



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).
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	2017194
2	Title of Examination Paper	Control Engineering
3	Module Code	SGEE 5009
4	Date and Time of Examination	18/5/23 09:30 - 12:00
5	Examination Venue	CSG Araig
6	Seat Number	13
7	Number of Answer Books handed in	

List the numbers of the questions you have attempted	Office Use
3	~~12~~ 13
5	~~3~~
2	0
1	1
Total	17

Mark checked and
agreed
L Williams

- ③ a) i) all coefficients are present and all are positive, therefore the system is stable. ✓
- ii) all coefficients are present but one is negative, therefore the system is Unstable. ✓
- iii) all coefficients are present and all are positive, therefore the system is ^{critically} stable, at best.

2 1/2

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

$$= \frac{3}{s(s+2)(s+4)} \quad 2 \times 4 = 8$$

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

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

$$G_o(s) = \frac{G(s)}{1+H(s)G(s)} \quad H(s) = k$$

$$= \frac{3/s^3+6s^2+4s}{1+k \cdot 3/s^3+6s^2+4s}$$

$$= \frac{3}{s^3+6s^2+4s+k4} \quad \text{error carried}$$

$$na = 1$$

$$na^{-1} = 6$$

$$na^{-2} = 4$$

$$na^{-3} = k4$$

$$b1 = na^{-2} - \left(\frac{na}{na^{-1}}\right) na^{-3}$$

$$= 4 - \left(\frac{1}{6}\right) k4$$

$$= 4 - k0.6$$

$$= 3.4k$$

$$c1 = na^{-3} - \left(\frac{na^{-1}}{b1}\right) b2$$

$$= k4 - \left(\frac{6}{3.4k}\right) 0$$

$$= k4$$

$$3k$$

$$b2 = na^{-4} - \left(\frac{na}{na^{-1}}\right) na^{-5}$$

$$= 0 - \left(\frac{1}{6}\right) 0$$

$$= 0$$

$$c2 = na^{-5} - \left(\frac{na^{-1}}{b1}\right) b3$$

$$= 0 - \left(\frac{6}{3.4k}\right) 0$$

$$= 0$$

①

①

⑥

S^3	na	na^{-2}
S^2	na'	na^{-3}
S^1	$b1$	$b2$
S^0	$c1$	$c2$

$\therefore$

S^3	1	4
S^2	6	$k4^{3k}$
S^1	$3.4k$	0
S^0	$k4$	0

$3k$

error carried

$k4 > 0$

$k > 4$

$4 < k$

$k > 0$

(1)

(1)

There is no sign change in column 1 therefore the system can be stable. The system is class 0 ✓

c) $G(s) = \frac{G_1(s)}{1+G_1(s)}$

~~$G(s)G_1(s) = 1+G_1(s)$~~

$G_1(s) = \frac{G(s)}{1-G(s)}$

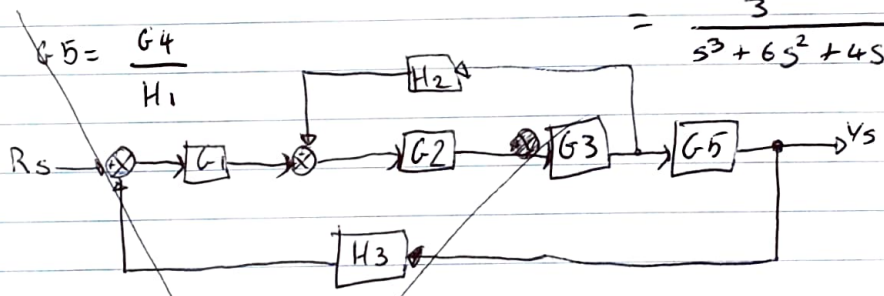
$G(s) = \frac{G_1(s)}{1+G_1(s)H(s)}$

$G(s)G_1(s) = \frac{G_1(s)}{1+G_1(s)H(s)}$

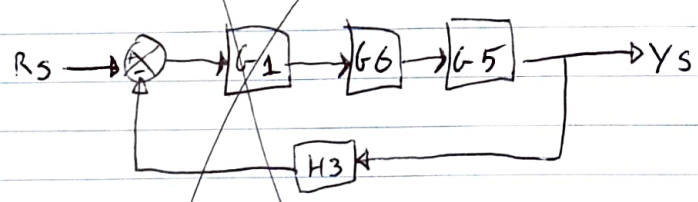
$= \frac{3/s^3 + 6s^2 + 4s}{1 + k(3/s^3 + 6s^2 + 4s)}$
 $= \frac{3}{s^3 + 6s^2 + 4s k4}$

(1/2)

5) a)



