higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

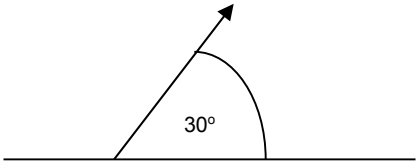
21 November 2022

This marking guideline consists of 11 pages.

QUESTION 1

1.1 1.1.1

U = 400m/s



V_Y = 400 sin 30°
= 200 m/s√

V_X = 400 COS 30°
= 346,410 m/s√

1.1.1 $S_V = \frac{U^2 \sin^2\theta}{2g}$

$= \frac{400^2 \times (\sin 30)^2}{2 \times 9,8}$ ✓

= 2040,816 m✓

An alternative method:

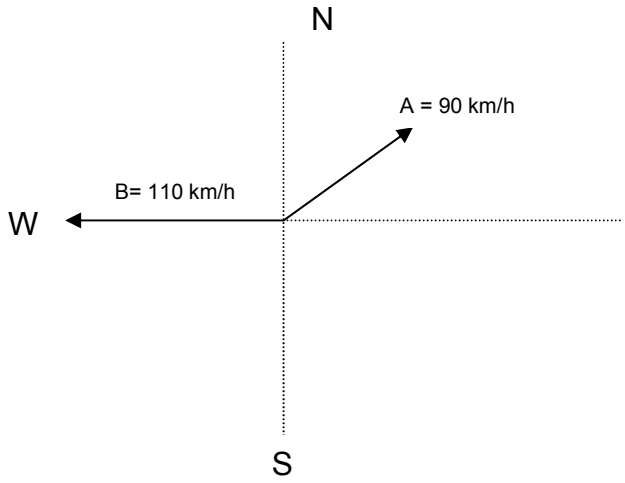
$S = \frac{v^2 - u^2}{2 \times g}$

$= \frac{0^2 - (400 \sin 30)^2}{2 \times 9,8}$ ✓

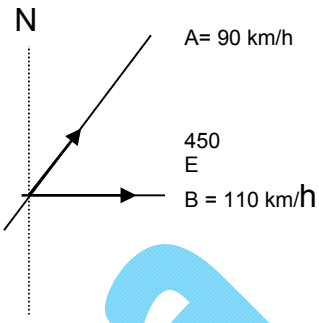
= 2040,816 m✓ (3)

1.1.2 $S_H = u_H \times t_H$
= 400 cos 30° × 2 × 20,408✓
= 14139,077 m✓ (2)

1.2



CHANGE TO



Stop B and change its direction

Σ_v = 110 km/h sin 0° + 90 km/h sin 45°
= 63,64 km/h✓

Σ_H = 110 km/h cos 0° + 90 km/h cos 45°
= 173,64 km/h✓

R = $\sqrt{63{,}64^2 + 173{,}64^2}$
= 184,965 km/h✓

θ = $tan^{-1}\frac{63{,}64}{173{,}64}$

= 20,128°✓

$A\bar{V}B$ = 184,935 km/h E 20,128°✓✓

OR

$A\bar{V}B$ = 184,935 km/h N 69,872°✓ (6)

1.3 $v(boat) = 35 \times \frac{1000}{3600}$

$\underline{v(boat) = 9,722 m/s}$

$v_R^2 = v_{boat}^2 + v_{river}^2$

$v_R = \sqrt{9,722^2 + 5^2}$ ✓

$\underline{v_R = 10,932 m/s}$ ✓

$\tan\theta = \frac{5}{9,722}$

$\theta = \tan^{-1}\frac{5}{9,722}$

$\underline{\theta = 27,217°}$ ✓

$v_R = 10,932 m/s \_ 27,217° West \_ of \_ North$ ✓ (4)

[15]

QUESTION 2

2.1 Angular acceleration of a body is the rate of change of its angular velocity. (2)

2.2 2.2.1 $v = u + at$

$\therefore \omega_2 = \omega_1 + at$

$\alpha = \frac{\omega_2 - \omega_1}{t}$

$= \frac{14 - 6}{13}$ ✓

$= 0,615$ rad/s² ✓

2.2.2 $\theta = \frac{(\omega_2)^2 - (\omega_1)^2}{2\alpha}$

$= \frac{(14)^2 - (6)^2}{2(0,615)}$ ✓

$= 130,081$ radians ✓

(2 × 2) (4)

