higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

CONTROL SYSTEMS N6

23 April 2021

This marking guideline consists of 8 pages.

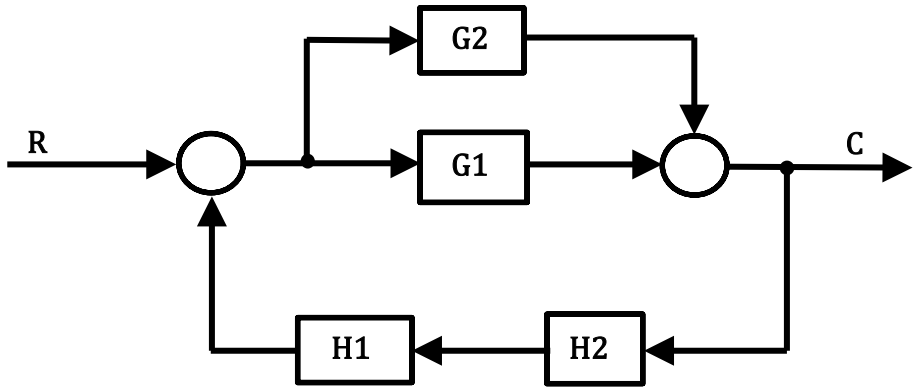
QUESTION 1

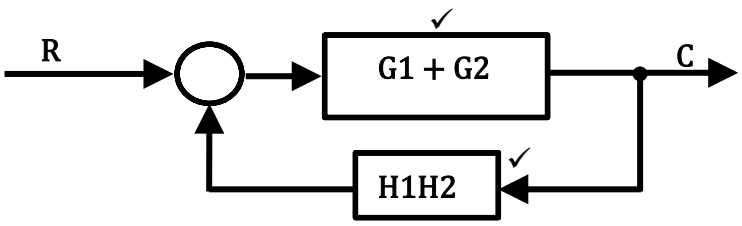
1.1 False
1.2 True
1.3 False
1.4 False
1.5 True
1.6 False
1.7 True
1.8 False
1.9 True
1.10 False

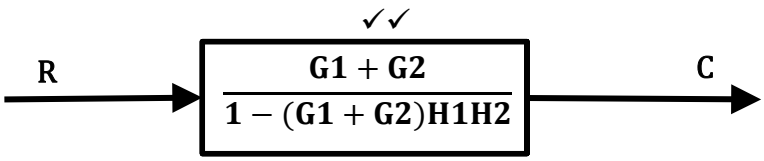
(10 × 1) **[10]**

QUESTION 2

2.1







$$\frac{\mathbf{C}}{\mathbf{R}} = \frac{\mathbf{G1 + G2}}{\mathbf{1 - (G1 + G2)H1H2}} \checkmark$$

$$\mathbf{C} = \frac{\mathbf{R(G1 + G2)}}{\mathbf{1 - (G1 + G2)H1H2}} \checkmark$$

(6)

2.2 2.2.1 $T_A = 15\sin 2t \quad \rightarrow \quad T_{A(s)} = \frac{A\omega}{s^2 + \omega^2}$ ✓ (1)

2.2.2 $$\frac{\text{Output}}{\text{Input}} = \frac{{\omega_n}^2}{s^2 + 2\zeta\omega_n s + {\omega_n}^2}$$

$$\frac{\text{Output}}{T_A} = \frac{{\omega_n}^2}{s^2 + 2\zeta\omega_n s + {\omega_n}^2} \checkmark$$

$$\text{Output}_s = \frac{T_A.{\omega_n}^2}{s^2 + 2\zeta\omega_n s + {\omega_n}^2} \checkmark$$

$$\text{Output}_s = \frac{A\omega.{\omega_n}^2}{(s^2 + \omega^2)(s^2 + 2\zeta\omega_n s + {\omega_n}^2)} \checkmark$$ (3)

[10]

QUESTION 3

3.1 43 dB (1)

3.2 246° (1)

3.3 0,6 rad/s (1)

3.4 43 dB/decade or -14 dB/octave (1)

3.5 8 rad/s (1)

3.6 4,5 rad/s (1)

3.7 -15 dB (1)

