



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

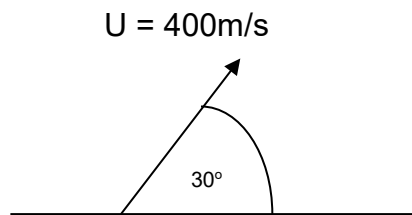
ENGINEERING SCIENCE N4

21 November 2022

This marking guideline consists of 11 pages.

QUESTION 1

1.1 1.1.1



$$V_Y = 400 \sin 30^\circ$$

$$= 200 \text{ m/s} \checkmark$$

$$V_X = 400 \cos 30^\circ$$

$$= 346,410 \text{ m/s} \checkmark$$

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

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

$$= \underline{2040,816 \text{ m}} \checkmark$$

An alternative method:

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

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

$$= \underline{2040,816 \text{ m}} \checkmark$$

(3)

1.1.2

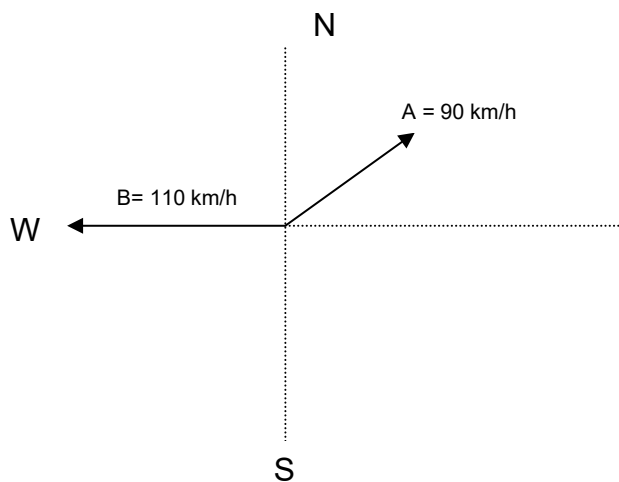
$$S_H = u_H \times t_H$$

$$= 400 \cos 30^\circ \times 2 \times 20,408 \checkmark$$

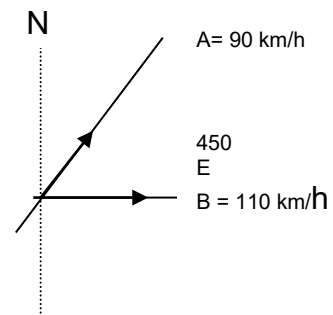
$$= \underline{14139,077 \text{ m}} \checkmark$$

(2)

1.2



CHANGE TO



Stop B and change its direction

$$\begin{aligned}\Sigma_v &= 110 \text{ km/h} \sin 0^\circ + 90 \text{ km/h} \sin 45^\circ \\ &= \underline{63,64 \text{ km/h}} \checkmark\end{aligned}$$

$$\begin{aligned}\Sigma_H &= 110 \text{ km/h} \cos 0^\circ + 90 \text{ km/h} \cos 45^\circ \\ &= \underline{173,64 \text{ km/h}} \checkmark\end{aligned}$$

$$\begin{aligned}R &= \sqrt{63,64^2 + 173,64^2} \\ &= \underline{184,965 \text{ km/h}} \checkmark\end{aligned}$$

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

$$= 20,128^\circ \checkmark$$

$$A\bar{V}B = 184,935 \text{ km/h E } 20,128^\circ \checkmark \checkmark$$

OR

$$A\bar{V}B = 184,935 \text{ km/h N } 69,872^\circ \checkmark$$

(6)

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

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

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

$$v_R = \sqrt{9,722^2 + 5^2} \quad \checkmark$$

$$\underline{v_R = 10,932 \text{ m/s}} \quad \checkmark$$

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

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

$$\underline{\theta = 27,217^\circ} \quad \checkmark$$

$$v_R = 10,932 \text{ m/s } 27,217^\circ \text{ West of North } \checkmark$$

(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 $v = u + at$
 $\omega_2 = \omega_1 + at$

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

$$= \frac{14 - 6}{13} \checkmark$$

$$= 0,615 \text{ rad/s}^2 \checkmark$$

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

$$= \frac{(14)^2 - (6)^2}{2(0,615)} \checkmark$$

$$= 130,081 \text{ radians } \checkmark$$

(2 × 2) (4)

