higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CONTROL SYSTEMS N6

14 AUGUST 2019

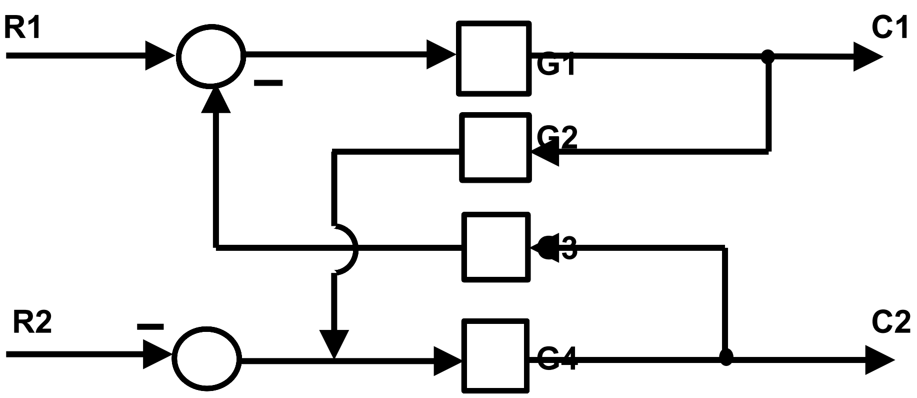
This marking guideline consists of 10 pages.

QUESTION 1

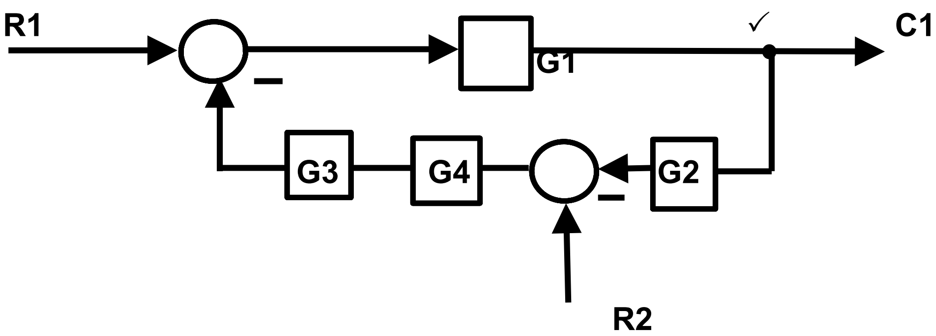
1.1	H
1.2	A
1.3	D
1.4	B
1.5	J
1.6	G
1.7	C
1.8	F
1.9	I
1.10	E

