 = 80 \sin(40)t + \frac{-9.81 \cos(24)t^2}{2}$$

$$0 = 80 \sin(40)t - 4.905 \cos(24)t^2$$

$$0 = t(80 \sin(40) - 4.905 \cos(24)t)$$

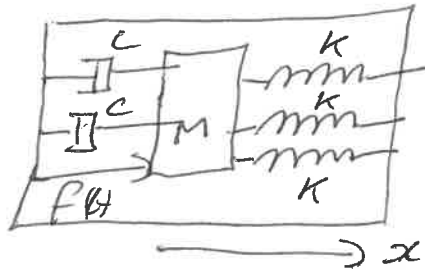
∴ TWO SOLUTIONS. FOR $s = 0$.

① $t = 0$ - i.e. AT START OF TRAVEL.

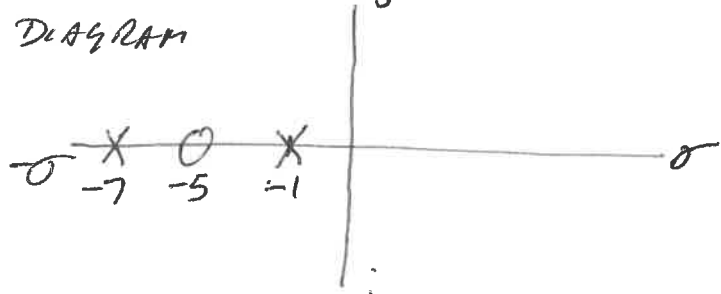
$$②. (80 \sin(40) - 4.905 \cos(24)t) = 0$$

$$\therefore t = \frac{80 \sin(40)}{4.905 \cos(24)} = 11.47 \text{ sec. (1)}$$

Question		marks
Q2	a) PARTICLE (A) $S = 17t^2 + 10t$ PARTICLE (B) $S = 9t^2 + 30$. Velocity (A) = $\frac{dS}{dt} = 34t + 10$. (1) Velocity (B) $\frac{dS}{dt} = 18t$. (1) When $V_{(A)} = 2V_{(B)}$. (1) $34t + 10 = 2 \times (18t)$. (1) $34t + 10 = 36t$ $36t - 34t = 10$ $2t = 10$ $\therefore t = 5 \text{ Seconds}$. (1) b) DISTANCE TRAVELLED BY (A) + (B) @ $t = 0$ $S_{(A)} = 17(0)^2 + 10(0) = 0$. @ $t = 4$ $S_{(A)} = 17 \times 4^2 + 10 \times 4 = 312 \text{ M}$ (2) $\therefore$ A TRAVELLS $312 - 0 = 312 \text{ M}$. @ $t = 0$ $S_{(B)} = 9(0)^2 + 30 = 30$. @ $t = 4$ $S_{(B)} = 9(4)^2 + 30 = 174$ (2) $\therefore$ B TRAVELLS $174 - 30 = 144 \text{ M}$. c) Acc (A) = $\frac{dV}{dt} = 34$ @ 1 sec = 34 M/S^2. (1)	

