

12 Pages

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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.
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SURNAME: white

FORENAME(S): Kai

1	Student Number	
2	Title of Examination Paper	Control engineering
3	Module Code	SGEES014
4	Date and Time of Examination	09/01/25 9.30
5	Examination Venue	
6	Seat Number	
7	Number of Answer Books handed in	

[illegible]

(Gweler yr ochr arall am y fersiwn Cymraeg)

36

1 a)

$$\frac{100}{(s+3)(s+2)(s+5)}$$

$$|G(j\omega)| = \frac{100}{(j\omega+3)(j\omega+2)(j\omega+5)}$$

$$= \frac{100}{(\sqrt{\omega^2+3^2})(\sqrt{\omega^2+2^2})(\sqrt{\omega^2+5^2})}$$

$$|K(j\omega) \text{ dB}| = \log 20 \left(\frac{100}{(\sqrt{\omega^2+3^2})(\sqrt{\omega^2+2^2})(\sqrt{\omega^2+5^2})} \right)$$

$$\omega = 0.6$$

$$= \log 20 \left(\frac{100}{(3.004)(2.006)(5.003)} \right)$$

$$= 10.415 \text{ dB}$$

Angle on
next page

$$B) \quad \frac{4(1 + \frac{j\omega}{5})}{(1 + \frac{j\omega}{15})(1 + \frac{j\omega}{35})}$$

$$\frac{4 \left(\frac{15 \times 35}{5} \right) (j\omega + 5)}{(j\omega + 15)(j\omega + 35)}$$

$$\frac{420(j\omega + 5)}{(j\omega + 15)(j\omega + 35)}$$

$$\frac{420(s+5)}{(s+15)(s+35)}$$

3

$$1a \quad \angle \theta = -\tan^{-1}\left(\frac{\omega}{3}\right) - \tan^{-1}\left(\frac{\omega}{2}\right) - \tan^{-1}\left(\frac{\omega}{5}\right)$$

$$\omega = 0.16$$

$$= -9.46^\circ$$



2

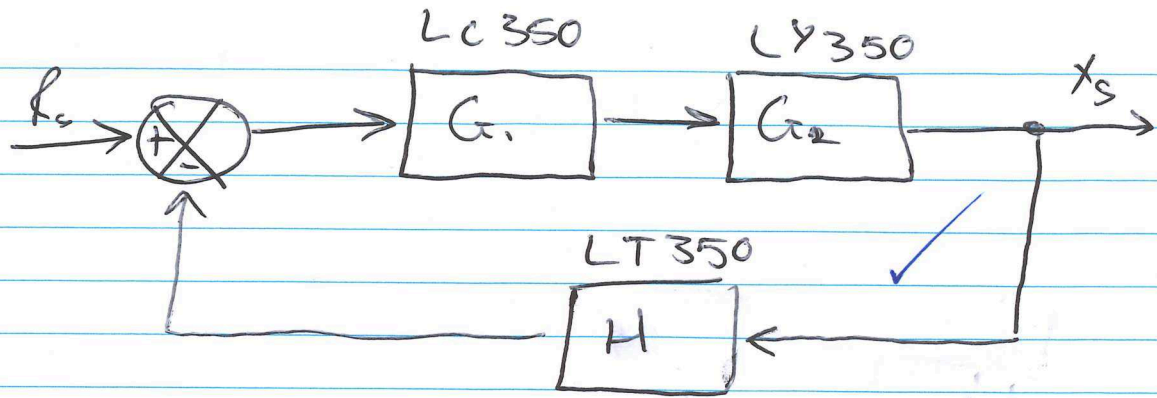
$$c) \quad PM = \theta - (-180^\circ)$$

$$= -67.5^\circ + 180^\circ = -247.5^\circ$$

✓ see fig.