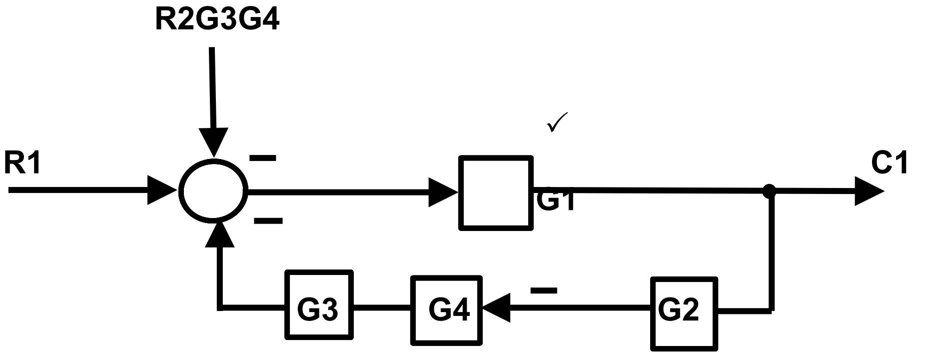
(10 × 1) **[10]**

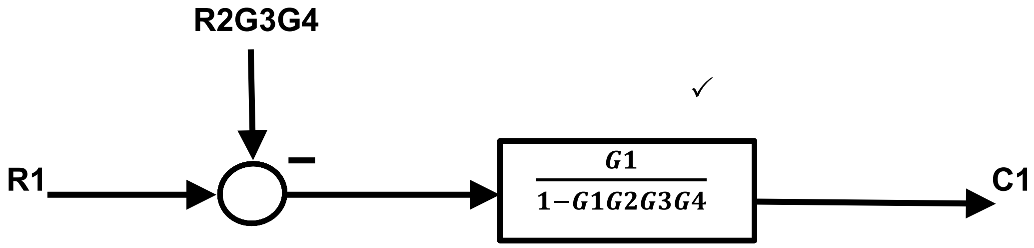
QUESTION 2

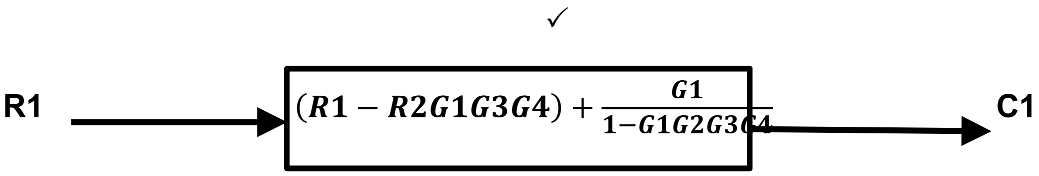


To determine C1:



