



12 Pages

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).
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1	Student Number	Jon19851773
2	Title of Examination Paper	Dynamics Control
3	Module Code	GOEE4002
4	Date and Time of Examination	13/05/2025 9:30 - 11:30
5	Examination Venue	Main Hall
6	Seat Number	D8
7	Number of Answer Books handed in	1

[illegible]

FORENAME(S): Dylan Evan

(Gweler yr ochr arall am y fersiwn Cymraeg)

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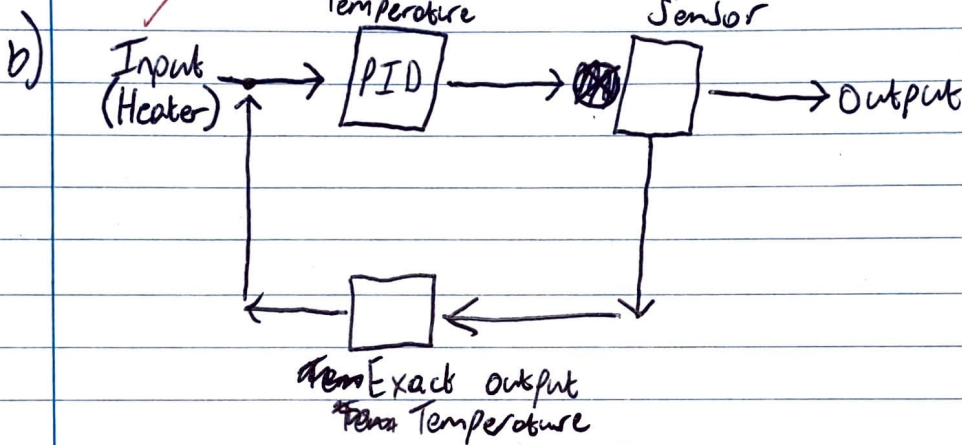
Q1)
a)



(2)

ii) It will not respond automatically because the open loop system doesn't have a feedback loop.

(1)



(3)

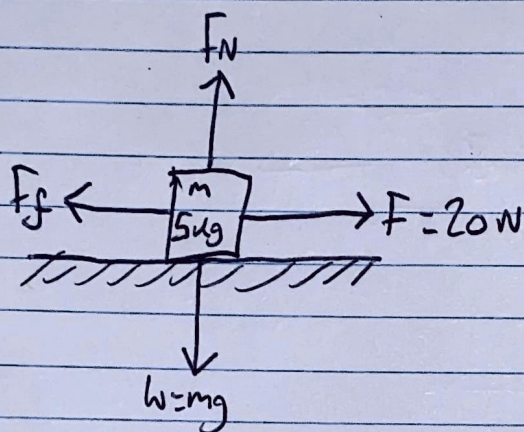
If the desired temperature isn't reached the feedback will tell the system to keep heating. Alternatively, if it had reached desired temperature, the heater will turn off.

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

i)

ii) Step input = $f(t) = 0$ when $t \leq t_0$
 $f(t) = A$ when $t > t_0$

Q2) a)



$$F_f = \mu mg = 0.3 \times 5 \times 9.81 = 14.715 \text{ N}$$

$$F_{\text{Net}} = ma$$

$$F - F_f = ma$$

$$a = \frac{F - F_f}{m} = \frac{20 - 14.715}{5} = 1.057 \text{ m/s}^2 \approx 1.06 \text{ m/s}^2$$

b) i) $F_d = -bv = -0.5 \times 2 = -1 \text{ N}$

$$F_{ss} = F_f + |F_d| = 14.715 + 1 = 15.715 \text{ N}$$

b) ii)

$$G(s) = \frac{1}{ms+b}$$

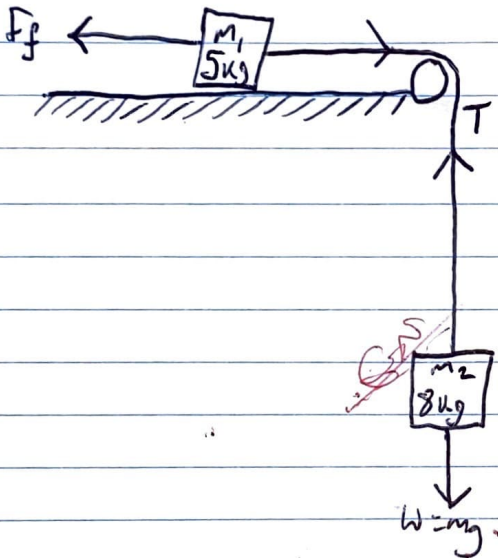
$$G(0) = \frac{1}{m(0)+b} = \frac{1}{b}$$

$$G(0) = \frac{1}{0.5 \text{ Ns/m}}$$

$$= \cancel{2 \text{ Ns/m}} \quad 2 \text{ Ns/m}$$

(4)

c)