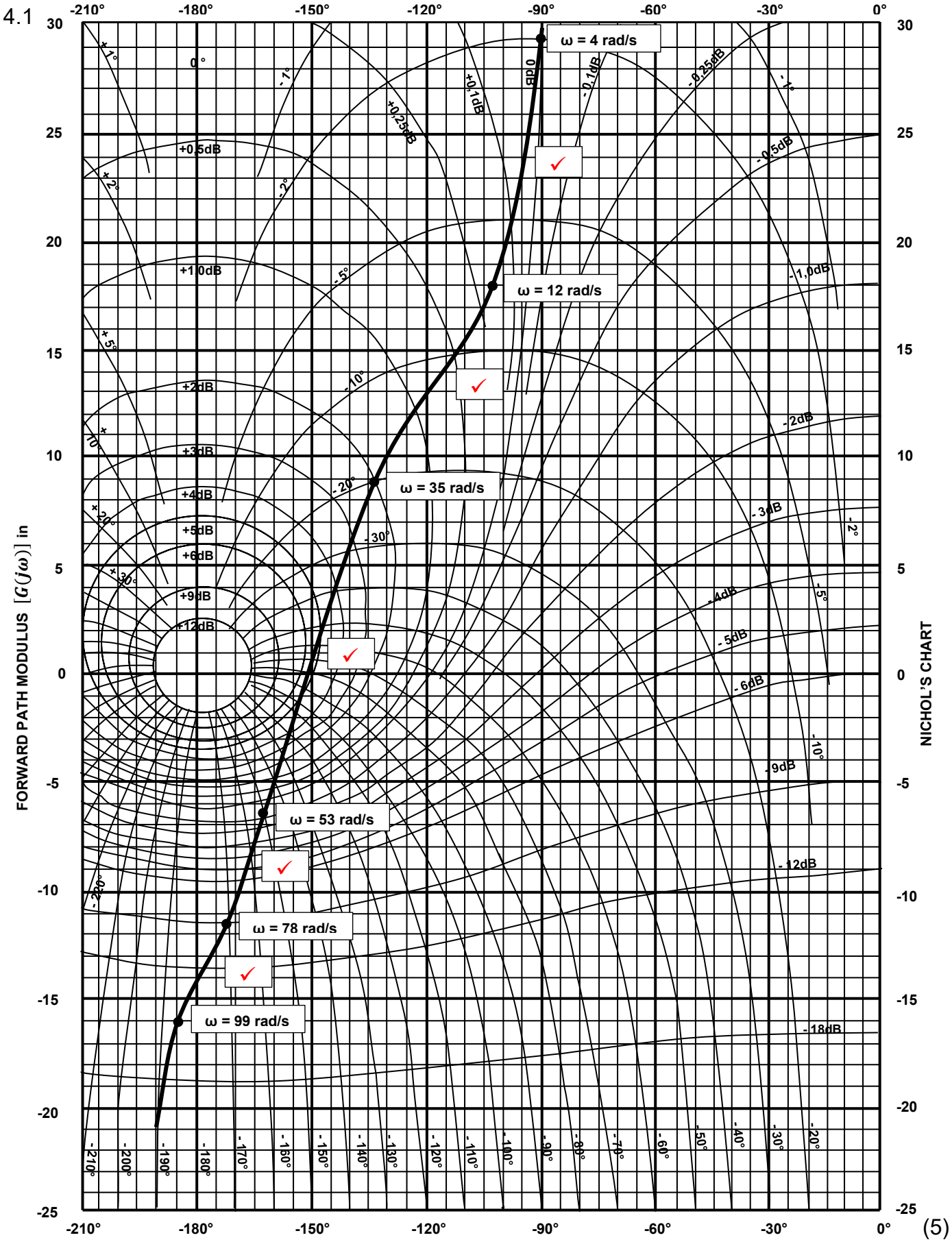
3.8 -48° (1)

3.9 The gain and phase margins are negative, thus indicating an unstable system. (2)

[10]

QUESTION 4

4.1



(5)

