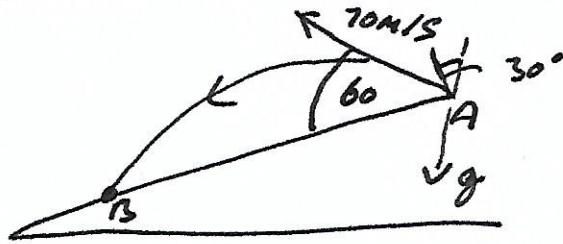


DYNAMICS CONTROL AND INSTRUMENTATION
M4X01405.

MAY 2021 - EXAM SOLUTIONS.

Q.



$\perp$ TO PLANE $u = 70 \sin 60^\circ$
 $s =$ $s = 0$
 $a = -g \cos 30^\circ$

$$s_0 = ut + \frac{1}{2} at^2$$

$$0 = ut + \frac{1}{2} at^2 \Rightarrow 0 = t(u + \frac{1}{2} at)$$

SOLUTION @ $t=0$ * START CONDITION

SOLUTION @ $u + \frac{1}{2} at = 0$

$$70 \sin 60 \Rightarrow \frac{1}{2} 9.81 \cos 30 t = 0$$

$$t = \frac{2 \times 70 \sin 60}{9.81 \cos 30} = 14.271 \text{ s}$$

b) u ALONG PLANE = $70 \cos 60$

a ALONG PLANE = $9.81 \cos 60$

$t = 14.271$ $s = ut + \frac{1}{2} at^2$

$$s = 70 \cos 60 \times 14.271 + \frac{1}{2} 9.81 \cos 60 \times 14.271^2$$

$$= 999 \text{ m}$$

Q2). A. $S = 3t^2 + 10t - 8$

$$VEL = \frac{ds}{dt} = 6t + 10 \text{ m/s}$$

$$Acc = \frac{dv}{dt} = 6 \text{ m/s}^2 \quad (1)$$

B. $S = 7t^3 + 4t^2 + 4$

$$VEL = \frac{ds}{dt} = 21t^2 + 8t$$

$$Acc = \frac{dv}{dt} = 42t + 8 \quad (1)$$

C. $S = 10t^3 + 30t + 2$

$$VEL = \frac{ds}{dt} = 30t^2 - 30$$

$$Acc = \frac{dv}{dt} = 60t \quad (1)$$

a) $VEL_B = 3 VEL_A$

$$21t^2 + 8t = 3(6t + 10)$$

$$21t^2 + 8t = 18t + 30$$

$$21t^2 - 10t - 30 = 0 \quad (1)$$

$$t = \frac{10 \pm \sqrt{100 + 2520}}{42} = \frac{10 \pm \sqrt{2620}}{42}$$

$$= \frac{10 \pm 51.18}{42} = \frac{61.18}{42} = 1.457 \text{ s} \quad (1)$$

OTHER SOLUTION IS TRIVIAL.

Q2 FOR A. $S = 3t^2 + 10t - 8$

$A_v = \frac{dS}{dt} = 6t + 10 \text{ m/s} \longrightarrow \textcircled{1}$

$A_a \frac{dv}{dt} = 6 \text{ m/s}^2 \text{ (PART B)}$

FOR B $S = 7t^3 + 4t^2 + 4$

$B_v = 21t^2 + 8t \longrightarrow \textcircled{1}$

$B_a = 42t + 8 \text{ (PART B)}$

FOR C $S = 10t^3 - 30t + 2$

$C_v = 30t^2 - 30 \longrightarrow \textcircled{1}$

$C_a = 60t \text{ (PART B)}$

$B_v = 3A_v$

$\therefore 21t^2 + 8t = 3(6t + 10)$

$21t^2 - 10t - 30 = 0$

$t = \frac{10 \pm \sqrt{100 - 2520}}{42} = \pm 0.457 \text{ s} \textcircled{1}$

CAN IGNORE -VE SOLUTION.

b) $B_a = 42t + 8$

$C_a = 60t$

$42t + 8 = 60t$

$t = 0.444 \text{ (s)}$

		$t = 0$	$t = 4$	
c)	70			
	A	-8	80	$\therefore 88 \text{ m} \textcircled{1}$
	B	4	516	$\therefore 512 \text{ m} \textcircled{1}$
	C	2	522	$\therefore 520 \text{ m} \textcircled{1}$

Q3.a)

$$G(s) = \frac{s+2}{s(s+1)(s+3)}$$

Find value at $s = -3 + 2j$

OPEN LOOP ZERO @ -2 .