Block 1

$$F - F_f - T = m_1 a$$

$$F - 14.715 - T = 5 \times 2$$

$$F - T = 10 + 14.715$$

$$F - T = 24.715 \text{ N}$$

Block 2

$$m_2 g - T = m_2 a$$

$$18 \times 9.81 - T = 8 \times 2$$

$$78.48 - T = 16$$

$$T = 78.48 - 16$$

$$T = 62.48 \text{ N}$$

Both
negatives
cancel

Q2) c) Sub T back into block 1

$$F - T = 24.715$$

$$F = 24.715 + T$$

$$F = 24.715 + 62.48$$

$$F = 87.195\text{N}$$

(4)

d) Voltage output = scaling factor $\times$ position

$$\text{Position} = 2\text{m/s} \times 5\text{s} = 10\text{m}$$

(4)

$$\text{Voltage output} = 0.01\text{V/m} \times 10\text{m}$$

$$= 0.1\text{V}$$

Q3) a) $G(s) = \frac{(s+3)}{(s+4)(s^2+3s+6)}$

Zeros: $s+3=0$

$s = -3$

Poles: $s+4=0$

$s = -4$

s^2+3s+6

$s = \frac{-b \pm \sqrt{b^2 - 4(ac)}}{2(a)}$

$s = \frac{-3 \pm \sqrt{3^2 - 4(1)(6)}}{2(1)}$

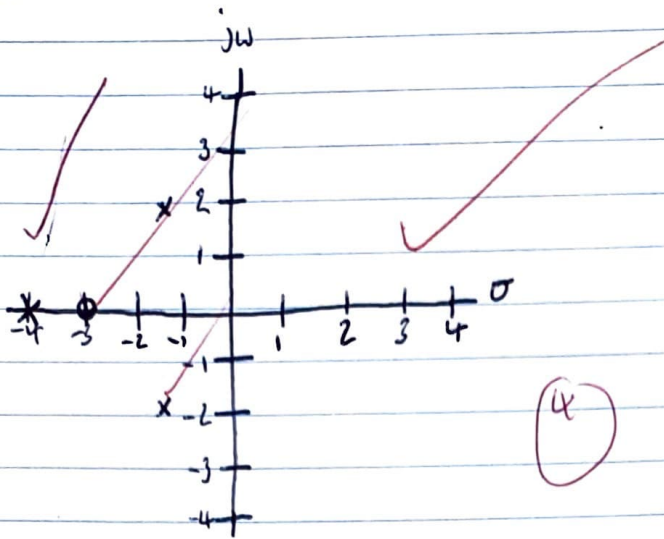
$s = \frac{-3 \pm \sqrt{-15}}{2}$

$s = \frac{-3 \pm 3.87j}{2}$

$s = -1.5 \pm 1.94j$

$-1.5 + 1.94j$ or $-1.5 - 1.94j$

(6)

Q3) a) Plotb) Evaluate $G(s)$ at $s = -2 + j$

$$\text{Numerator: } (-2 + j) + 3 = 1 + j$$

$$\text{Denominator: } (-2 + j) + 4 = 2 + j$$

$$s^2 = (-2 + j)(-2 + j)$$

$$= 4 - 2j - 2j - 1$$

$$= 3 - 4j$$

$$3s = 3(-2 + j)$$

$$= -6 + 3j$$

Simplify:

$$3 - 4j - 6 + 3j + 6$$

$$= 3 - j$$

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

$$6 - 2j + 3j + 1$$

$$= \frac{1+j}{7+j}$$

$$G(s) = \frac{1+j}{7+j} \times \frac{7-j}{7-j}$$

$$G(s) = \frac{7-j+7j+1}{49-\cancel{7j}+\cancel{7j}+1} = \frac{8+6j}{50}$$

$$G(s) = \frac{8+6j}{50}$$

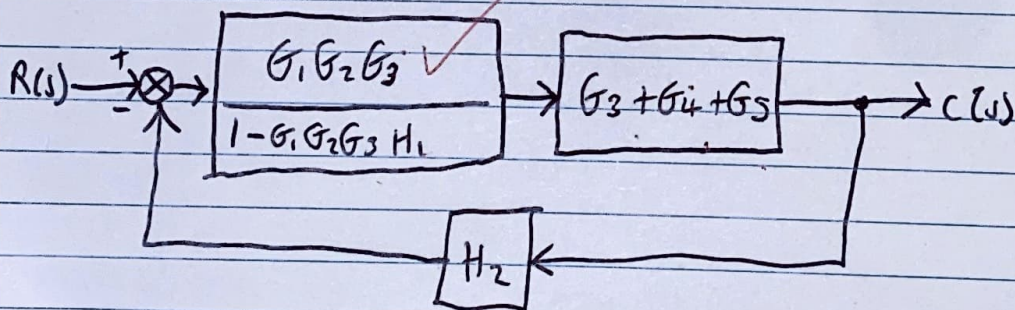
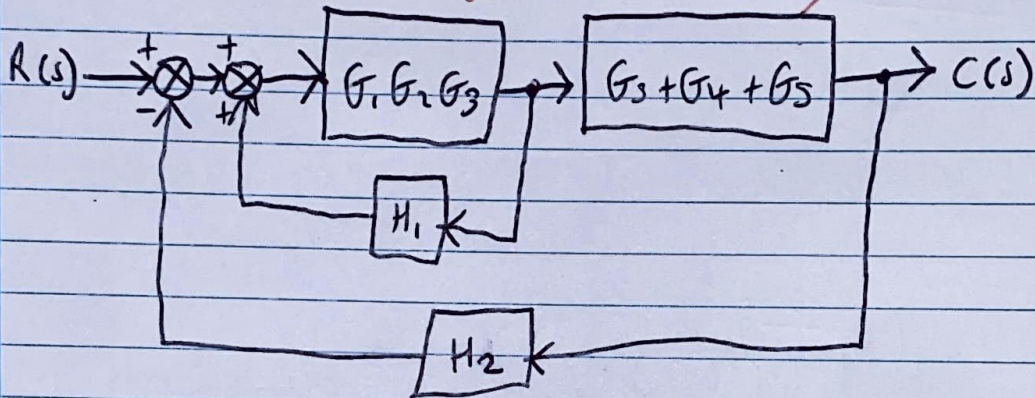
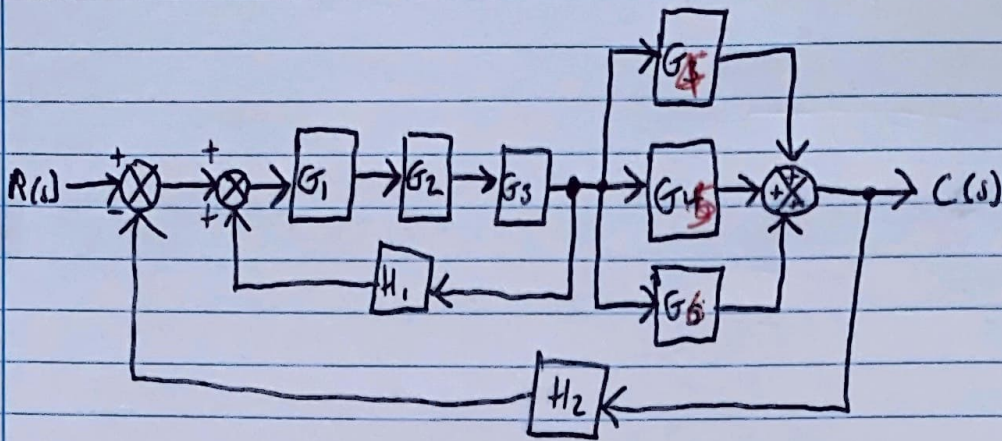
$$G(s) = 0.16 + 0.12j$$

