

Complete, fold and seal
(see note 2 below)

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Examination Answer Books

12 Pages

Instructions to Candidates

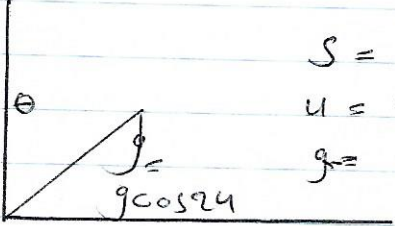
1. Please give the information requested in the boxes below.
2. Enter your name in the space provided to the right, fold over and seal down (using the label provided) to hide your name.
3. The answers must be legibly written. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.
4. Write your answers in ink.
5. Begin each answer on a fresh page. Do all rough work in the answer book and cross it through.
6. No part of this book is to be torn out; it must be handed in complete.
7. If more books than one are used, fasten them together using the tags available from the invigilator(s).
8. **Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the examination venue.**

1	Student Number	1804596/1
2	Title of Examination Paper	Dynamics Control and Instrument
3	Module Code	M4X0140S
4	Date and Time of Examination	15/5/19
5	Examination Venue	W2 Gower College
6	Seat Number	1
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
Q1	10 ✓
Q2	9 ✓
Q3	14 ✓
Q4	13 ✓
Q5	10 ✓
Q6	7 ✓
Total	~~63~~ 63

(Gweler yr ochr arall am y fersiwn Cymraeg)

88/0
90/0

$$\begin{array}{ll}
 S = 0 & S = x = ? \\
 u = u \sin \theta & u = v = u \cos \theta \\
 v = ? & g = ? \\
 g = -g &
 \end{array}$$


In the inclined plane

$$(A) S = ut + \frac{1}{2}at^2$$

$$0 = 680 \sin 40 + \frac{1}{2}(9.81) \cos 24 (t^2)$$

$$0 = 51.4t - 4.48t^2$$

$$t(51.4 - 4.48t) = 0$$

$$t = 0$$

$$51.4 - 4.48t = 0$$

$$51.4 = 4.48t$$

$$t = 11.47 \text{ seconds}$$



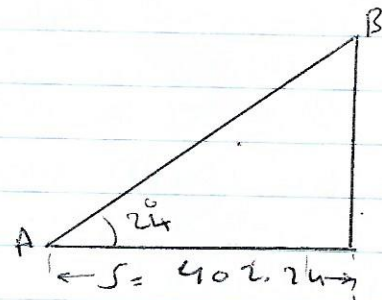
6 ✓

(B) in horizontal plane

$$S = \left(\frac{u+v}{2}\right)t$$

$$S = 80 \cos 64 (11.47)$$

$$S = 402.24 \text{ m}$$



$$\cos 24 = \frac{402.24}{AB}$$

$$AB = \frac{402.24}{\cos 24}$$

$$AB = 440.31 \text{ m}$$



4 ✓

Question Two

$$A \quad S = 24t^2 + 18t - 17$$

$$\frac{dS}{dt} = V = 48t + 18 \quad \checkmark$$

$$\frac{dV}{dt} = a = 48 \quad \checkmark$$

$$B \quad S = 14t^2 + 5t + 25$$

$$\frac{dS}{dt} = V = 28t + 5 \quad \checkmark$$

$$\frac{dV}{dt} = a = 28 \quad \checkmark$$

$$(a) \quad V_A = 3V_B$$

$$48t + 18 = 3(28t + 5)$$

$$28t + 18 = 84t + 15$$

$$18 - 15 = 84t - 28t$$

$$3 = 56t$$

$$t = 18.66 \text{ seconds}$$

$$(b) \text{ when } t = 0$$

$$S_A = 24t^2 + 18t - 17$$

$$= -17 \text{ m}$$

$$\text{distance travelled} = 439 - (-17) = \underline{456 \text{ m}} \quad \checkmark$$

$$\text{when } t = 4$$

$$S_A = 24(4)^2 + 18(4) - 17$$

$$= 439 \text{ m}$$

$$S_B = 14t^2 + 5t + 25$$

$$= 25 \text{ m}$$

$$\text{distance travelled} = 269 - 25 = 244 \text{ m}$$

$$S_B = 14t^2 + 5t + 25$$

$$S_B = 14(4)^2 + 5(4) + 25$$

$$= 269$$

(C)

$$\text{acceleration of A} = \frac{d^2s}{dt^2} = 48$$

$$a = 48$$

$$\text{acceleration of B} \frac{d^2s}{dt^2} = 28$$

$$a = 28$$

✓

Question Three

(a)