4.2

ω (rad/s)	4	12	35	53	78
Magnitude in dB	29,3	18	8,8	-6,5	-11,5
Phase in degrees	-90°	-102,5°	-133°	-162,5°	-172,5°
	✓	✓	✓	✓	✓

(5)
[10]

QUESTION 5

5.1

$$G(s)H(s) = \frac{3A}{s(0{,}25s+1)(0{,}125s+1)}$$

$$= \frac{3.A}{0{,}25 \times 0{,}125} \times \frac{1}{s(s+\frac{1}{0{,}25})(s+\frac{1}{0{,}125})} \checkmark$$

$$= \frac{3.A}{0{,}03125} \times \frac{1}{s(s+4)(s+8)} \checkmark$$

$$= \frac{96}{s(s+4)(s+8)}$$

$K_o = 96$✓ (3)

5.2 Open-loop poles = 0 ; -4 ; -8✓
Zeroes = None✓ (2)

5.3

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

$$= \frac{(0-4-8)-0}{3-0} \checkmark$$

$$= \frac{-12}{3}$$

$= -4$ ✓ (2)

5.4

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

$$= \frac{(2K+1)180}{3-0}$$

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

$\psi = 60°$ when $K = 0$ ✓
$\psi = 180°$ when $K = 1$✓
$\psi = 300°$ when $K = 2$✓
$\psi = 420°$ when $K = 3$ $(420° = 360° + 60° \rightarrow K = 0°)$ (3)
[10]

QUESTION 6

6.1
- Adding
- Subtracting
- Multiplying
- Dividing
- Differentiating
- Integrating (Any 4 × 1) (4)

6.2 A wheel perforated by a number of equally spaced holes is rotated at a certain speed.✓ The wheel is positioned so that a light beam passes through one of the holes to reach the photocell.✓ An AC amplifier selects and transmits the required frequency signal to produce an output.✓ (3)

6.3 The wheel system is subjected to wear and tear. (1)

6.4 $V_o = \frac{R_f}{R_1}(V_2 - V_1)$

$= \frac{10}{6}(240 - 90)$✓

$= 250\ \text{V}$✓ (2)

[10]

QUESTION 7

7.1
- Small DC servos
- Large DC servos
- Small AC servos
- Large AC servos (4)

7.2
- Inability to operate at low speeds
- Produces eddy currents due to back emf
- Poor positioning control (3)

7.3 The purpose of a rectifier is to convert alternating current (AC) to direct current (DC) so that the current flows in one direction only. (2)

7.4 Linear variable differential transformer (1)

[10]

QUESTION 8

8.1 8.1.1 A: Thyristor/SCR
B: Bridge rectifier
C: Armature (3)

8.1.2 The armature speed is controlled by the rate at which the thyristor is triggered.✓ For every half-wave cycle of the bridge rectifier, the field coil produces a magnetic flux.✓ The thyristor becomes forward biased on every alternate half cycle when triggered by the trigger circuit during this period.✓ The armature is supplied with half-wave rectification depending on the conduction angle of the triggering circuit.✓ (4)

8.2 The conduction angle of a thyristor is the angle at which the thyristor conducts through it. The angle of conduction is dependent on the trigger circuit. This angle can be varied by firing the thyristor at different time intervals at its gate terminal. (3)
[10]

QUESTION 9

9.1
- Proportional controller
- Integral controller
- Derivative controller (3)

9.2 9.2.1 Internal spur-gear pump (1)

9.2.2 A: Pump outlet
B: Idler gear
C: Pump inlet
D: Crescent seal
E: Drive gear (5)

9.2.3 Rotary pumps (1)
[10]

QUESTION 10

10.1 Lissajous figures are usually used for determining the frequency of unknown sinusoidal signals. (2)

10.2 Impedance mismatching (1)

10.3 Mismatching results in reflections that are re-reflected to the load. (2)

10.4 Frequency-response test (1)

10.5 A saw-tooth wave can be generated by charging and discharging a capacitor using proper RC time constants. (2)

10.6 $$\text{p.r.f} = \frac{1}{\text{period}}$$
$$= \frac{1}{4 \times 10^{-6}} \checkmark$$
$$= 250\,000 \text{ pulses/s} \checkmark$$ (2)
[10]

TOTAL: 100