



SURNAME:

Sidhu

12 Pages

FORENAME(S):

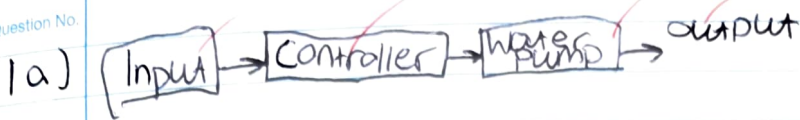
kobe

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.**

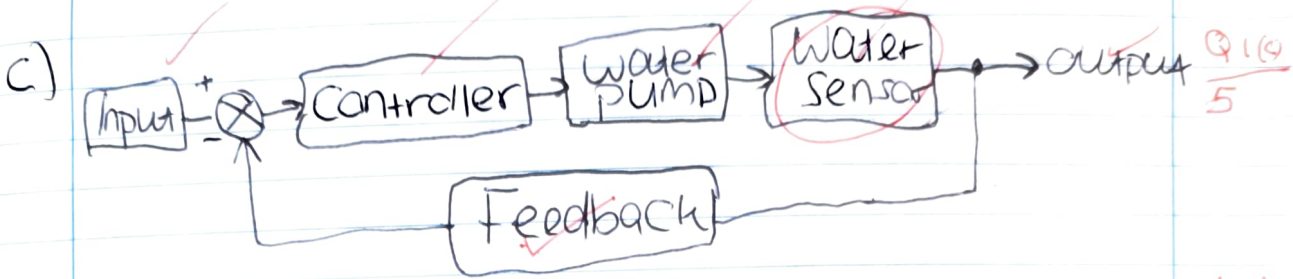
[illegible]

49% RK

49% ✓ E.N.



b) Due to the open loop system having no feed back, the open loop system won't respond.



d) $G(s) = \frac{5}{s+3}$

$G_{OL}(s) = K_p \cdot G(s)$

$G_{OL}(s) = K_p \frac{5}{s+3}$

$T(s) = \frac{G_{OL}(s)}{1 + G_{OL}(s)H(s)}$

$T(s) = \frac{\frac{5K_p}{s+3}}{1 + \frac{5K_p}{s+3}}$

$T(s) = \frac{5K_p}{s+3+5K_p}$

(ii)

$L_{sen} = 100\text{cm}$

$L(s) = \frac{100}{s}$

$L_{ss} = \lim_{s \rightarrow 0} s \cdot T(s) L(s)$

$L_{ss} = \lim_{s \rightarrow 0} s \cdot \frac{5K_p}{s+3+5K_p} \cdot \frac{100}{s}$

$L_{ss} = \lim_{s \rightarrow 0} \frac{5K_p \cdot 100}{s+3+5K_p}$

$L_{ss} = \frac{500K_p}{3+5K_p}$

Q1(a)
4

Q1(b)
1

Q1(c)
5

Q1(d)

(i) 4

Q1(b)
(ii) 5

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

Q3(a)
4

Zeros = $s+3=0$
= $s=-3$ ✓ ①

Poles_{p1} = $s+4=0$
= ~~$s=-4$~~ ✓ ①

Poles_{p23} = $s^2+3s+6=0$
Using quadratic formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

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

$$x = \frac{-3 \pm \sqrt{9 - 24}}{2}$$

$$x = \frac{-3 \pm \sqrt{9 - 24}}{2}$$

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

$$\frac{-3}{2} = -1.5, \quad \frac{\sqrt{15}}{2} = 1.94, \quad \frac{\sqrt{15}}{2} = 1.94j$$

