higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

04 April 2023

This marking guideline consists of 12 pages.

QUESTION 1: GENERAL

1.1 An object remains at rest or moves in a straight line✓ with uniform velocity unless acted upon by an unbalanced force.✓ (2)

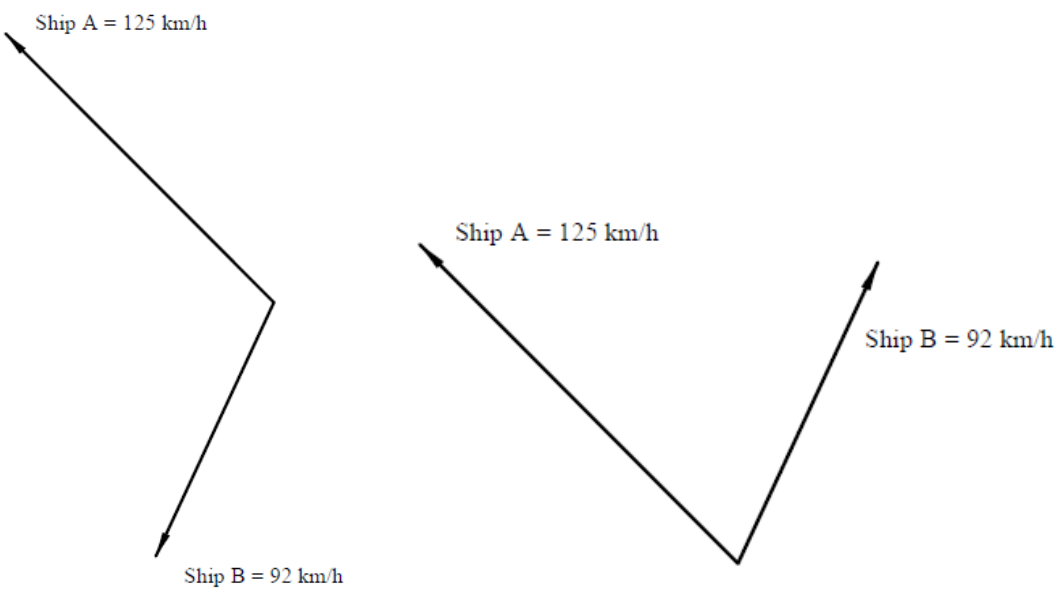
1.2 Angular displacement is the motion from one position✓ to another position in a circular course.✓ (2)

1.3 The pressure in given mass of gas varies✓ directly with the absolute temperature of the gas when the volume is kept constant.✓ (2)

1.4 When a pressure is exerted on the surface of a liquid,✓ this force is transmitted with the same intensity in all directions through the liquid.✓ (2)
[8]

QUESTION 2: KINEMATICS

2.1



$F_X = 125\cos 45° - 92\cos 65°$

$F_X = 49,507 km/h (West)$ ✓

$F_Y = 125\sin 45° + 92\sin 65°$

$F_Y = 171,769 km/h (North)$ ✓

$R = \sqrt{F_X + F_Y}$

$R = \sqrt{49,507 + 171,769}$

$R = 178,761 km/h$ ✓

$\theta = \tan^{-1}\frac{F_Y}{F_X}$

$\theta = \tan^{-1}\frac{171,769}{49,507}$

$\theta = 73,92°$ ✓

Velocity of Boat A relative to Boat B is 178,761 km/h West 73,92° North. ✓ (5)

2.2 2.2.1 $V_y = 850\sin 38°$

$V_y = 523.312 m/s$ ✓

$v^2 = u^2 - 2gs$

$0 = 523.312^2 - 2(9,8)s$

$s = \frac{-523.312^2}{-2(9.8)}$

$s = 13,972 km$ ✓

2.2.2 $v = u + gt$

$0 = 523.312 - 9.8t$ ✓

$t = 53,399 \sec.$ ✓

2.2.3 $t = 2 \times 53.99$

$t = 106,798 \sec$ ✓

$s = \bar{v}.t$

$s = 699.81 \times 106.789$

$s = 74,738 km$ ✓

(3 × 2) (6)

2.3 2.3.1 $\frac{\sin A}{a} = \frac{\sin B}{b}$

$\frac{\sin A}{55} = \frac{\sin 45}{300}$

$\sin A = \frac{55.\sin 45}{300}$ ✓

$\sin A = 0,130$

$A = 7,449°$

$A = 180° - 45° - 7,449°$

$A = 127,551°$ ✓

2.3.2 $\frac{R}{\sin 127,551} = \frac{300}{\sin 45}$

$R = \frac{300}{\sin 45} \times \sin 127,551$ ✓

$R = 336,361 km/h$ ✓

(2 × 2) (4)