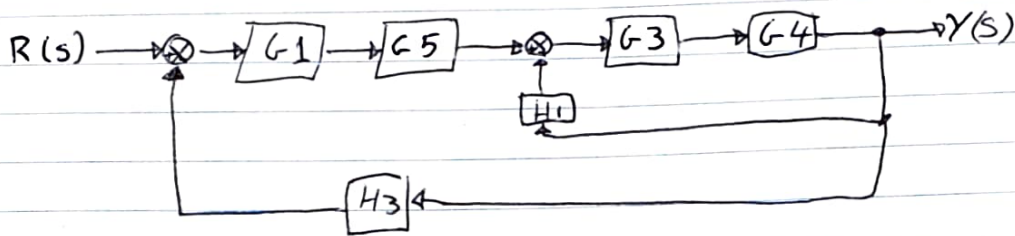
$G_6 = \frac{G_2 G_3}{1 + H_2 G_2 G_3}$



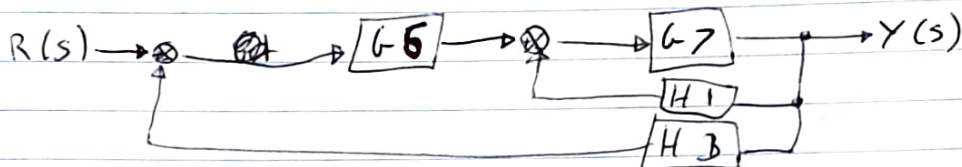
$T = \frac{G1 G6 G5}{1 + H3 G1 G6 G5}$
 $= \frac{G1 G6 \frac{G4}{H1}}{1 + H3 G1 G6 \frac{G4}{H1}}$
 $= \frac{G1 G2 G3}{1 + H3 G1 G6 \frac{G4}{H1}}$

$$= \frac{G_1 (G_2 G_3 / 1 + H_2 G_2 G_3) G_4 / H_1}{1 + H_3 G_1 (G_2 G_3 / 1 + H_2 G_2 G_3) G_4 / H_1}$$

5 a)

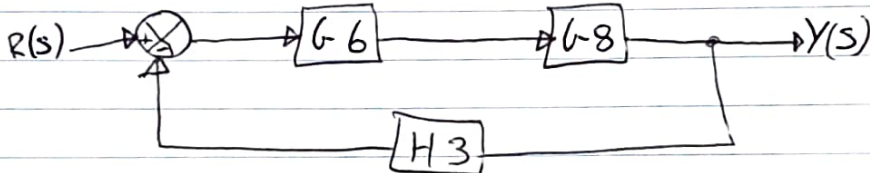


$$G_5 = \frac{G_2}{1 + H_2 G_2} \quad \text{X}$$



$$G_6 = G_1 G_5$$

$$G_7 = G_3 G_4$$



$$G_8 = \frac{G_7}{1 + H_1 G_7}$$

$$T = \frac{G_6 G_8}{1 + H_3 G_6 G_8}$$

$$= \frac{G_1 G_5 G_8}{1 + H_3 G_1 G_5 G_8}$$

$$= \frac{G_1 G_2 G_8}{1 + H_2 G_2}$$

$$\frac{1 + H_3 G_1 \frac{G_2}{1 + H_2 G_2} G_8}{1 + H_2 G_2}$$

$$= \frac{G_1 G_2 G_7}{1 + H_2 G_2 \quad 1 + H_1 G_7}$$

$$\frac{1 + H_3 G_1 \frac{G_2}{1 + H_2 G_2} \frac{G_7}{1 + H_1 G_7}}{1 + H_2 G_2 \quad 1 + H_1 G_7}$$

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

$$\frac{1 + H_3 G_1 \frac{G_2}{1 + H_2 G_2} \frac{G_3 G_4}{1 + H_1 G_3 G_4}}{1 + H_2 G_2 \quad 1 + H_1 G_3 G_4}$$

3

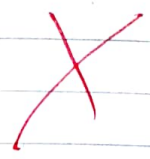
5

Question

Examiner Only

$$\frac{G_1 \frac{G_2}{1+H_2 G_2} \frac{G_3 G_4}{1+H_1 G_3 G_4}}{1+H_3 G_1 \frac{G_2}{1+H_2 G_2} \frac{G_3 G_4}{1+H_1 G_3 G_4}}$$

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

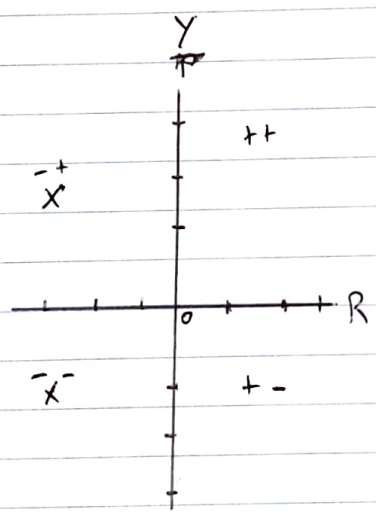


$$= \frac{2 \times 2 \times 3}{2 \times 2 \times 2 \times 3}$$

$$= \frac{12}{24}$$

$$S = 0.5$$

c)



2) $\frac{Y(s)}{R(s)} =$

Equation 1 = $Y(s) = \frac{25}{s(s+1)} - \frac{25}{s(s+1)} + R(s)$

Equation 2 = $\frac{25}{s(s+1)}$

Equation 2 = $\frac{25}{s(s+1)} = \frac{25}{s(s+1)} R(s) - Y(s)$

1) a)