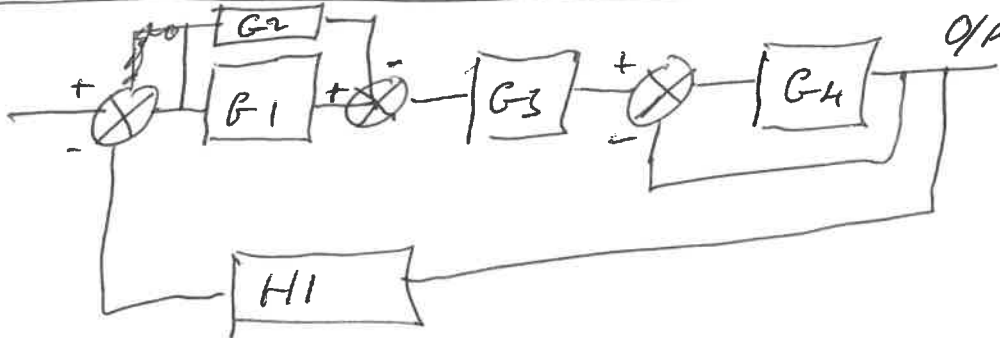
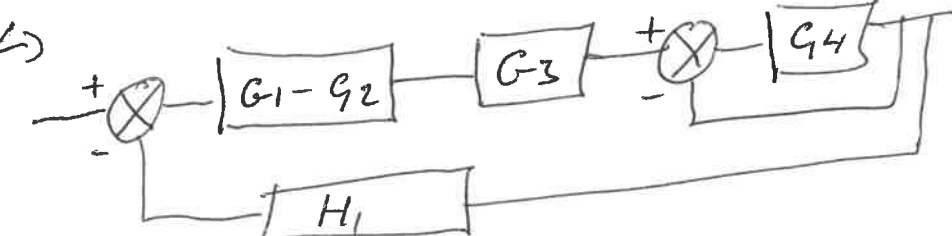
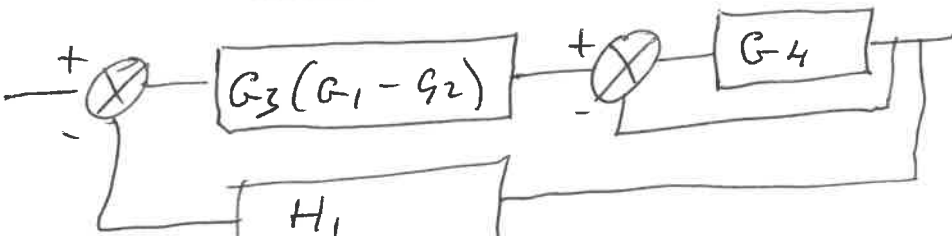
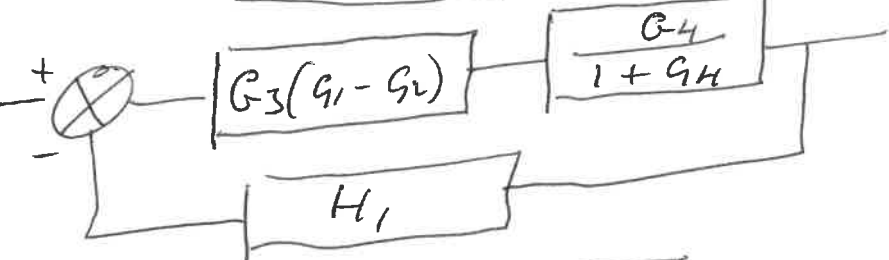
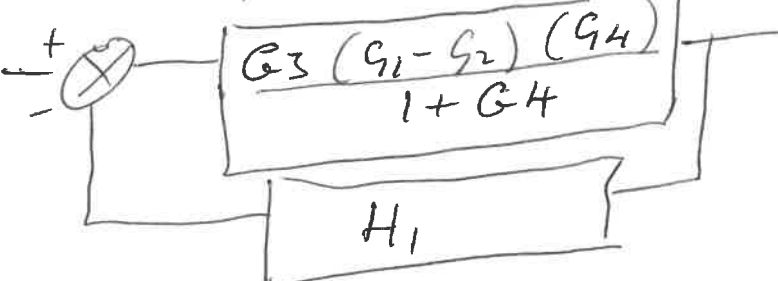
Question		marks
Q3	 $\longrightarrow x$	
a)	TRANSFER FUNCTION = $\frac{Q_o}{Q_i}$ INPUT FORCE = $F(t) = M a. = M \frac{d^2 x}{dt^2}$ (1) RESTORING FORCES DUE TO SPRINGS. ASSUMING LINEAR REGION - HOOKE'S LAW. $F_{spring} = K x$. $\therefore$ 3 SPRINGS = $3 K x$. RESISTING FORCE DUE TO DAMPERS $= C \frac{dx}{dt}$ $\therefore$ 2 DAMPERS = $2 C \frac{dx}{dt}$ (1) RESULTANT FORCE $= F(t) - F_{spring} - F_{damper} = M a.$ (1) $\therefore F(t) - 3 K x - 2 C \frac{dx}{dt} = M \frac{d^2 x}{dt^2}$ (1) $F(t) = M \frac{d^2 x}{dt^2} + 2 C \frac{dx}{dt} + 3 K x$ (1) TAKE Laplace Transform INITIAL CONDITIONS = 0. $F(s) = M s^2 X(s) + 2 C s X(s) + 3 K X(s).$ (1) $F(s) = X(s) (M s^2 + 2 C s + 3 K).$ TF = $\frac{X(s)}{F(s)} = \frac{1}{M s^2 + 2 C s + 3 K}.$ (1)	