The force affecting mass (m) = $f = ma$ The resistance of the spring (K) = $l = kx$ The resistance of the damper (C) = Cv total force of the system = $f = ma$

$$f(t) - C_n v - k_n x = ma$$

f(t) -

$$\text{as } v \text{ is } \frac{dx}{dt} = \dot{x}$$

$$a = \frac{d^2 x}{dt^2} = \ddot{x}$$

So

$$f(t) - C_1 v - C_2 v - k_1 x - k_2 x - k_3 x = ma$$

$$f(t) - (C_1 + C_2 + C_3) \dot{x} - x(k_1 + k_2 + k_3) = ma$$

$$f(t) - \ddot{x}(C_1 + C_2) - x(k_1 + k_2 + k_3) = m\ddot{x}$$

$$f(t) = m\ddot{x} + \ddot{x}(C_1 + C_2) + x(k_1 + k_2 + k_3)$$

By taking Laplace transform.

$$F(s) = m s^2 X(s) + s X(s) (C_1 + C_2) + X(s) (k_1 + k_2 + k_3)$$

$$F(s) = X(s) [m s^2 + s (C_1 + C_2) + (k_1 + k_2 + k_3)]$$

$$\frac{F(s)}{X(s)} = m s^2 + s (C_1 + C_2) + (k_1 + k_2 + k_3)$$

$$\frac{X(s)}{F(s)} = \frac{1}{m s^2 + s (C_1 + C_2) + (k_1 + k_2 + k_3)}$$

(b)

$$\frac{X(s)}{F(s)} = \frac{1}{ms^2 + s(c_1 + c_2) + (k_1 + k_2 + k_3)}$$

$$= \frac{1}{6s^2 + s(3+3) + (8+8+8)}$$

$$= \frac{1/6}{s^2 + s + 4}$$

Comparing the above equation with the standard formula below:

$$\frac{1}{s^2 + 2\zeta s \omega_n + \omega_n^2}$$

where ζ = damping factor
 ω_n = natural frequency

$$\omega_n^2 = 4$$

$$\omega_n = \sqrt{4} = 2 \text{ Radian/s}$$

$$\text{as } \omega = 2\pi f$$

$$\text{So } f = \frac{\omega}{2\pi} = \frac{2}{2\pi} = \frac{1}{\pi} \text{ Hz}$$

(c) Comparing the equations

$$2\zeta s \omega_n = s$$

$$2\zeta(2) = 1$$

$$\zeta = \frac{1}{4} = 0.25$$

(d) as ζ the damping factor is < than 1
 So the system is underdamped

Question four

a) Zero: $s+5=0$ so $s=-5$

Poles $s^2+8s+7=0$

$$\begin{array}{c} s \quad +7 \\ \times \\ s \quad +1 \end{array}$$

$$(s+7)(s+1)=0$$

$$s=-7$$

$$s=-1$$

as all the poles are negative, then the system is stable. ✓

(b) The D.C response is when s term is zero
So

$$\frac{(s+5)}{(s+7)(s+1)} = \frac{5}{7} \quad \checkmark$$

(c) $\text{Step} = 3 = \frac{3}{s}$

$$\frac{3(s+5)}{s(s+7)(s+1)} = \frac{A}{s} + \frac{B}{(s+7)} + \frac{C}{s+1} \quad \checkmark$$

$$3(s+5) = A(s+7)(s+1) + Bs(s+1) + Cs(s+7) \quad \checkmark$$

when $s=0$

$$3(5) = A(7)(1)$$

$$15 = 7A$$

$$A = \underline{2.5}$$

when $s=-7$

$$3(-7+5) = B(-7)(-7+1)$$

$$-6 = 42B$$

$$B = \underline{-7}$$

$$\left(\frac{-6}{42} \right)$$

when $s = -1$

$$3(-1+5) = C(-1)(-1+7)$$

$$12 = -6C$$

$$C = -2$$

$$= \frac{A}{s} + \frac{B}{(s+7)} + \frac{C}{s+1}$$

$$= \frac{2.5}{s} - \frac{7}{s+7} - \frac{2}{s+1}$$

taking laplace inverse

$$\mathcal{L}^{-1} \frac{2.5}{s} = \mathcal{L}^{-1} \frac{7}{s+7} - \mathcal{L}^{-1} \frac{2}{s+1}$$

$$= 2.5 - 7e^{-7t} - 2e^{-t}$$

after 2 second :-

$$= 2.5 - 7e^{-14} - 2e^{-2}$$

$$= 2.5 + 0 - 2.7$$

$$= 2.7706$$

Question five

$$2s^5 + 3s^4 + 2s^3 + s^2 - s + 4$$

$$\begin{array}{l|lll} s^5 & 2 & 2 & -1 \\ s^4 & 3 & 1 & 4 \\ s^3 & \alpha & y & z \\ s^2 & & & \\ s^1 & & & \\ s^0 & & & \end{array}$$

$$\alpha_3 = - \frac{\begin{vmatrix} 2 & 2 \\ 3 & 1 \end{vmatrix}}{3} = - \frac{(2 - 6)}{3} = \frac{+4}{3}$$