[15]

QUESTION 3: ANGULAR MOTION

3.1 3.1.1

$$r = D \div 2$$

$$r = \left(\frac{175}{1000}\right) \div 2$$

$$\underline{r = 0,0875m} \checkmark$$

$$T = F.r$$

$$T = 68 \times 0,0875$$

$$\underline{T = 5,95Nm} \checkmark$$

3.1.2

$$W = T.\theta$$

$$W = T \times 5 \times 2\pi$$

$$W = 5,95 \times 5 \times 2\pi \checkmark$$

$$\underline{W = 186,925J} \checkmark$$

(2 × 2) (4)

3.2 3.2.1

$$\alpha = \frac{2\pi(n_2 - n_1)}{t}$$

$$\alpha = \frac{2\pi(25 - 210)}{25} \checkmark$$

$$\underline{\alpha = -46,496r/\min} \checkmark$$

3.2.2

$$n_{ave} = \frac{n_1 + n_2}{2}$$

$$n_{ave} = \frac{210 + 25}{2} \checkmark$$

$$\underline{n_{ave} = 117,5r} \checkmark$$

(2 × 2) (4)

3.3

$$\omega = \frac{\Delta\Theta}{\Delta t}$$

$$\Delta\Theta = \omega.\Delta t \checkmark$$

$$\Delta\Theta = 95 \times 0,5$$

$$\underline{\Delta\Theta = 47,5rad} \checkmark$$

(2)
[10]

QUESTION 4: DYNAMICS

4.1 4.1.1

$$F_\mu = \mu.W.\cos\theta$$
$$F_\mu = 0,4\times(45\times9,8)\times\cos(25)\checkmark$$
$$\underline{F_\mu = 159,873N} \quad \checkmark$$

4.1.2

$$F_\uparrow = F_\mu + W.\sin\theta$$
$$F_\uparrow = 159,873 + (45\times9,8)\times\sin 25 \quad \checkmark$$
$$\underline{F_\uparrow = 346,248N} \quad \checkmark$$

4.1.3

$$F = T_R \times W\sin\Theta$$
$$T_R = \frac{F}{W\sin\Theta}$$
$$T_R = \frac{346,248}{(45\times9,8)\sin(25)}$$
$$T_R = 1,857N$$

(3 × 2) (6)

4.2 4.2.1

$$\theta = \tan^{-1}\frac{1}{25}$$
$$\underline{\theta = 2,29^\circ} \quad \surd$$

$$h = s.\sin\theta$$
$$h = 15\sin 2,29$$
$$\underline{h = 0,599m}\surd$$

$$PE = mgh$$
$$PE = 12\times9,8\times0,599 \quad \checkmark$$
$$\underline{PE = 70,442N} \quad \checkmark$$

4.2.2

$$h = 30\sin 2,29$$
$$\underline{h = 1,199m} \quad \surd$$

$$KE = PE$$
$$\tfrac{1}{2}m.v^2 = mgh \quad \surd$$
$$\tfrac{1}{2}(12)\times v^2 = 12\times9,8\times1,199 \quad \checkmark$$
$$v = \sqrt{\frac{141,002}{6}}$$
$$\underline{v = 4,848m.s^{-1}} \quad \checkmark$$

(2 × 3) (6)

[12]

QUESTION 5: STATICS

5.1 5.1.1

$$R_A = F_1 + F_2$$
$$R_A = -40000 - (5000 \times 6) \quad \checkmark$$
$$\underline{R_A = -70kN} \quad \checkmark$$