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

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

$$v = \omega \cdot R$$

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

$$\omega = \frac{33,333}{0,3} \quad \checkmark$$

$$\omega = 111,11\text{rad/s} \quad \checkmark$$

2.3.2

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

$$\alpha = \frac{0 - 111,11}{25} \quad \checkmark$$

$$\alpha = -4,444\text{rad/s}^2 \quad \checkmark$$

(2 × 2) (4)

2.4 $T = I\alpha$

$$T = 4 \times 37,816 \quad \checkmark$$

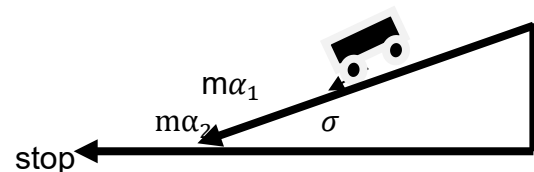
$$T = 150,816\text{Nm} \quad \checkmark$$

(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



$$F_s - F_\mu = m\alpha \quad \checkmark$$

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

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

$$\therefore \alpha_1 = 0,16\text{ m/s}^2 \quad \checkmark$$

On the incline:

$$v^2 = u^2 + 2a_1s_1 \quad \checkmark$$

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

$$\therefore v_1 = 4,454\text{ m/s} \quad \checkmark$$

(6)

3.2.2 $F = -F_\mu = -200\text{ N}$ only friction force

(1)

3.2.3 On the horizontal road

$$v^2 = u^2 + 2a_2 s_2 \checkmark$$

$$\therefore 0^2 = (4,454)^2 + 2(-0,167) s_2$$

$$\therefore s_2 = 59,396 \text{ m} \checkmark$$

NOTE: $-F\mu = ma_2$

$$\therefore -200 = 1200 a_2$$

$$\therefore a_2 = -0,167 \text{ m/s}^2 \checkmark$$

(3)

3.3

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

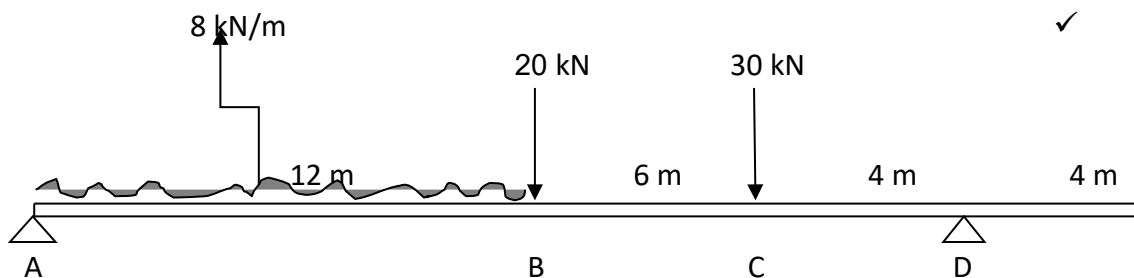
$$P = \frac{(300 \times 9,8) \times 10}{2 \times 60} \checkmark$$

$$P = 245 \text{ N} \checkmark$$

(2)

[14]**QUESTION 4**

4.1



(1)

4.2

Take moments about A

$$\Sigma \curvearrowright \text{ moments} = \Sigma \curvearrowleft \text{ moments}$$

$$(48 \times 6) + (20 \times 12) + (30 \times 18) = D \times 22 \checkmark$$

$$D = 48,545 \text{ kN} \checkmark$$

Take moments about D:

$$\Sigma \curvearrowleft \text{ moments} = \Sigma \curvearrowright \text{ moments}$$