$$x = -1.5 \pm 1.94j$$

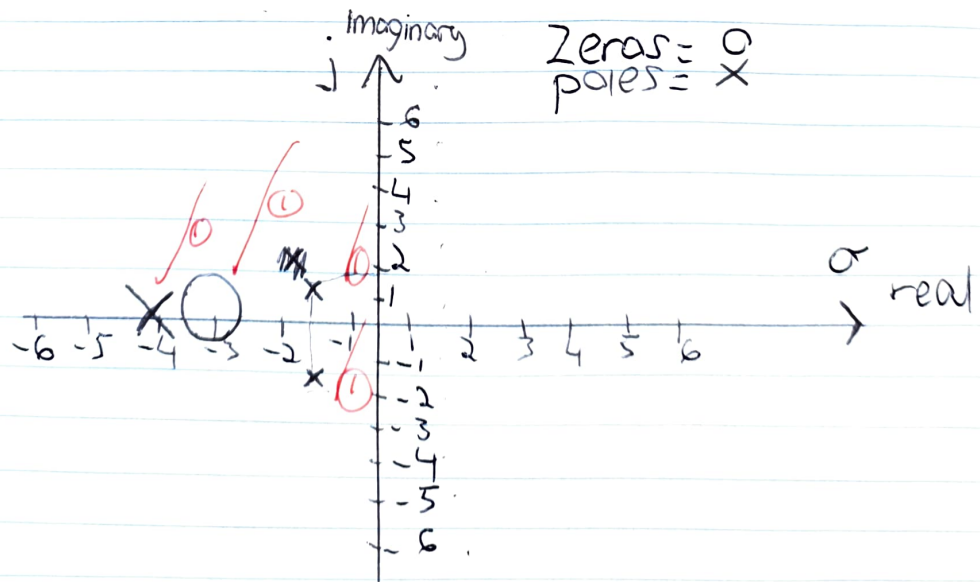
Poles_{p2} = $-1.5 + 1.94j$ ✓ ①

Poles_{p3} = $-1.5 - 1.94j$ ✓ ①

3b)

Zeros = 0
poles = x

Q3(b)
4



3c) All poles and zeros are in the negative σ axis so, the open loop system will be stable. ✓ ①

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

$s = -1 + 2j$ ✓ ①

Numerator = $-1 + 2j + 3$
 $= 2 + 2j$ ✓ ①

Denominator

First term = $-1 + 2j + 4$
 $= 3 + 2j$ ✓ ①

or

Second term $(-1 + 2j)^2 + 3(-1 + 2j) + 6$
 $(-1 + 2j)^2 = (-1 + 2j)(-1 + 2j) = 1 - 2j - 2j + 4j^2$ ✓ ①
 $1 + 4j^2 - 4j = 1 + 4(-1) - 4j = -3 - 4j$

$3(-1 + 2j) = -3 + 6j + 6 = 3 + 6j$ ✗

Adding second term

$-3 - 4j + 3 + 6j = 2j$

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

multiply denominator

$(10j)(3 + 2j) = 30j + 20j^2 = 50j$

$G(-1 + 2j) = \frac{2 + 2j}{50j}$

$G(-1 + 2j) = \frac{2}{50} + \frac{2j}{50} = 0.04 + 0.04j$ ✗

~~Polar form of $G(s)$ is $r \angle \theta$~~ Polar form = $r \angle \theta$ ✓ ①

Magnitude = $r = \sqrt{a^2 + b^2}$

Angle = $\theta = \tan^{-1}\left(\frac{b}{a}\right)$ ✓ ①

Q 3c)

2

Q 3d)

6

$$r = \sqrt{0.04^2 + 0.04^2}$$

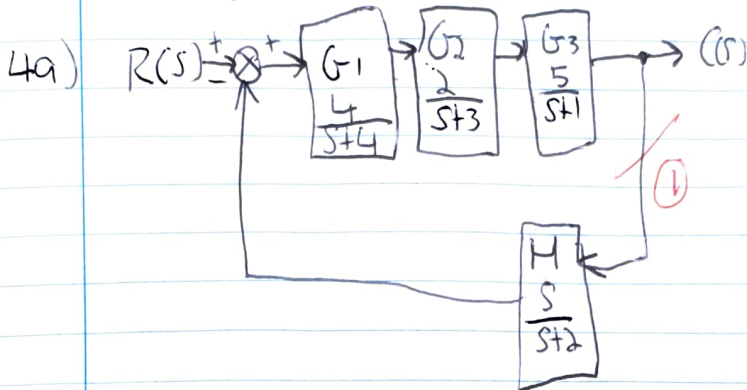
$$r = 0.056$$

$$\theta = \tan^{-1}\left(\frac{b}{a}\right)$$

$$\theta = \tan^{-1}\left(\frac{0.04}{0.04}\right)$$

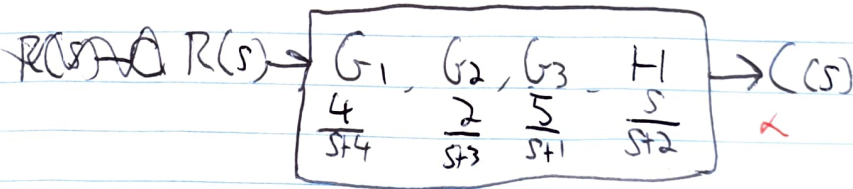
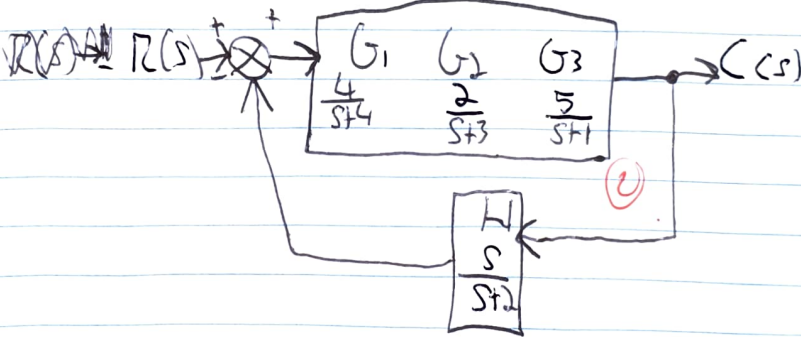
$$\theta = 45^\circ$$