$$y_3 = - \frac{\begin{vmatrix} 2 & -1 \\ 3 & 4 \end{vmatrix}}{3} = - \frac{(8 - (-3))}{3} = \frac{-11}{3}$$

$$z_3 = 0$$

$$\begin{array}{l|lll} s^5 & 2 & 2 & -1 \\ s^4 & 3 & 1 & 4 \\ s^3 & 4/3 & -11/3 & 0 \\ s^2 & \alpha & y & z \\ s^1 & & & \\ s^0 & & & \end{array}$$

$$\alpha_2 = - \frac{\begin{vmatrix} 3 & 1 \\ 4/3 & -11/3 \end{vmatrix}}{4/3} = - \frac{(-11 - 4/3)}{4/3} = 9.25$$

$$y = - \frac{\begin{vmatrix} 3 & 4 \\ 4/3 & 0 \end{vmatrix}}{4/3} = - \frac{-4(4/3)}{4/3} = \underline{\underline{4}}$$

$$z = 0$$

s^5	2	2	-1
s^4	3	1	4
s^3	4/3	$-\frac{11}{3}$	0
s^2	9.25	4	0
s^1	x	y	2
s^0			

$$x = - \frac{\begin{vmatrix} 4/3 & -\frac{11}{3} \\ 9.25 & 4 \end{vmatrix}}{9.25} = - \frac{\left(\frac{16}{3} + 33.91\right)}{9.25}$$

$$= -4.25$$

$$y = - \frac{\begin{vmatrix} 4/3 & 0 \\ 9.25 & 0 \end{vmatrix}}{9.25} = 0$$

$$z = 0$$

s^5	2	2	-1
s^4	3	1	4
s^3	4/3	$-\frac{11}{3}$	0
s^2	9.25	4	0
s^1	-4.25	0	0
s^0	x	y	2

$$X = - \frac{\begin{vmatrix} 9.25 & 4 \\ -4.25 & 0 \end{vmatrix}}{-4.25} =$$

$$+ \left(+ \frac{4(4.25)}{+4.25} \right) = \underline{\underline{4}}$$

$$Y = - \frac{\begin{vmatrix} 9.25 & 0 \\ -4.25 & 0 \end{vmatrix}}{-4.25} = 0$$

$$Z = 0$$

s^5	2	2	-1
s^4	3	1	4
s^3	$4/3$	$-11/3$	0
s^2	9.25	4	0
s^1	-4.25	0	0
s^0	4	0	0

So the system is unstable by looking at the first column one of the numbers is negative which going to be on the positive part of the pole zero diagram.

there are Two positive poles as there are Two changes in the signs on the first column.

Question six

$$\frac{[G_1(s) - G_2(s)] G_3(s) \left[\frac{G_4(s)}{1 + G_4(s)} \right]}{1 + \left[G_1(s) G_3(s) - G_2(s) G_3(s) \left(\frac{G_4(s)}{1 + G_4(s)} \right) \right]} H_1(s)$$

$$= \frac{[G_1(s) G_3(s) - G_2(s) G_3(s)] \left(\frac{G_4(s)}{1 + G_4(s)} \right)}{1 + \left[G_1(s) G_3(s) - G_2(s) G_3(s) \left(\frac{G_4(s)}{1 + G_4(s)} \right) \right]} H_1(s)$$

$$= \cancel{1 + G_4(s)} \cdot \cancel{[G_1(s) G_3(s) - G_2(s) G_3(s)]} \cdot (1 + G_4(s))$$

$$\frac{[G_1(s) G_3(s) - G_2(s) G_3(s)] [G_4(s)]}{1 + G_4(s) + [G_1(s) G_3(s) - G_2(s) G_3(s)] G_4(s)} H_1$$

$$= \frac{G_1 G_3 G_4 - G_2 G_3 G_4}{1 + G_4 + G_1 G_3 G_4 H_1 - G_2 G_3 G_4 H_1}$$

$$1 + G_4 + G_1 G_3 G_4 H_1 - G_2 G_3 G_4 H_1$$

S.

(b)

$$TF = \left[\frac{100 \times 2}{1 + 200(0.4)} \right] (5) \frac{mV}{Pa}$$

$\frac{deg}{V}$

$$= \frac{1000}{1 + 80} = \frac{12.34}{12.34}$$

$$\left[\frac{200 \frac{deg}{V}}{1 + 200(0.4) \frac{mV}{deg}} \right] 5 \frac{mV}{Pa}$$

✓

$$= \frac{12.3}{12.34} \frac{deg}{Pa}$$

when 1000 Pa input $\Rightarrow$

$$= 1000 \times 12.34$$

~~12.34~~ degrees

$$= 12345 \text{ deg}$$