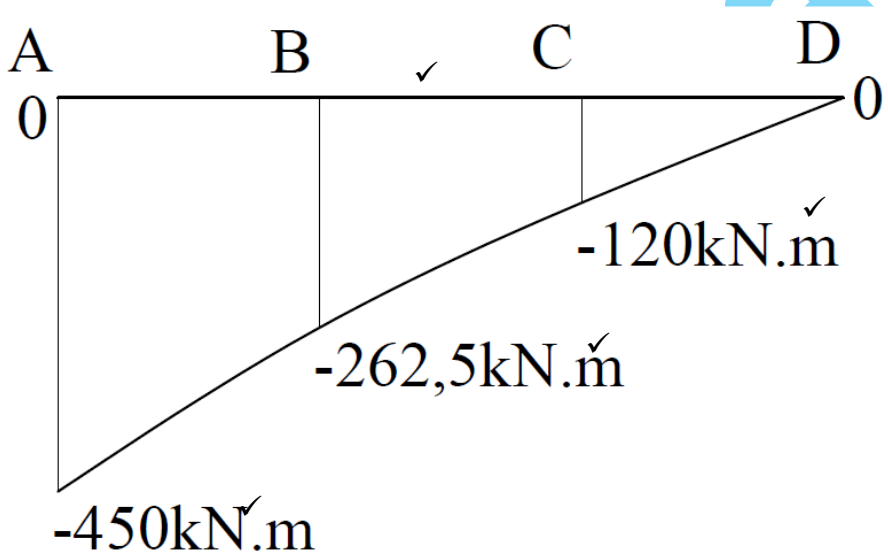
(2)

5.1.2

$$BMD = 0 \quad \checkmark$$
$$BMC = -(40k \times 3) = -120kN.m \quad \checkmark$$
$$BMB = -(40k \times 6) - [(5k \times 3) \times \tfrac{3}{2}] = -262,5kN.m \quad \checkmark$$
$$BMA = -(40k \times 9) - [(5k \times 6) \times \tfrac{6}{2}] = -450kN.m \quad \checkmark$$

(4)

5.1.3



(4)

5.2

Figure	Area	✓Centroid	Moment
Rectangle	$A = L \times B$ $A = 50 \times 45$ √ $\underline{A = 2250mm^2}$	$Centroid = \frac{1}{2}h$ $Centroid = \frac{1}{2}50$ √ $Centroid = 25mm$	$moment = F.s$ $moment = 2250 \times 25$ ✓ $moment = 56250N.m$
Triangle	$A = \frac{1}{2}B \times H$ $A = \frac{1}{2} \times 35 \times 50$ √ $\underline{A = 875mm^2}$	$Centroid = \frac{1}{3}h$ $Centroid = \frac{1}{3}50$ √ $Centroid = 16,667mm$	$moment = F.s$ $moment = 875 \times 16,667$ ✓ $moment = 14583,625N.m$
Total	3125 mm²	**y**	Moment=70833,625 N.m

$$moment = F.s$$
$$3125 \times y = 70833,625$$
$$y = \frac{70833,625}{3125}$$
$$y = 22,667mm \quad \checkmark$$

(5)

[15]

QUESTION 6: HYDRAULICS

6.1 $d = 55mm = 0,055m$

$l = 106mm = 0,106m$

$D = 144mm = 0,144m$

6.1.1 $Vol._per_stroke = \frac{\pi d^2}{4} \times L$

$Vol = \frac{\pi(0,055)^2}{4} \times 0,106$ ✓

$Vol = 0,000252m^3$ ✓

6.1.2 $F = 75N$

$\frac{W}{F} = \frac{D^2}{d^2}$

$\frac{W}{F} = \frac{0,106^2}{0,055^2}$

$W = 75 \times 3,714$ ✓

$W = 278,579N$ ✓

(2 × 2) (4)

6.2 $m = 750kg$

$d = \frac{450}{1000} = 0,45m$

$p = 2MPa$

$p = \frac{W}{A}$

$p = \frac{m.g}{A}$

$m = \frac{p.A}{g}$ ✓

$m = \frac{2 \times 10^6 \times \frac{\pi.0,45^2}{4}}{9,8}$

$\underline{m = 32457,781kg}$ ✓

$m_{tot} = m_{ram} + m_{add}$

$m_{add} = m_{tot} - m_{ram}$ ✓

$m_{add} = 32457,781 - 750$

$\underline{m_{add} = 31707,781kg}$ ✓

(4)

6.3 $vol/stroke = 12,5\ell$

$vol/stroke = \frac{12,5}{1000}$

$\underline{vol/stroke = 0,0125m^3}$ ✓

$F_E = 27kN$

$D = 250mm$

$\underline{D = 0,25m}$

6.3.1 $vol/stroke = \frac{\pi D^2}{4} \times L$

$L = \frac{4 \times vol/stroke}{\pi D^2}$

$L = \frac{4 \times 0,0125}{\pi 0,25^2}$ ✓

$\underline{L = 0,255m}$ ✓ (3)

6.3.2 $W = F.s$

$W = 27 \times 10^3 \times 0,255$ ✓

$\underline{W = 6885J}$ ✓ (2)

[13]