Question		marks
Q3 b)	$M=5, C=3, K=10.$ $\therefore TF = \frac{1}{5s^2 + 6s + 30}$ STANDARD FORM FOR SECOND ORDER SYSTEM $\frac{K \omega_n^2}{s^2 + 2\zeta s \omega_n + \omega_n^2}$ $\therefore TF = \frac{\frac{1}{5}}{s^2 + \frac{6}{5}s + 6.}$ CORRELATING TERMS. $\omega_n^2 = 6 \therefore \omega_n = \sqrt{6} = 2.449 \text{ RAD/S.}$ $\text{OR } \frac{2.449}{2\pi} \text{ Hz} = 0.389 \text{ Hz.}$	(1) (1) (1) (1) (1)
c)	$2\zeta \omega_n = \frac{6}{5}$ $\therefore 2\zeta \times 2.449 = \frac{6}{5}$ $\zeta = \frac{6}{5 \times 2 \times 2.449} = 0.245.$	(1) (1) (1)
d).	0.245 is < 1 $\therefore$ SYSTEM IS UNDER DAMPED.	(1)

Question		marks
Q4 a)	$G(s) = \frac{s+5}{s^2+8s+7} = \frac{(s+5)}{(s+1)(s+7)}$ ZERO AT -5, POLES AT -1, -7. PZ DIAGRAM  ALL POLES IN LEFT HAND PLANE ∴ SYSTEM IS STABLE.	(1) (1) (1) (1)
b)	D.C. RESPONSE PUT $s=0$ $\therefore \frac{0+5}{0^2+8(0)+7} = \frac{5}{7}$	(2) (1)
c)	APPLYING A UNIT STEP. $= \frac{1}{s} \frac{(s+5)}{s^2+8s+7} \quad \text{OR} \quad \frac{(s+5)}{s(s+1)(s+7)}$ USE PARTIAL FRACTIONS $\frac{(s+5)}{s(s+1)(s+7)} = \frac{A}{s} + \frac{B}{(s+1)} + \frac{C}{(s+7)}.$	(1)

Question		marks
Q4c CONT	$\therefore (S+5) = A(S+1)(S+7) + B S (S+7) + C S (S+1)$ $S=0 \quad 5 = A(0+1)(0+7) = 7A.$ $A = \frac{5}{7} \quad (\text{AS BEFORE})$ $S=-1$ $(-1+5) = B(-1)(-1+7).$ $4 = -6B. \quad B = -\frac{4}{6} = -\frac{2}{3}$ $S=-7.$ $(-7+5) = C(-7)(-7+1).$ $-2 = 42C.$ $C = -\frac{1}{21}$ $\therefore \frac{(S+5)}{S(S+1)(S+7)} = \frac{5}{7S} - \frac{2}{3(S+1)} - \frac{1}{21(S+7)}$ convert to time domain. $\mathcal{L}^{-1} y = \frac{5}{7} + \frac{2}{3} e^{-t} - \frac{1}{21} e^{-7t}$ @ $t=2$ with mag 3 step $y = \frac{15}{7} - 2e^{-2} - \frac{3}{21} e^{-21}$ $= 1.872. \quad \text{Ans}$	(1) (1) (1) (1) (1)