$$G(-1+2j) = 0.056 \angle 45^\circ$$



Q4(a)
6

Q4(b)
0



$$T(s) = \frac{Y(s)}{R(s)} = \frac{G(s)}{1 + G(s)H(s)} \quad \checkmark \text{ ①}$$

$$T(s) = \frac{40}{(s+4)(s+3)(s+1)} \quad \checkmark \text{ ②}$$

$$1 + \left(\frac{40}{(s+4)(s+3)(s+1)}\right) \left(\frac{s}{s+2}\right)$$

$$T(s) = \frac{40s}{(s+4)(s+3)(s+1)(s+2)} \quad \checkmark$$

4b) Second order

5a) (iii) The Circuit is a Lowpass filter as the supply voltage ~~qpp~~ first goes through the resistor then to the non-polarised capacitor which connects to ground. With the capacitor connecting to ground it only allows low currents to pass through it.

Q5(a)
(iii) 2

5b) $\omega_d = \frac{1}{\sqrt{LC}}$ ✓ (1)
 $\omega_d = \frac{1}{\sqrt{2 \times 25 \times 10^{-6}}}$ ✓ (1)
 $\omega_d = 141.42 \text{ rad/s}$ ✓ (1)

Q5(b)
(i) 6

$$\frac{R}{L} = 2\zeta\omega_d \quad \checkmark (1)$$

$$\frac{150}{2} = 2\zeta\omega_d$$

$$75 = 2\zeta\omega_d$$

$$\zeta = \frac{75}{2\omega_d}$$

$$\zeta = \frac{75}{2 \times 141.42}$$

$$\zeta = \frac{75}{282.84}$$

$$\zeta = 0.265 \text{ rad/s} \quad \checkmark (1)$$

$$\omega_d = \omega_n \sqrt{1 - \zeta^2}$$

$$\omega_d = 141.42 \sqrt{1 - 0.265^2}$$

$$\omega_d = 136.34$$

~~The system is overdamped~~

$$T = \frac{2\pi}{\omega_d} \quad T = \frac{2\pi}{136.34(0.265)} = 0.027$$

The system is underdamped ✓ (1)

5.iii) ~~The Current~~

5.iii) ~~The Current will be 0.~~

2a) $F_f = \mu \cdot m \cdot g \cdot 81$ $\times$

Q2(a)
0

$$F_f = 0.25 \cdot 6 \cdot 9.81$$

$$F_f = 14.715$$
 $\times$

~~Q2a~~ $F_{net} = F_f - F - F_f$

~~F_{net}~~ Δ

$$F_{net} = 40 - 14.715 = 25.285 \text{ N}$$

$$a = \frac{25.285}{6} = 4.214 \text{ m/s}^2$$
 $\times$

5.iii) ~~The Current will be 0A as~~ $\checkmark$ ⁽¹⁾ capacitors block DC from passing through them.

Q5(b)
1



ENW(AU) CYNTAF:

12 Tudalen

1. Rhowch yr holl wybodaeth y gofynnir amdani yn y blychau isod.
2. Rhowch eich enw yn y lle a ddarparwyd ar y dde, plygwch ef a'i selio i lawr (gan ddefnyddio'r label a ddarparwyd) i guddio'ch enw.
3. Rhaid i'r atebion fod mewn llawysgrifen ddarllenadwy. Gall yr Arholwyr naill ai anwybyddu sgrïpt annarllenadwy, neu drefnu iddi gael ei theipio a chael yr ymgeisydd i dalu.
4. Ysgrifennwch eich atebion mewn inc.
5. Dechreuwch bob ateb ar dudalen newydd. Gwnewch unrhyw fras nodiadau yn y llyfr atebion a thynnu llinell drwyddynt.
6. Ni ddylid rhwygo unrhyw ran o'r llyfr hwn; rhaid ei gyflwyno yn gyfan.
7. Os defnyddir mwy nag un llyfr, rhwymwch hwy gyda'i gilydd gan ddefnyddio'r tagiau sydd ar gael oddi wrth y gwyliwr/gwylwyr.
8. Rhaid dychwelyd pob llyfr. Ni chaniateir mynd â llyfrau atebion, wedi eu defnyddio neu heb eu defnyddio, allan o'r lleoliad arholi o dan unrhyw amgylchiadau.

[illegible]

(See the other side for English version)