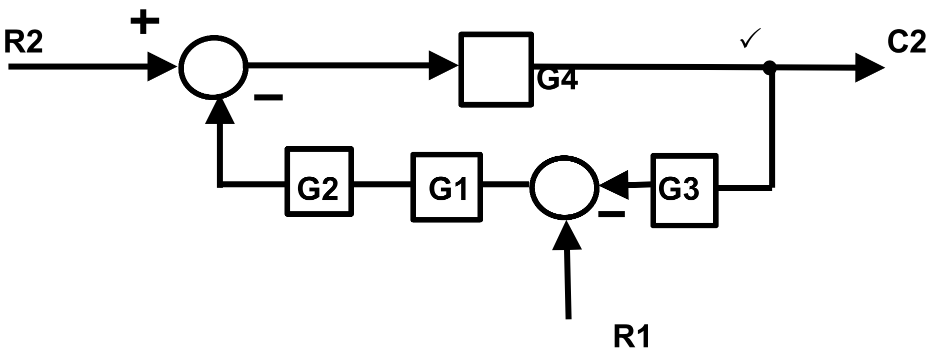


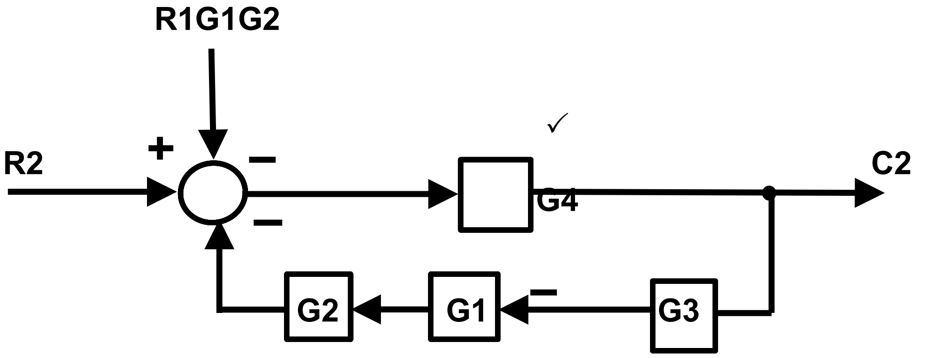


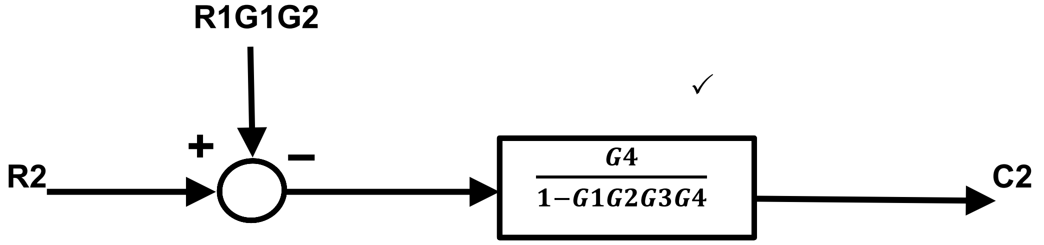


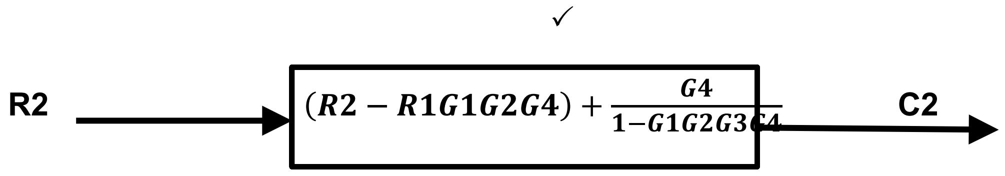
$$C1 = \frac{R1G1 - R2G1G3G4}{(1-G1G2G3G4)}$$ ✓

To determine C2:









$$C2 = \frac{R2G4 - R1G1G3G4}{(1 - G1G2G3G4)}$$ ✓

[10]