OPEN LOOP POLES @ $0, -1, -3$

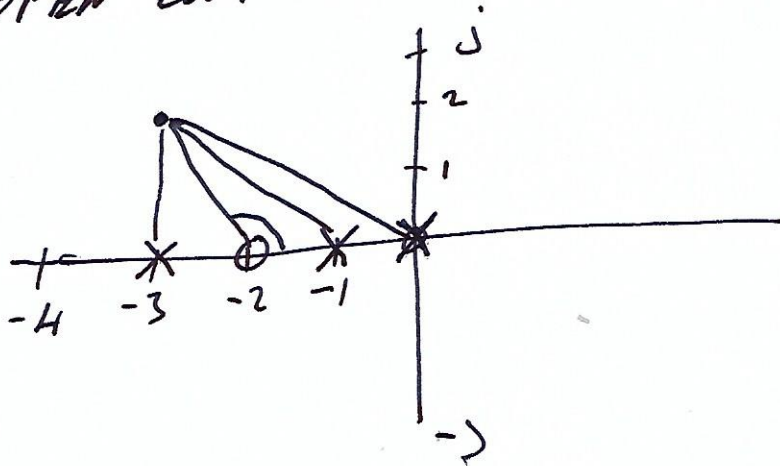


DIAGRAM (1)

$$\theta = \sum \text{ZERO ANGLES} - \sum \text{POLE ANGLES.} \quad (1)$$

Zero at -2  $= 180 - \tan^{-1} 2 = 116.5^\circ$

Poles at $-3 = 90^\circ$ at -1  $= 180 - 45 = 135$.

Pole at $0 =$  $= 180 - \tan^{-1}(\frac{2}{3}) = 146.31$

$$\therefore \theta = 116.5 - 90 - 135 - 146.31 = \underline{\underline{-254.8}} \quad (2)$$

$$\text{Mag} = \frac{\pi \text{ ZERO LENGTHS}}{\pi \text{ POLE LENGTHS}} \quad (1)$$

Zero = $\sqrt{5}$, POLES = $2, \sqrt{8}, \sqrt{13}$.

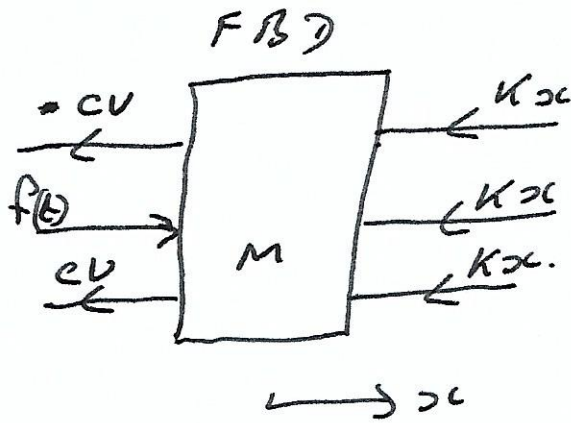
$$= \frac{\sqrt{5}}{2 \times \sqrt{8} \times \sqrt{13}} = 0.1096. \quad (1)$$

b). IT CAN NOT BE ON R. LOCUS BECAUSE.

a) THE ANGLE IS NOT A MULTIPLE OF 180

(3)

Q4



$$M = 6, C = 2, K = 3.$$

$$f(t) = -3Kx - 2C\dot{x} = M\ddot{x} \quad (\text{NEWTON}). \quad (2)$$

$$P. F(s) = Ms^2 X(s) + 2Cs X(s) + 3K X(s) \quad (2)$$

ASSUMING ZERO INITIAL CONDITION.

$$F(s) = X(s) (Ms^2 + 2Cs + 3K) \quad (1)$$

$$\frac{X(s)}{F(s)} = \frac{1}{Ms^2 + 2Cs + 3K} \quad (1)$$

$$G(s) = \frac{1}{6s^2 + 4s + 6}$$

STANDARD FORM

$$= \frac{1/6}{s^2 + \frac{4}{6}s + 1} \leftarrow \omega_n^2 = 1 \quad (1)$$

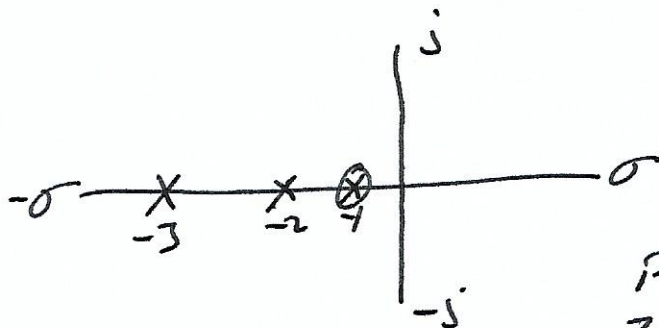
$$f(Hz) = \frac{1}{2\pi} \quad (1)$$

$$2\zeta\omega_n = \frac{4}{6}$$

$$\therefore \zeta = \frac{2}{6} \quad \text{DAMPING FACTOR} \quad (1)$$

$$< 1 \quad \text{SO UNDER DAMPED} \quad (1)$$

Q5/a)



POLES AT $-3, -1$.

