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26/05/21

Dynamics control and instrumentation exam.

Question 1

a)

	Vert	Horiz
S	60	0
U	$70 \sin 60^\circ$	$70 \cos 60^\circ$
V		

A $9.81 \cos 60$

T

$$S = Ut + \frac{1}{2}at^2$$

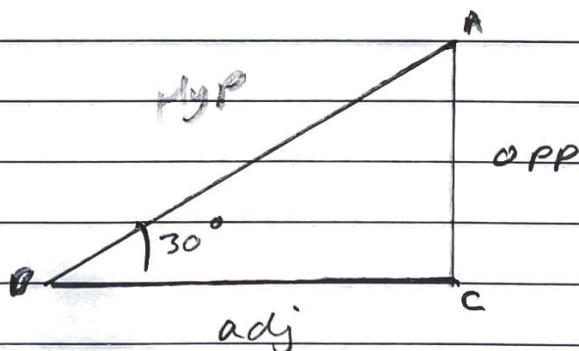
$$0 = t(U + \frac{1}{2}at)$$

$$U + \frac{1}{2}at = 0$$

$$0 = 70 \sin 60 + \frac{1}{2} 9.81 \cos 60$$

$$t = \frac{-70 \sin 60}{-\frac{1}{2} 9.81 \cos 60} = \frac{70 \sin 60}{\frac{1}{2} 9.81 \cos 60} = 24.718s$$

b)



Soh Cal Toa

$$\cos 30^\circ = \frac{BC}{BA} = \frac{BA}{\cos 30^\circ}$$

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Q1 b continued.

BQ

$$BC = 70 \cos 60$$

$$70 \cos 60 \times 24.718 = 865.13 \text{ m}$$

$$BA = \frac{865.13}{\cos 30^\circ} = 998.966$$

(2)

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Question 2

$$\text{Particle A} = S = 3t^2 + 10t - 8$$

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

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

a)

$$\text{Vel A} = 6t + 10$$

$$\text{Vel B} = 21t^2 + 8t$$

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

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

$$21t^2 = 10t + 30$$

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

$$a = 21$$

$$-10 \pm \sqrt{10^2 - 4 \times 21 \times -30}$$

$$b = -10$$

$$2 \times 21$$

$$c = -30$$

$$t = 1.457$$

b)

$$\text{accel B} = 42t + 8$$

$$\text{accel C} = 30t^2 - 30 = 60t$$

$$42t + 8 = 60t$$

$$8 = 18t$$

$$t = \frac{8}{18}$$

$$t = \frac{8}{18}$$

3

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Q2

c)

$$A = S = 3(4^3) + (10 \times 4) - 8 = 80$$

Particle A $S = 80\text{m}$

$$B = S = 7(4^3) + 4 \times (4^2) + 4 = 516$$

Particle B $S = 516\text{m}$

$$C = S = 10(4^3) + 30(4) + 2 = 522$$

Particle C $S = 522\text{m}$.

(4)

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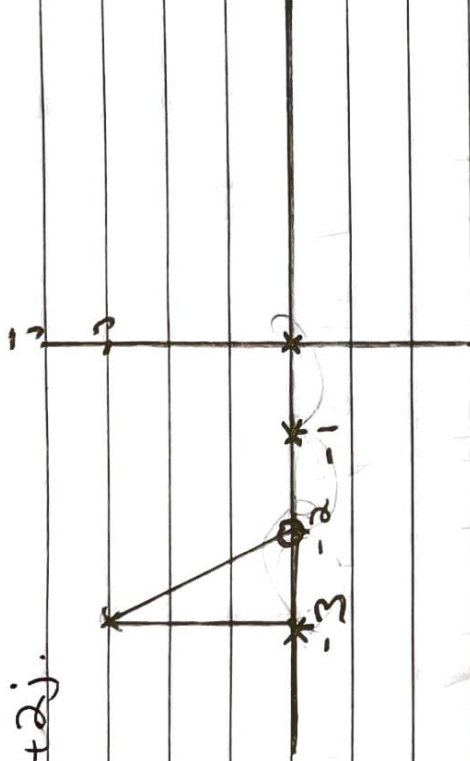
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Question 3

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

$-3+2j$.