QUESTION 3

3.1

$$G(s)H(s) = \frac{35}{s(1+0{,}4s)}$$

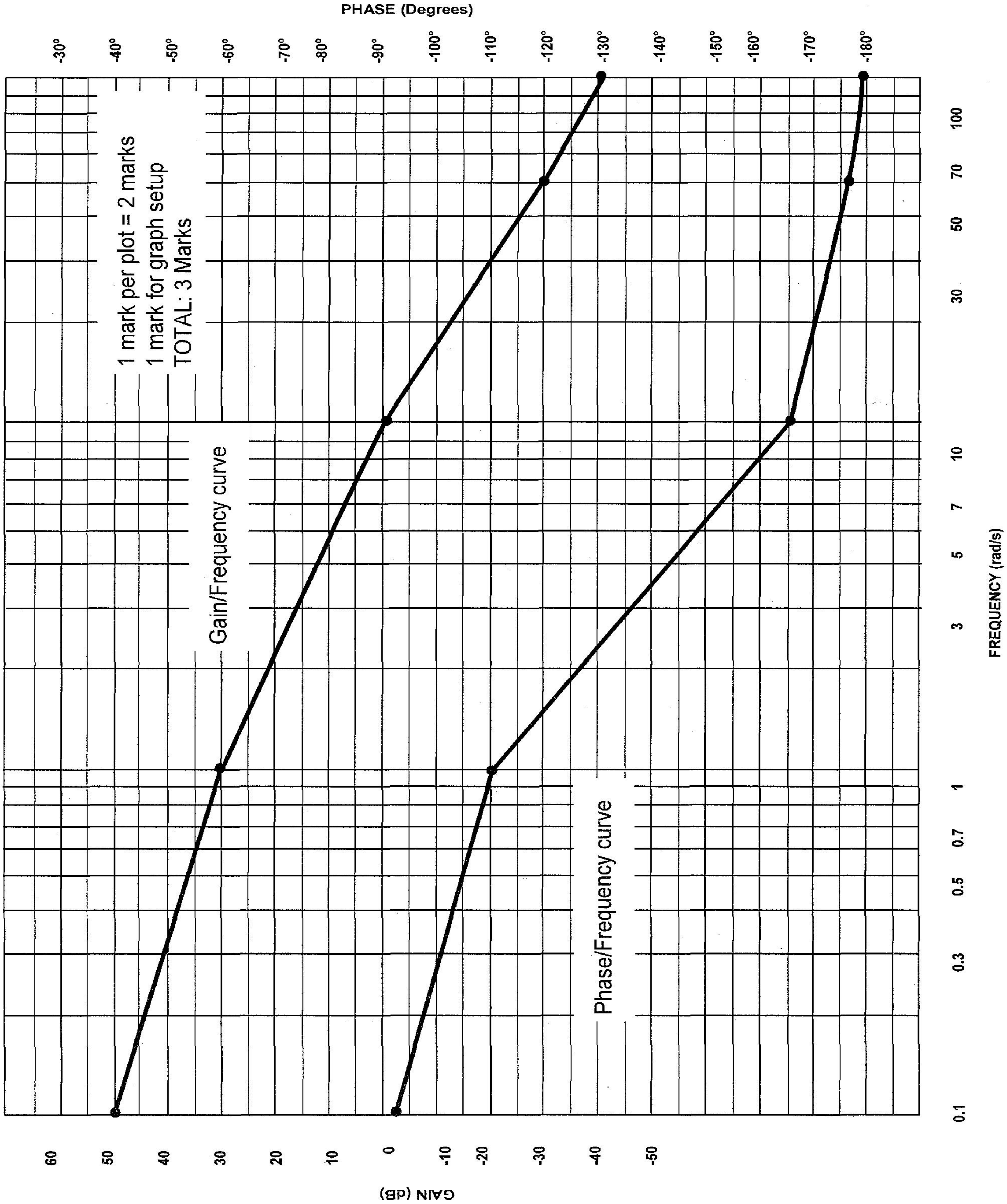
✓✓

$$G(jw)H(jw) = \frac{35}{j\frac{\omega}{1}(1+j\frac{\omega}{2{,}5})}$$

ω (rad/sec)	Gain A (dB)	θ (Degrees)	
0,1	50,87	- 92,29°	✓
1	30,24	- 111,8°	✓
10	- 1,424	- 165,96°	✓
50	- 29,13	- 177,14°	✓
100	- 41.164	- 178,57°	✓

(7)

3.2


PHASE (Degrees)
-30° -40° -50° -60° -70° -80° -90° -100° -110° -120° -130° -140° -150° -160° -170° -180°
1 mark per plot = 2 marks
1 mark for graph setup
TOTAL: 3 Marks
Gain/Frequency curve
Phase/Frequency curve
FREQUENCY (rad/s)
0.1 0.3 0.5 0.7 1 3 5 7 10 30 50 70 100
GAIN (dB)
60 50 40 30 20 10 0 -10 -20 -30 -40 -50

(3)
[10]

QUESTION 4

4.1	4.1.1	Gain margin = 11,9 dB	(1)
	4.1.2	Phase margin = 38°	(1)
	4.1.3	Gain crossover frequency = 23 rad/sec	(1)
	4.1.4	Phase crossover frequency = 31.8 rad/sec	(1)
	4.1.5	Un-damped natural resonant frequency = 24 rad/sec	(1)
	4.1.6	Peak frequency response = 26,5 rad/sec	(1)
	4.1.7	Peak magnitude and phase = 4 dB and - 118°	(2)
	4.1.8	Closed-loop bandwidth = 30 rad/sec	(1)
4.2	Stable		(1)

[10]

QUESTION 5

5.1

$$G(s)H(s) = \frac{20(0{,}25s+1)}{s(0{,}05s+1)(0{,}5s+1)}$$

$$= \frac{20\times0{,}25(s+\frac{1}{0{,}25})}{s\times0{,}05\times0{,}5(s+\frac{1}{0{,}05})(s+\frac{1}{0{,}5})} \quad \checkmark$$

$$= \frac{5(s+4)}{s\times0{,}025(s+20)(s+2)}$$

$$= \frac{200(s+4)}{s(s+20)(s+2)} \quad \checkmark$$

$K_o = 200$ ✓ (3)

5.2 Open-loop poles = 0 ; - 2 ; - 20 Zero's = - 4 ✓✓ (2)

5.3

$$S_c = \frac{\sum Poles - \sum Zeros}{N_p - N_z}$$

$$= \frac{(0-2-20)-(-4)}{3-1} \quad \checkmark$$

$$= \frac{-18}{2}$$

$S_c = -9$ ✓ (2)