2.3 2.3.1 $R = \frac{600}{2} = 300mm = 0,3m$

$v = 120 \times \frac{1000}{3600} = 33,333m/s$

$v = \omega.R$

$\omega = \frac{v}{R}$

$\omega = \frac{33,333}{0,3}$ ✓

$\underline{\omega = 111,11rad/s}$ ✓

2.3.2 $\alpha = \frac{\omega_2 - \omega_1}{t}$

$\alpha = \frac{0 - 111,11}{25}$ ✓

$\underline{\alpha = -4,444rad/s^2}$ ✓

(2 × 2) (4)

2.4 $T = I\alpha$

$T = 4 \times 37,816$ ✓

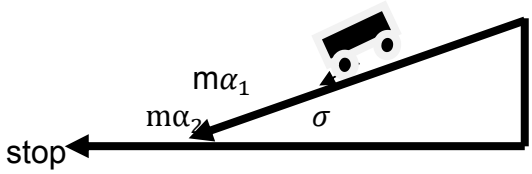
$\underline{T = 150,816Nm}$ ✓

(2)
[12]

QUESTION 3

3.1 Coefficient of the friction is the ratio of the friction force and the normal reaction (weight). (2)

3.2 3.2.1



$F_s - F\mu = m\alpha$ ✓

$\therefore mg\sin\theta - 200 = 1200\alpha_1$

$\therefore 1200(9,8)\left(\frac{1}{30}\right) - 200 = 1200\alpha_1$ ✓

$\therefore \alpha_1 = 0,16\ m/s^2$ ✓

<u>On the incline:</u>

$v^2 = u^2 + 2a_1s_1$ ✓

$\therefore v^2 = 0^2 + 2(0,16)(62)$ ✓

$\therefore v_1 = 4,454\ m/s$ ✓ (6)

3.2.2 F = -Fμ = -200 N ✓ only friction force (1)

3.2.3 On the horizontal road

$v^2 = u^2 + 2\alpha_2 s_2$ ✓

$\therefore 0^2 = (4{,}454)^2 + 2(-0{,}167)S_2$

$\therefore s_2 = 59{,}396m$ ✓

NOTE: $-F\mu = ma_2$

$\therefore -200 = 1200\, a_2$

$\therefore a_2 = -0{,}167_{m/s}2$ ✓

(3)

3.3

$$P = \frac{W}{t}$$

$$P = \frac{(300 \times 9{,}8) \times 10}{2 \times 60}$$ ✓

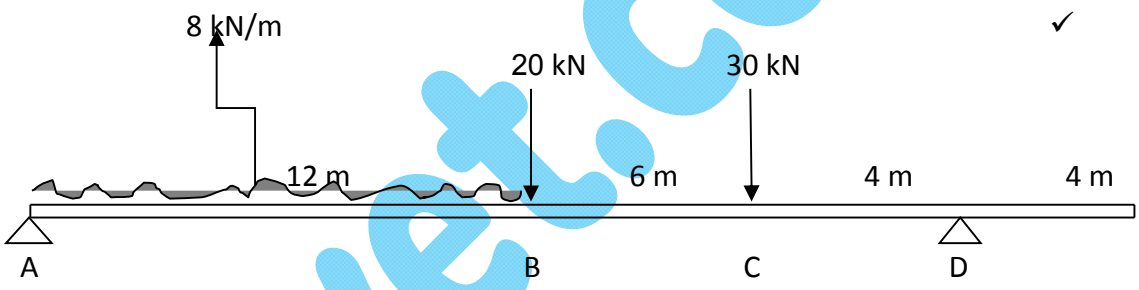
$$\underline{P = 245N}$$ ✓

(2)

[14]

QUESTION 4

4.1



✓

(1)

4.2 Take moments about A

Σ ↷ moments = Σ ↶ moments

(48 × 6) + (20 × 12) + (30 × 18) = D x 22✓

D = 48,545 kN✓

Take moments about D:

Σ ↶ moments = Σ ↷ moments

A x 22 = (48 × 16) + (20 × 10) + (30 × 4) ✓

A = 49,454 kN✓

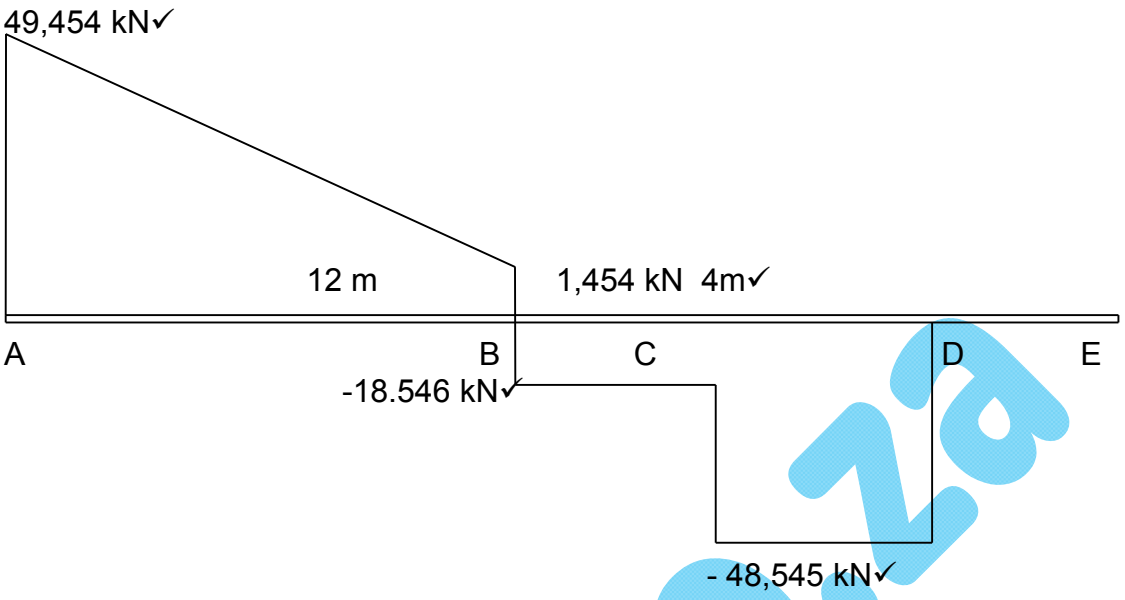
Test: Σ↑F = 49,454 + 48,545 = 98 kN

✓

Σ↓F = 48 + 20+ 30 = 98 kN

(5)

4.3

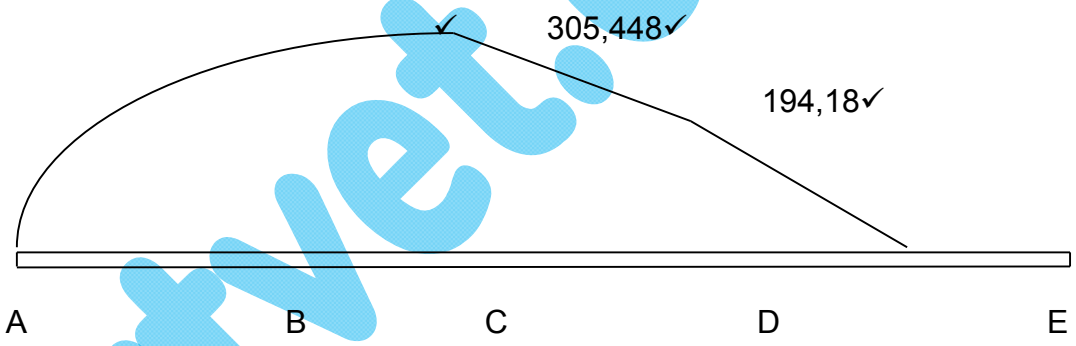


(4)

4.4 BM at B = (-48 × 6) + (49,454 × 12) = 305,448 kNm✓

BM at C = (4 × 48,545) = 194,18 kNm✓ (2)

4.5



(3)

[15]

QUESTION 5

5.1
- Mass-loaded or weight-loaded accumulator
- Spring-loaded accumulator
- Air or gas type accumulator

(3)

5.2 5.2.1

$$P = \frac{F}{A}$$

F = P × A

$$mg = P \times \frac{\pi D^2}{4}$$

$$m \times 9{,}8 = 1 \times 10^6 \times \frac{\pi(0{,}350)^2}{4}$$ ✓

$$m_t = \frac{1\times10^6}{9{,}8} \times \frac{\pi(0{,}350)^2}{4}$$ ✓

m_t = 9817,48 kg ✓

Additional mass required = total mass – mass of ram
= 9817,48 – 650
= 9167,48 kg ✓ (4)

5.2.2 Work done during working stroke of machine serve = F × S

= (m_t × g) × distance moved
= (9167,48 × 9,8) × 0,250 ✓
= 24052,83 J ✓
= 24,05 kJ (2)