ZERO AT -2

(1)

(1)

SYSTEM IS STABLE

(1)

b/

$$\frac{1}{s} \frac{4(s+1)}{(s+2)(s+3)} = \frac{A}{s} + \frac{B}{(s+2)} + \frac{C}{(s+3)} \quad (1)$$

$$4(s+1) = A(s+2)(s+3) + Bs(s+3) + Cs(s+2) \quad (1)$$

PUT $s=0$

$$4 = 6A \quad A = \frac{4}{6} \quad (1)$$

PUT $s=-2$

$$-4 = B(-2) \quad \therefore B = 2 \quad (1)$$

PUT $s=-3$

$$-8 = 3C \quad \therefore C = -\frac{8}{3} \quad (1)$$

$\therefore$ SYSTEM RESPONSE

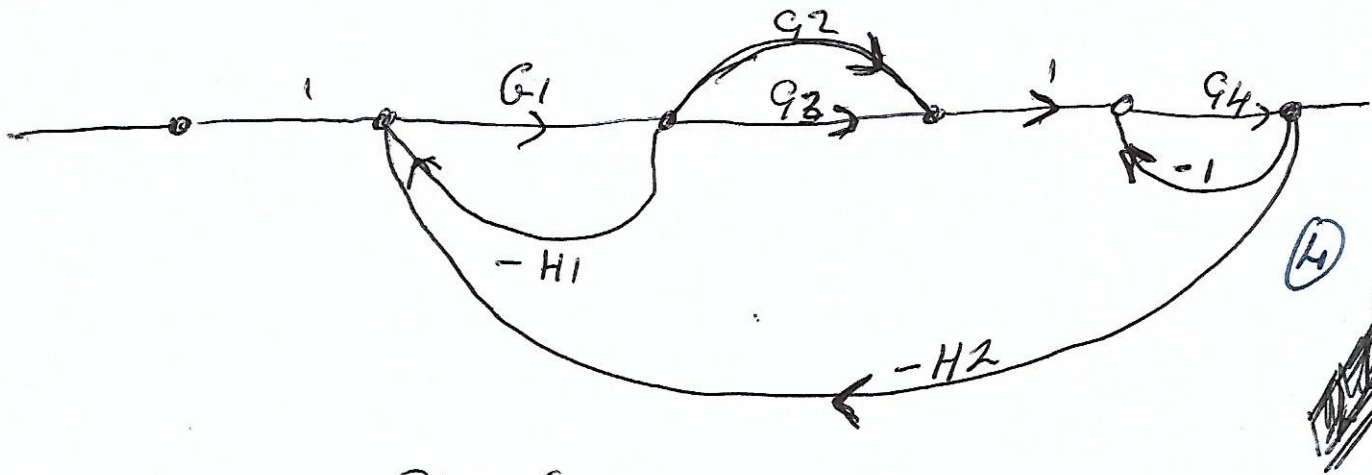
$$= \frac{4}{6s} + \frac{2}{s+2} - \frac{8}{s+3}$$

$\mathcal{L}^{-1} \Rightarrow \frac{4}{6} + 2e^{-2t} - 8e^{-3t}$

AT $t = 0.8$

$$\frac{4}{6} + 2e^{-1.6} + \frac{8}{3}e^{-2.4} = 0.829 \quad (1)$$

Q6



FORWARD PATHS

$G_1 \quad G_2 \quad G_4$

①

$G_1 \quad G_3 \quad G_4$

LOOPS. $-G_1 H_1, -G_4,$

$-G_1 G_2 G_4 H_2$

①

$-G_1 G_3 G_4 H_2$

$$T = \frac{\sum_{i=1}^N P_i \Delta_i}{\Delta} \quad \text{①}$$

NON TOUCHING LOOPS

$(-G_1 H_1, -G_4)$

①

$$\Delta = 1 - (-G_1 H_1 - G_4 - G_1 G_2 G_4 H_2 - G_1 G_3 G_4 H_2) + (-G_1 H_1 - G_4) \quad \text{①}$$

$$\Delta = 1 + G_1 H_1 + G_4 + G_1 G_2 G_4 H_2 + G_1 G_3 G_4 H_2 + G_1 H_1 G_4$$

$$= \frac{G_1 G_2 G_4 + G_1 G_3 G_4}{1 + G_1 H_1 + G_4 + G_1 G_2 G_4 H_2 + G_1 G_3 G_4 H_2 + G_1 H_1 G_4} \quad \text{①}$$