5.4 $\psi = \dfrac{(2K+1)180}{N_p - N_z}$

$= \frac{(2K+1)180}{2} \; if \; \mathrm{K} = 0, 1, 2, 3, \infty$ ✓

$\psi = 90° \; when \; K = 0$ ✓

$\psi = 270° \; when \; K = 1$ ✓ (3)

[10]

QUESTION 6

6.1 6.1.1 $F(t) = 15 \cos 135t$

$F(s) = \frac{15s}{s^2 + 135^2}$ ✓✓

$F(s) = \frac{15s}{s^2 + 18225}$ ✓ (3)

6.1.2 $F(t) = \dfrac{60}{5}(1 - e^{-5t})$

$F(s) = \frac{60}{s(s+5)}$ ✓✓ (2)

6.2 $F(s) = \dfrac{45\omega}{(s^2 + \omega^2)(s+7)(s+5)}$

$$F(t) = 45\left[\frac{\omega e^{-7t}}{(5-7)(\omega^2+7^2)} + \frac{\omega e^{-5t}}{(7-5)(\omega^2+5^2)} + \frac{\sin(\omega t - \Psi)}{(\omega^2+7^2)(\omega^2+5^2)^{\frac{1}{2}}}\right]$$ ✓✓

$$F(t) = 45\left[\frac{\omega e^{-7t}}{(-2)(\omega^2+49)} + \frac{\omega e^{-5t}}{(2)(\omega^2+25)} + \frac{\sin(\omega t - \Psi)}{(\omega^2+49)(\omega^2+25)^{\frac{1}{2}}}\right]$$ ✓

where

$\Psi = tan^{-1} \frac{\omega(7+5)}{(7\times5) - \omega^2} \; (0 < \Psi < \pi)$ ✓

$\Psi = tan^{-1} \frac{\omega(12)}{(35) - \omega^2} \; (0 < \Psi < \pi)$ ✓ (5)

[10]

QUESTION 7

7.1

$$\Psi = \frac{1}{\sqrt{1-\zeta^2}} \times tan^{-1}\left[\frac{\sqrt{1-\zeta^2}}{-\zeta}\right] + \pi\ rad$$

$$\Psi = \frac{1}{\sqrt{1-0{,}12^2}} \times tan^{-1}\left[\frac{\sqrt{1-0{,}12^2}}{-0{,}12}\right] + 180° \checkmark$$

$$\Psi = 1{,}0073 \times \frac{(-83{,}1° + 180°)}{57{,}3}$$

$$\Psi = 1{,}703\ rad \checkmark$$

(2)

7.2 Amplitude of first peak $= \varphi = \left[1 + e^{\frac{-\zeta\pi N}{\sqrt{1-\zeta^2}}}\right]$

$$= \left[1 + e^{\frac{-0{,}12\times\pi\times1}{\sqrt{1-0{,}12^2}}}\right] \checkmark$$

$$= 1{,}684\ units \checkmark$$

(2)

7.3 % Overshoot $= e^{\frac{-\zeta\,\pi N}{\sqrt{1-\zeta^2}}}$

$$= e^{\frac{-0{,}12\times\pi\times1}{\sqrt{1-0{,}12}}} \times 100 \checkmark$$

= 68,4 % ✓

(2)

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

$$\omega_d = 6 \times \sqrt{1-0{,}12^2} \checkmark$$

$$\omega_d = 5{,}96\ rad/s \checkmark$$

(2)