$$A \times 22 = (48 \times 16) + (20 \times 10) + (30 \times 4) \checkmark$$

$$A = 49,454 \text{ kN} \checkmark$$

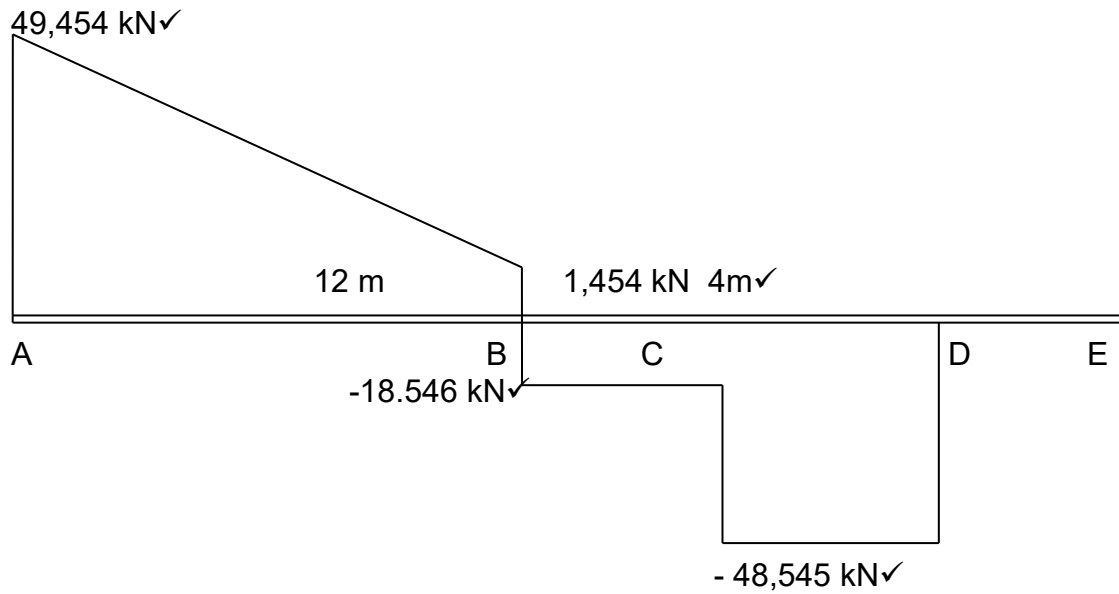
$$\text{Test: } \Sigma \uparrow F = 49,454 + 48,545 = 98 \text{ kN}$$

 $\checkmark$

$$\Sigma \downarrow F = 48 + 20 + 30 = 98 \text{ kN}$$

(5)

4.3



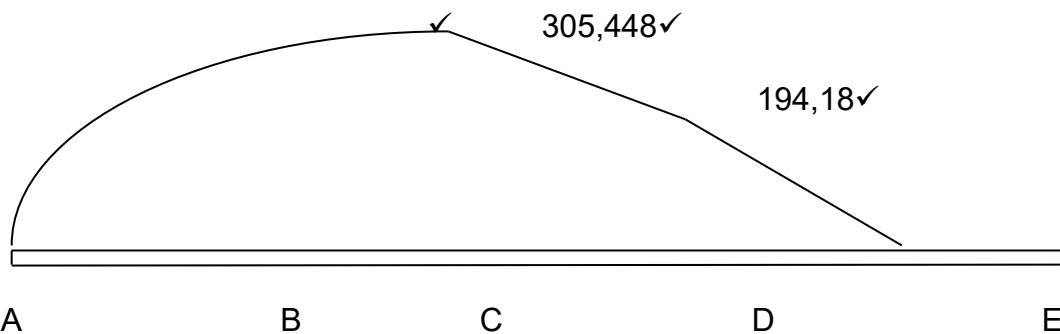
(4)

4.4 $BM \text{ at } B = (-48 \times 6) + (49,454 \times 12) = 305,448 \text{ kNm}$ ✓

$BM \text{ at } C = (4 \times 48,545) = 194,18 \text{ kNm}$ ✓

(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

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

$$F = P \times A$$

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

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

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

$$\underline{m_t = 9817,48 \text{ kg} \checkmark}$$

$$\begin{aligned} \text{Additional mass required} &= \text{total mass} - \text{mass of ram} \\ &= 9817,48 - 650 \\ &= \underline{9167,48 \text{ kg} \checkmark} \end{aligned}$$

(4)

5.2.2 Work done during working stroke of machine serve = $F \times S$

$$\begin{aligned} &= (m_t \times g) \times \text{distance moved} \\ &= (9167,48 \times 9,8) \times 0,250 \checkmark \\ &= 24052,83 \text{ J} \checkmark \\ &= 24,05 \text{ kJ} \end{aligned}$$