3

2a)



$$G_1 = K_p$$

$$G_2 = \frac{0.25}{110s+1}$$

$$H = \frac{1}{2s+1}$$

$$G = K_p \frac{0.25 K_p}{110s+1}$$

$$TF = \frac{G_s}{1+G_s H_s}$$

$$= \frac{0.25 K_p}{110s+1} \frac{1}{1 + \left(\frac{0.25 K_p}{110s+1} \right) \left(\frac{1}{2s+1} \right)}$$

$$= \frac{0.25 K_p (2s+1)}{(110s+1)(2s+1) + 0.25 K_p}$$

$$= \frac{0.125 K_p (s+0.5)}{220s^2 + 112s + 1 + 0.25 K_p}$$

$$= \frac{0.125 K_p (s+0.5)}{220 \left(s^2 + \frac{112}{220}s + \frac{1}{220} \right)} \quad K_p = 1.10$$

3

2

1

1

1

a 3a

$$G_{20} = \frac{2}{s+1} \times \frac{1}{s(s+3)}$$

$$= \frac{2}{s+1} \times \frac{1}{s^2+3s}$$

c)

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

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

$$= \frac{2}{s^3+4s^2+3s} \div \left(1 + \frac{2K}{s^3+4s^2+3s} \right)$$

$$= \frac{2}{(s^3+4s^2+3s) + 2K} \quad \checkmark$$

$$a_1 = 1 \quad a_2 = 4 \quad a_3 = 3 \quad a_4 = 2K$$

s^3	1	3	
s^2	4	2	
s^1	10	0	X
s^0	20		

$$s^2 = (4 \times 3) - (1 \times 2)$$

$$= 10$$

$$s^3 = (10 \times 2) - 0$$

$$= 20$$

4 a)

$$TF = \frac{25}{s^2 + 4s}$$

$$\frac{G}{1+GH} ?$$

Compare w

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

$$b) i) \omega_n^2 = 25 \quad \omega_n = \sqrt{25} = 5$$

$$ii) 2\zeta\omega_n = 1 \quad \zeta = \frac{1}{2 \times 5} = \frac{1}{10} = 0.1$$

$$iii) \omega = \omega_n \sqrt{1 - \zeta^2} \\ = 5 \sqrt{1 - (0.1)^2} \\ = 4.97 \text{ rad/s}$$

knock on error.

$$iv) t_r = \frac{\pi - \tan^{-1} \frac{\omega_n \sqrt{1 - \zeta^2}}{\zeta}}{\omega_n \sqrt{1 - \zeta^2}}$$

$$= \frac{\pi - \tan^{-1} \left(\frac{\sqrt{1 - 0.01}}{0.1} \right)}{5 \sqrt{1 - 0.01}} = 0.34 \text{ sec}$$

$$v) t_p = \frac{\pi}{\omega_n \sqrt{1 - \zeta^2}} = \frac{\pi}{5 \sqrt{1 - 0.01}} = 0.63 \text{ sec}$$

$$vi) 100e^{\frac{-\zeta\pi}{\sqrt{1 - \zeta^2}}} = 100e^{\frac{-0.1\pi}{\sqrt{1 - 0.01}}} = 72.92\%$$

$$vii) t_s = \frac{4}{\zeta\omega_n} = \frac{4}{0.1 \times 5} = 8 \text{ sec}$$

$$viii) n = \frac{2}{\pi} \sqrt{\frac{1}{\zeta^2} - 1} = \frac{2}{\pi} \sqrt{\frac{1}{0.01} - 1} = 6.33$$

a

$$c) \quad s^2 + 4s + 25 = 0$$

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

c)

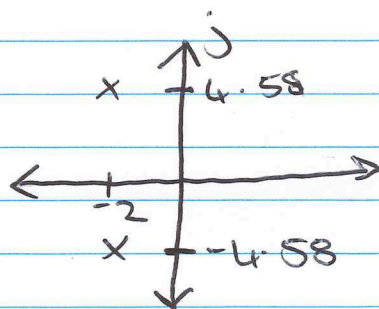
$$\frac{-4 \pm \sqrt{4^2 - 4 \times 25}}{2}$$

$$\frac{-4 \pm \sqrt{16 - 100}}{2}$$

$$= \frac{-4 \pm \sqrt{-84}}{2}$$

$$= \frac{-4 \pm j9.17}{2}$$

$$= -2 \pm j4.58$$



Poles in left hand plane so system is stable.