7.5 Peak time $t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

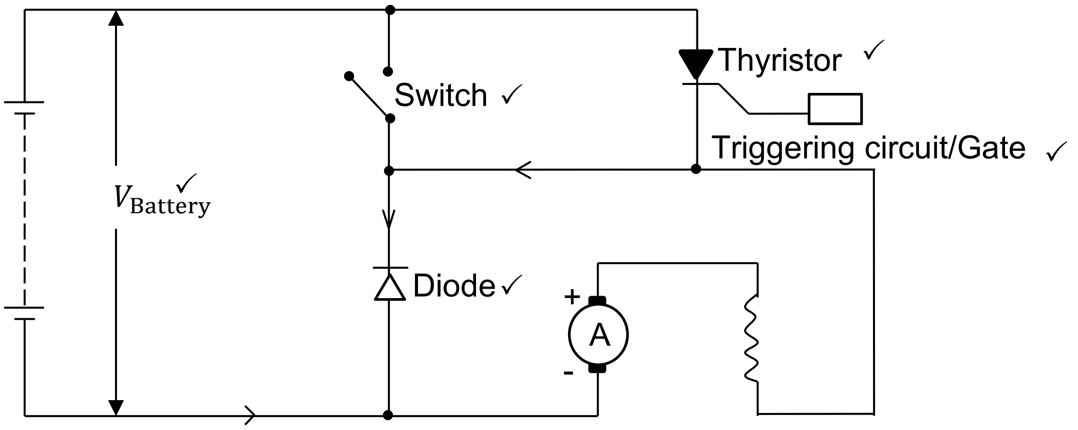
$$= \frac{\pi}{6\sqrt{1-0{,}12^2}} \checkmark$$

$$= 0{,}53\ sec \checkmark$$

(2)
[10]

QUESTION 8

8.1



(5)

8.2

- Switch is open and thyristor conducts (fires) by applying a current pulse to the gate.✓
- Switch closes for sufficient time to allow the thyristor current to fall to zero allowing it to revert to its nonconducting state.✓
- Switch opens and the current through the motor decreases at such a rate that the emf in the armature exceeds the rotational emf by an amount sufficient to a current around the closed circuit formed by the motor and diode.✓✓
- Operation is repeated after a time period.✓ (5)

[10]

QUESTION 9

9.1 It is used to move a liquid against the force of gravity from one place to another. (1)

9.2 9.2.1 A – Outlet
B – Inlet
C – Vacuum
D – High pressure (4)

9.2.2 Rotary pump (1)

9.3

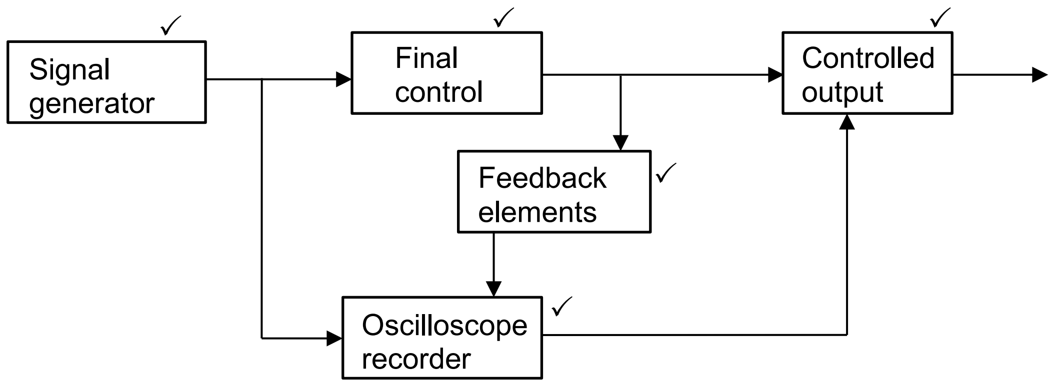
- The pistons are arranged parallel to the shaft of the pump motor.
- The driving flange of the pump rotates the cylinder barrel.
- The axial reciprocation of the pumping pistons in the cylinder is caused by the shoe retainer, which is spring loaded towards the cam plate.
- The piston stroke and the quantity of oil delivered are limited by the angle of the cam plate. (4)

[10]

QUESTION 10

10.1
- Apply the two signals to the deflecting plates (inputs).
- Make two measurements from the display which could be a straight line, an ellipse or a circle.
- Switch off the time base by fully turning the stability control anticlockwise and ensure the two signals are of the same frequency. (3)

10.2



(5)

10.3

$$p.r.f = \frac{1}{Period}$$

$$p.r.f = \frac{1}{8 \times 10^{-6}} \checkmark$$

$$= 125\ 000\ pulses/sec \checkmark$$

(2)
[10]

TOTAL: 100