Length of zero

$$\sqrt{3^2 + 2^2} = 3.16$$

Length of poles.

$$\sqrt{3^2 + 2^2} = 3.6$$

$$\frac{+3}{+3} = 3$$

$$\sqrt{3^2 + 3^2} = 4.24$$

$$M = \frac{3.16}{3.16 * 3 * 4.24} = 0.069$$

$$M = 0.069$$

5

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Question 4)

a) $m=6, c=2, k=2$

$$F(t) = -kx(t) - c\dot{x}(t) - kx(t) - c\dot{x}(t) - c\frac{dx}{dt} - c\frac{dx}{dt} = m\frac{d^2x}{dt^2}$$

$$F(t) = -3kx - 2c\frac{dx}{dt} = m\frac{d^2x}{dt^2}$$

$$F(t) = -6kx(t) - 4c\frac{dx}{dt} = 6\frac{d^2x}{dt^2}$$

$$F(t) = 6\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 6kx(t)$$

$$F(s) = 6s^2 X(s) + 4s X(s) + 6 X(s)$$

$$F(s) = X(s)(6s^2 + 4s + 6)$$

$$T.F = \frac{X(s)}{F(s)} = \frac{1}{6s^2 + 4s + 6} = \frac{1}{6}$$

b)

$$\omega_0^2 = 1$$

$$\omega_0 = \sqrt{1} = 1$$

$$\text{in Hz } \frac{1}{2\pi} = 0.159$$

$$c) \frac{4}{6} s = 2g\omega s = \frac{1}{3} = g\omega = \frac{1}{3} = g\sqrt{1}$$

$$y = \frac{1}{3} = 0.3$$

D) $y = 0.3$ is less than 1 so system is underdamped.

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Questions

a)

$$G(s) = \frac{4(s+1)}{(s+2)(s+3)}$$

Zeros at -1

Poles at -2, -3

The system is stable as poles exist on left hand side of the plane.

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

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

Set $s=0$ for A

$$A \cdot 4(0+1) = A(0+2)(0+3) + B(0)(0+3) + C(0)(0+2)$$

$$4 = A \cdot 6$$

$$A = \frac{4}{6} = \frac{2}{3}$$

For B set $s = -2$

$$4(-2+1) = A(-2+2)(-2+3) + B(-2)(-2+3) + C(-2)(-2+2)$$

$$4(-1) = -2B$$

$$-4 = -2B$$

$$B = \frac{-4}{-2} = \frac{4}{2} \quad B = 2$$

(7)

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For C set s to -3

$$4(s+1) = A(s+2)(s+3) + B(s)(s+3) + C(s(s+2))$$

$$4(-3+1) = A(-3+2)(-3+3) + B(-3)(-3+3) + C(-3)(-3+2)$$

$-1 \times 0 \times 0$ $-3 \times 0 \times 0$ -3×-1

$$-8 = 3C$$

$$C = \frac{-8}{3}$$

System output is

$$\frac{2}{3s} + \frac{2}{3(s+2)} - \frac{8}{3(s+3)} = \frac{2}{3} + 2e^{-2t} - \frac{8}{3}e^{-3t}$$

at 0.8 sec

$$\frac{2}{3} + 2e^{-1.6} - \frac{8}{3}e^{-2.4} = 0.82854$$

System output to 3.d.p

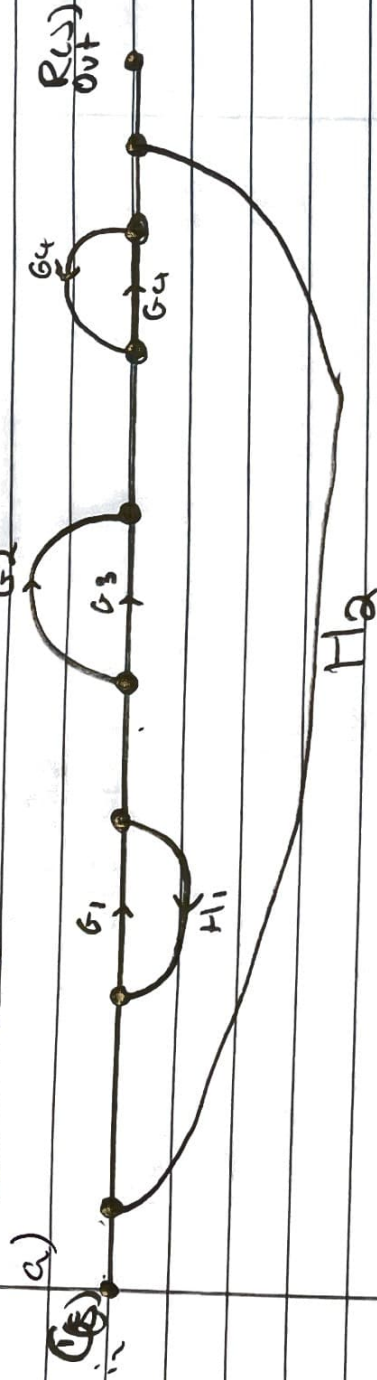
$$= 0.829$$

8

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Question 6



b) Mason's $T = \frac{1}{\Delta} \sum_k P_k \Delta_k$

For $\Delta = 1 - G_1 H_1 + (G_4) \neq (G_1 H_1 + G_4)$

$\Delta_{11} = 1$

$\Delta_{21} = 1$

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

$= \frac{(G_1 G_2 G_4)_1 + (G_1 G_2 G_4)}{1 - (G_1 H_1 + G_4) + G_1 H_1 + G_4}$

9