(2)

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

$$P = \frac{24052,83}{6} \checkmark$$

$$\begin{aligned} &= 4008,81 \text{ W} \checkmark \\ &= 4,008 \text{ kW} \end{aligned}$$

(2)

$$\begin{aligned} 5.3 \quad V &= A \times h \times 3 \\ &= \frac{\pi D^2}{4} \times h \times 3 \\ &= \frac{\pi(0,1)^2}{4} \times 0,15 \times 3 \checkmark \\ &= 0,00353 \text{ m}^3 \checkmark \\ &= 3,53 \times 10^{-3} \text{ m}^3 \end{aligned}$$

$$\begin{aligned} \text{Power} &= \text{Pressure} \times \text{Volume} \\ &= 4 \times 10^6 \times 3,53 \times 10^{-3} \times (130 \div 60) \times (85 \div 100) \checkmark \\ &= 26004,33 \text{ W} \checkmark \\ &= 26,004 \text{ kW} \end{aligned}$$

(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 ($\times 10^{-4}$)	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 $F = \delta \times A$
 $= 120 \times 10^6 \times \frac{\pi \times (0,03)^2}{4}$ ✓
 $= 0,084823 \times 10^6 \text{ N}$ ✓

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

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

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

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

$$= 5,573 \times 10^{-5} \text{ m}$$
✓

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

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

$$x_T = x_1 + x_2$$

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

$$= 6,535 \times 10^{-5} \text{ m}$$
✓

(8)
[14]

QUESTION 7

- 7.1
- Isochoric
 - Isobaric
 - Isothermal
- (Any 2 × 1) (2)

7.2

$$\Delta A = A_0 \cdot 2 \propto \Delta t$$

$$= (60 \times 73) \times 2 \times (17 \times 10^{-6}) \times 50 \checkmark$$

$$= 7,446 \text{ cm}^2 \checkmark$$


60cm

73 cm (2)

7.3

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

$$\rho_1 = 0^\circ\text{C}$$

$$= 273 \text{ K}$$

$$m_1 = 1,07 \times 10^4 \text{ kg}$$

$$V_1 = 1 \text{ m}^3 \checkmark$$

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

$$\rho_2 = ? \quad V_2 = ?$$

$$T_2 = 70^\circ\text{C} = 273$$

$$\frac{70}{343\text{K}} \checkmark$$

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

$$= 1 \times 200 \times 10^{-6} \times 70 \checkmark$$

$$= 0,014 \text{ m}^3 \checkmark$$

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

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

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

$$= 1,055 \times 10^4 \text{ kg/m}^3 \checkmark \quad (6)$$

7.4 $R = 0,44 \text{ m}$
 $t = 22 \text{ }^{\circ}\text{C}$
 $\alpha = 20 \times 10^{-6} / ^{\circ}\text{C}$
 $20,11 \text{ kPa}$

$$\Delta d, t_2 = 84 \text{ }^{\circ}\text{C}$$

$$\begin{aligned}\Delta t &= t_2 - t_1 \\ &= 84 \text{ }^{\circ}\text{C} - 22 \text{ }^{\circ}\text{C} \\ &= 62 \text{ }^{\circ}\text{C} \checkmark\end{aligned}$$

$$\begin{aligned}a_o &= \frac{\pi(d_o)^2}{4} \\ &= \frac{\pi(0,88\text{m})^2}{4} \\ &= 0,608212\text{m} \checkmark\end{aligned}$$

$$\begin{aligned}\Delta a &= 2a_o \alpha \Delta t \\ &= 2(0,608212 \text{ m}^2)(20 \times 10^{-6} / ^{\circ}\text{C})(62 \text{ }^{\circ}\text{C}) \checkmark \\ &= 0,1508 \times 10^{-2} \text{ m}^2 \checkmark\end{aligned}$$

$$\Delta a = \frac{\pi \Delta d^2}{4}$$

$$\begin{aligned}\Delta d &= \sqrt{\frac{4(0,1508 \times 10^{-2})}{\pi}} \\ &= 0,044 \text{ m} \checkmark\end{aligned}$$

(5)
[15]

TOTAL: 100