5.2.3 $Power\ transmitted = \frac{work\ done}{time}$

$$P = \frac{24052{,}83}{6}$$ ✓

= 4008,81 W ✓
= 4,008 kW (2)

5.3 V = A × h × 3

$= \frac{\pi D^2}{4}$ × h × 3

$= \frac{\pi(0{,}1)^2}{4}$ × 0,15 × 3 ✓

= 0,00353 m^3 ✓

= 3,53 × 10^{-3} m^3

Power = Pressure × Volume
= 4 × 10^6 × 3,53 10^{-3} ×(130 ÷ 60) × (85 ÷100) ✓
= 26004,33 W ✓
= 26,004 kW (4)

[15]

QUESTION 6

6.1 Hooke's law states that within the elastic limit of any body the ratio of the stress to the strain produced is a constant.✓ This constant is called the modulus of elasticity of the material of the body.✓ The length modulus of elasticity is called Young's modulus.✓ (3)

6.2

$\sigma = MPa$ Load	0	25,06	98,94	173,1	27,6	321,8
ε (X10^{-4})	0	1,0	4,4	8,1	11,9	16

1 ½ mark for any correct answer per row
½ mark for correct stress y-axis
½ mark for correct strain x-axis
1 mark for straight line
1 mark for more dots (3)

6.3 $F = \delta \times A$

$= 120 \times 10^6 \times \frac{\pi \times (0,03)^2}{4}$✓

$= 0,084823 \times 10^6$ N✓

$E = \frac{\sigma}{\epsilon}$

$= \frac{F}{A} \times \frac{L}{x}$

$x_1 = \frac{F \times L}{A_1 \times E}$

$= \frac{0,084823 \times 10^6 \times 0,165}{0,0012566 \times 200 \times 10^9}$✓

$= 5,573 \times 10^{-5}$ m✓

$x_2 = \frac{F \times L}{A_2 \times E}$

$= \frac{0,084823 \times 10^6 \times 0,16}{0,0070686 \times 200 \times 10^9}$✓

$= 9,6 \times 10^{-6}$ m✓

$x_T = x_1 + x_2$

$= (5,573 \times 10^{-5} + 9,6 \times 10^{-6})$ m✓

$= 6,535 \times 10^{-5}$ m✓ (8)

[14]

QUESTION 7

7.1
- Isochoric
- Isobaric
- Isothermal

(Any 2 × 1) (2)

7.2 $\Delta A = A_0 .2 \propto \Delta t$

= (60 × 73) × 2 ×(17 × 10^{-6}) ×50✓

= 7,446 cm^2✓

(2)

7.3 $\rho_1 = 1{,}07 \times 10^4 kg/m^3$

$\rho_1 = 0^0C$ $m_1 = 1{,}07 \times 10^4$ kg

= 273 K $V_1 = 1\ m^3$ ✓

$\gamma = 200 \times 10^{-6}/^0C$

$\rho_2 = ?$ $V_2 = ?$

$T_2 = 70^0C = 273$

$\frac{70}{343K}$ ✓

$\Delta V = V_1 \gamma \Delta t$

= 1 × 200 × 10^{-6} × 70✓

= 0,014 m^3✓

$\therefore V_2 = 1{,}014\ m^3$

$\rho_2 = \frac{m}{v_2}$

= $\frac{1{,}07 \times 10^4 kg}{1{,}014 m^3}$✓

= 1,055 × 10^4 kg/m^3✓ (6)

7.4 R = 0,44 m
t = 22 °C
α = 20 × 10^{-6}/ °C
20,11 kPa

Δd , t_2 = 84 °C

$$\Delta t = t_2 - t_1$$
$$= 84^oC - 22^oC$$
$$= 62^oC \checkmark$$

$$a_o = \frac{\pi(d_0)^2}{4}$$
$$= \frac{\pi(0.88m)^2}{4}$$
$$= 0{,}608212m \checkmark$$
$$\Delta a = 2a_o\alpha\Delta t$$
$$= 2(0{,}608212\ m^2)(20\times10^{-6}/^oC)(62\ ^oC) \checkmark$$
$$= 0{,}1508\times10^{-2}\ m^2 \checkmark$$

$$\Delta a = \frac{\pi\Delta d^2}{4}$$
$$\Delta d = \sqrt{\frac{4(0{,}1508\times10^{-2})}{\pi}}$$
$$= 0{,}044\ m \checkmark$$

(5)
[15]

TOTAL: 100