QUESTION 7: STRESS, STRAIN & YOUNG'S MODULES

7.1 $A = L \times B$

$A = 0,45 \times 0,45$ ✓

$\underline{A = 0,2025m^2}$ ✓

$F = \sigma.A$

$F = 5,5 \times 10^6 \times 0,2025$ ✓

$\underline{F = 1,114MN}$ ✓ (4)

7.2 $F = 15000 \times 9,8$

$F = 147000N$ ✓

$\tau = \frac{F}{2A}$

$A = \frac{F}{2\tau}$

$A = \frac{147000}{2 \times 45 \times 10^6}$ ✓

$\underline{A = 1,633 \times 10^{-3} m^2}$ ✓

$A = \frac{\pi D^2}{4}$

$D = \sqrt{\frac{4.A}{\pi}}$

$D = \sqrt{\frac{4 \times 1,633 \times 10^{-3}}{\pi}}$ ✓

$D = 0,0455m$

$\underline{D = 45,5mm}$ ✓ (5)

7.3 *Given*:

$l_o = 4m$

$\sigma = 30MPa$

$E = 117GPa$

$F = 85kN$

7.3.1 $\sigma = \frac{F}{A}$

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

$A = \frac{85 \times 10^3}{30 \times 10^6}$

$A = 2,833 \times 10^{-3} m^3$ ✓

$A = \frac{\pi D^2}{4}$

$D = \sqrt{\frac{4A}{\pi}}$

$D = \sqrt{\frac{4(2,833 \times 10^{-3})}{\pi}}$ ✓

$\underline{D = 0,06m}$

$\underline{D = 60mm}$ ✓ (3)

7.3.2 $E = \frac{\sigma}{\varepsilon}$

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

$\varepsilon = \frac{30 \times 10^6}{117 \times 10^9}$ ✓

$\underline{\varepsilon = 256,41 \times 10^{-6}}$ ✓ (2)

[14]

QUESTION 8: HEAT

8.1 *Given*:

$V_o = 10\ell$

$V_o = 0,01m^3$

$t_o = 21°C$

$t_f = 38°C$

$\delta = 764 \times 10^{-6} / K$

$\Delta V = V_o \times \delta \times \Delta t$

$\Delta V = 0,01 \times 764 \times 10^{-6} \times (38 - 21)$ ✓

$\underline{\Delta V = 0,129 \times 10^{-3} m^3}$

$\underline{\Delta V = 0,129\ell}$ ✓ (2)

8.2 $V_1 = 39m^3$

$P_1 = 0,15MPa$

$P_2 = 5kPa$

$P_1.V_1 = P_2.V_2$

$0,15 \times 10^6 \times 39 = 5 \times 10^3 \times V_2$

$V_2 = \frac{5850000}{5 \times 10^3}$ ✓

$\underline{V_2 = 1170m^3}$ ✓ (2)

8.3 $T = 110°C = 110 + 273 = 383K$

$p = 750kPa$

$V = 0,42m^3$

$R = 2,08kJ / kg.K$

$pV = mRT$

$m = \frac{pV}{RT}$ ✓ ✓

$m = \frac{750 \times 10^3 \times 0,42}{2,08 \times 10^3 \times 383}$

$\underline{m = 0,395kg}$ ✓ (3)

8.4 $V = L \times B \times H$

$V = 0,045 \times 0,036 \times 0,028$

$V_o = 45,36 \times 10^{-6} m^3$

$\gamma = 3 \times \alpha = 3 \times 23 \times 10^{-6} / °C = 69 \times 10^{-6} / °C$ ✓

$\Delta V = \gamma V \Delta T$

$\Delta V = 69 \times 10^{-6} \times 45,36 \times 10^{-6} (45 - 18)$ ✓

$\underline{\Delta V = 84,506 \times 10^{-9} m^3}$ ✓ (3)

8.5 $\beta = 2 \times \alpha$

$\beta = 2 \times 17 \times 10^{-6}$

$\underline{\beta = 34 \times 10^{-6}}$ √

$A_o = L \times B$

$A_o = 0,105 \times 0,642$

$\underline{A_o = 0,0674 m^2}$ √

$A_f = A_o + A_o \times \beta \times \Delta t$

$A_f = 0,0674 + (0,0674 \times 34 \times 10^{-6} \times (325 - 15))$ ✓

$\underline{\underline{A_f = 0,0681 m^2}}$ ✓

$\underline{\underline{A_f = 68100 mm^2}}$

(3)
[13]

TOTAL: 100