Question		marks																														
Q5.	$2s^5 + 3s^4 + 2s^3 + s^2 - s + 4.$ Rough Method. <table style="border-collapse: collapse; margin-right: 20px;"> <tr><td style="padding: 5px;">s^5</td><td style="border-right: 1px solid black; padding: 5px; text-align: center;">2</td><td style="padding: 5px; text-align: center;">2</td><td style="padding: 5px; text-align: center;">-1</td><td style="padding: 5px; text-align: center;">0</td></tr> <tr><td style="padding: 5px;">s^4</td><td style="border-right: 1px solid black; padding: 5px; text-align: center;">3</td><td style="padding: 5px; text-align: center;">1</td><td style="padding: 5px; text-align: center;">4</td><td style="padding: 5px; text-align: center;">0</td></tr> <tr><td style="padding: 5px;">s^3</td><td style="border-right: 1px solid black; padding: 5px; text-align: center;">$\frac{4}{3}$</td><td style="padding: 5px; text-align: center;">$-\frac{11}{3}$</td><td style="padding: 5px; text-align: center;">0</td><td style="padding: 5px;"></td></tr> <tr><td style="padding: 5px;">s^2</td><td style="border-right: 1px solid black; padding: 5px; text-align: center;">$\frac{37}{4}$</td><td style="padding: 5px; text-align: center;">4</td><td style="padding: 5px; text-align: center;">0</td><td style="padding: 5px;"></td></tr> <tr><td style="padding: 5px;">s^1</td><td style="border-right: 1px solid black; padding: 5px; text-align: center;">$-\frac{157}{37}$</td><td style="padding: 5px; text-align: center;">0</td><td style="padding: 5px; text-align: center;"></td><td style="padding: 5px;"></td></tr> <tr><td style="padding: 5px;">s^0</td><td style="border-right: 1px solid black; padding: 5px; text-align: center;">4</td><td style="padding: 5px; text-align: center;">0</td><td style="padding: 5px; text-align: center;"></td><td style="padding: 5px;"></td></tr> </table> ~~$\frac{37}{4}$ 4~~ $\frac{37}{4}$ 4 $-\frac{157}{37}$ 0 $\frac{37}{4}$ $-\frac{157}{37}$ (2) (2) (2) (2) BUILD TABLE VALUES. $s_1 = - \frac{\begin{vmatrix} 2 & 2 \\ 3 & 1 \end{vmatrix}}{3} = - \frac{(2 - 6)}{3} = \frac{4}{3}$ $s_2 = - \frac{\begin{vmatrix} 2 & -1 \\ 3 & 4 \end{vmatrix}}{3} = - \frac{(8 + 3)}{3} = -\frac{11}{3}$ $s^2 = - \frac{\begin{vmatrix} 3 & 1 \\ \frac{4}{3} & -\frac{11}{3} \end{vmatrix}}{\frac{4}{3}} = - \frac{(-\frac{33}{3} - \frac{4}{3})}{\frac{4}{3}} = + \frac{37}{4}$ $s_1^2 = - \frac{\begin{vmatrix} 3 & 4 \\ \frac{4}{3} & 0 \end{vmatrix}}{\frac{4}{3}} = 4.$ $s^1 = - \frac{\begin{vmatrix} \frac{4}{3} & -\frac{11}{3} \\ \frac{37}{4} & 4 \end{vmatrix}}{\frac{37}{4}} = - \frac{\frac{16}{3} + \frac{407}{12}}{\frac{37}{4}} = -\frac{157}{37}$	s^5	2	2	-1	0	s^4	3	1	4	0	s^3	$\frac{4}{3}$	$-\frac{11}{3}$	0		s^2	$\frac{37}{4}$	4	0		s^1	$-\frac{157}{37}$	0			s^0	4	0			
s^5	2	2	-1	0																												
s^4	3	1	4	0																												
s^3	$\frac{4}{3}$	$-\frac{11}{3}$	0																													
s^2	$\frac{37}{4}$	4	0																													
s^1	$-\frac{157}{37}$	0																														
s^0	4	0																														

Question		marks
Q5 CONT	THERE ARE TWO CHANGES OF SIGN IN 1ST COLUMN $\therefore$ SYSTEM IS UNSTABLE WITH 2 POLES IN RH PLANE.	(2)
Q6 a)	 $\hookrightarrow$    	(1) (1) (1)

P.T.O

Question		marks
Q6a CONT	$= \frac{G_3 G_4 (G_1 - G_2)}{(1 + G_4)}$ $1 + \frac{G_3 G_4 H_1 (G_1 - G_2)}{(1 + G_4)}$ $= \frac{G_3 G_4 (G_1 + G_2)}{1 + G_4 + G_3 G_4 H_1 (G_1 - G_2)}$ ANS	(1) (1)
Q6b.	$= - \left[\frac{5mV/Pa}{0.4mV/deg} \right] \times 100 \times 2^\circ/V$ $= - \frac{5mV/Pa}{0.4mV/deg} \times 200^\circ/V$ $= - \frac{5mV/Pa}{0.4mV/deg} \times \frac{200^\circ/V}{1 + 200 \times 0.4 \times 10^{-3}}$ $= - \frac{5mV}{Pa} \times \frac{200}{\frac{27}{25}} = - \frac{27}{25}$ ↑ deg/V PTO	(1) (1) (1)

Question		marks
Q66 CONT	$\varepsilon = \left[\frac{.25}{27} \right]$ deg/Pa. $\times 1000 \text{ Pa} = 925.925^\circ.$ ANS	(1) (1)