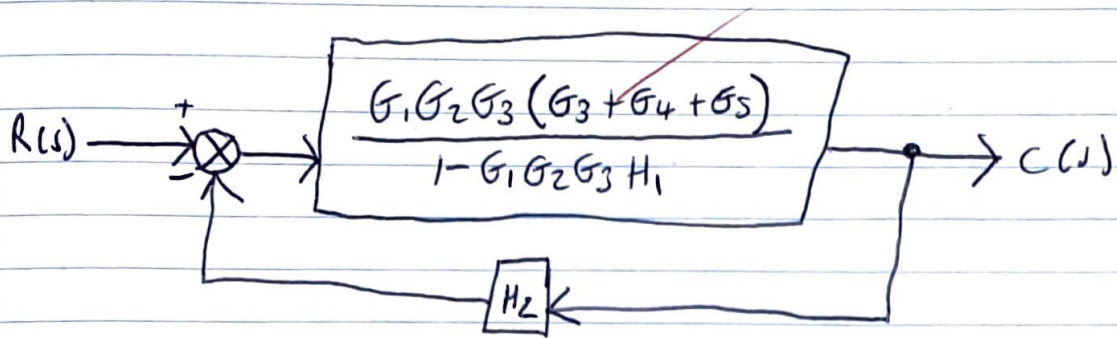
$$\text{Angle} = \tan^{-1}\left(\frac{0.12}{0.16}\right)$$

$$= 36.87^\circ$$

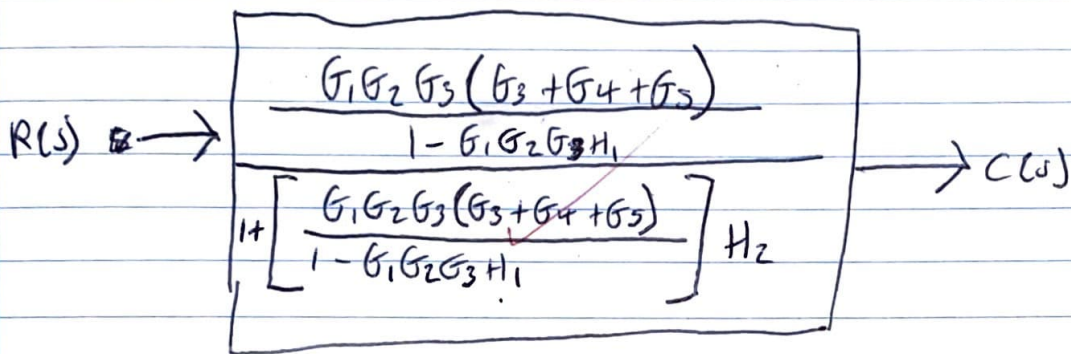
Typing error in paper

Q4)





18



$$\frac{C(s)}{R(s)} = \frac{G_1 G_2 G_3^2 (G_3 + G_4 + G_5)}{(1 - G_1 G_2 G_3 H_1) \left[1 + \frac{G_1 G_2 G_3 (G_3 + G_4 + G_5)}{1 - G_1 G_2 G_3 H_1} H_2 \right]}$$

Q5) $RLC \rightarrow R = 150\Omega, L = 2H, C = 25\mu F$

$$\frac{d^2 i}{dt^2} + \frac{R}{L} \frac{di}{dt} + \frac{1}{LC} i = \frac{V}{LC}$$

$$\frac{d^2 \theta_0}{dt^2} + 2\xi\omega_n \frac{d\theta_0}{dt} + \omega_n^2 \theta_0 = b_1 \omega_n^2 \theta_0$$

$$2\xi\omega_n = \frac{R}{L} = \frac{150}{2} = 75 \text{ Hz} \quad (3)$$

$$(b) \xi\omega_n = \frac{75}{2} = 37.5 \text{ Hz} \quad (2)$$

$$\omega_n^2 = \frac{1}{LC} = \frac{1}{2 \times (25 \times 10^{-6})}$$

$$= 20,000$$

$$a) \omega_n = \frac{20,000}{2} = 10,000 \text{ Hz}$$

$$\xi = \frac{37.5}{10,000}$$

$$= 3.75 \times 10^{-3}$$

$$d) \tau = \frac{1}{\xi\omega_n}$$

$$\tau = \frac{1}{37.5} = 0.0265$$

Q5) a)

e)

$$V_t = V_0$$

$$V_0 = 10V$$

$$I = \frac{V}{R} = \frac{V_0}{R} = \frac{10}{150}$$

$$I_{ss} = 0.06A$$

(4)

(1)

Q5) b) overdamped < 1 Underdamped > 1 Critically damped $= 1$

x

The system is overdamped

Q5) c) Damped Frequency: $\omega_d = \omega_n \sqrt{1 - \xi^2}$

$$= 10,000 \sqrt{1 - (3.75 \times 10^{-6})^2}$$

$$= 9999.98 \text{ Hz}$$

(1)

(1)

