higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

1 AUGUST 2019

This marking guideline consists of 14 pages.

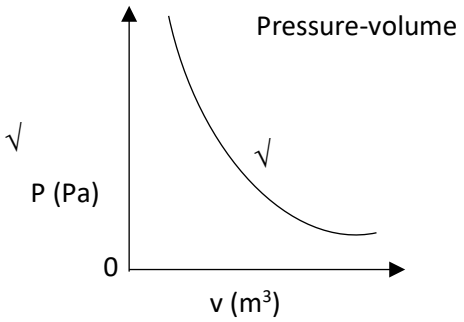
Copyright reserved

NOTE: √ = ½ mark
✓ = 1 mark

QUESTION 1

1.1 1.1.1 At a constant temperature the pressure of the given mass of an ideal gas is inversely proportional to its volume.✓

$P_1V_1 = P_2V_2$ √ or $P \propto \frac{1}{V}$ √



(3)

1.1.2 For every action there is equal and opposite reaction.✓

- Jumping off a small rowing boat into the water pushes the diver forward towards the water. The same forces used to push forward make the boat move backwards.✓✓
- Air rushing out of a balloon causes an opposite reaction so that the balloon flies up.✓✓
- Diving from a diving board pushes the springboard down.✓✓ It springs back and forces you into the air.

(1 mark for law + 2 marks for any relevant example) (3)

1.2 1.2.1 Sum of all moments to the left or right of the fulcrum (1)

1.2.2 Property of material that allows the object to return to its original form when load causing strain is removed (2)

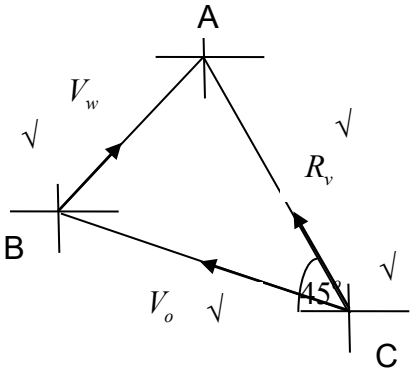
1.2.3 Rate of angular velocity measured in rad/s^2 (1)

1.3
- Tensile stress
- Shear stress
- Compressive stress

(Any 2 × 1) (2)

Copyright reserved

1.4



½ a mark for correctly labelled side with correct direction as well as correct angle (2)

1.5
- Air or gas type accumulator
- Spring accumulator
- Mass-loaded accumulator (2 × 1) (2)

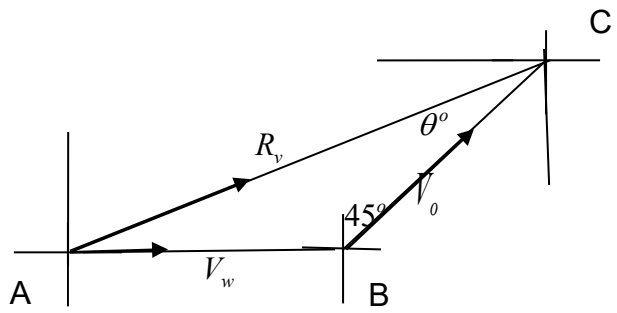
[16]

QUESTION 2

2.1 $V_o = 200\ km/h$ E

$V_w = 112\ km/h \quad N43^o E$

$R_v = ...$



$B = 90^\circ + 45^\circ$

$= 135^\circ$

$b = \sqrt{a^2 + b^2 - 2ab\cos B}$

$b = \sqrt{112^2 + 200^2 - 2(112)(200)Cos135}$

$= 290{,}211\ km/h$ ✓

$\frac{SinA}{a} = \frac{SinB}{b}$

$A = \sin^{-1}(\frac{1120.Sin135}{290{,}211})$ ✓

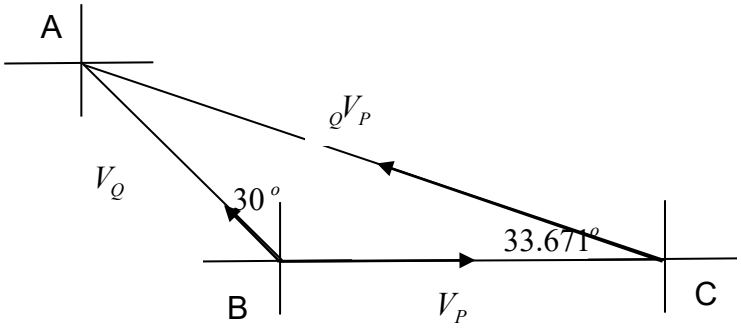
$= 15{,}836^\circ$ ✓

$R_v = 290{,}211\ km/h \quad W15{,}836^\circ N$ ✓ (4)

2.2 $V_P = 120\ km/h$ E

$V_Q = ...\quad N43^\circ W$

${}_QV_P = 234{,}307\ km/h\quad W33{,}671^\circ N$



$C = \sqrt{a^2 + b^2 - 2ab\cos C}$

$b = \sqrt{120^2 + 234{,}367^2 - 2(120)(234{,}367)Cos33.671}$ ✓

$= 150{,}00\ km/h$ ✓

✓

$V_Q = 150{,}00\ km/h\quad N30^\circ W$ ✓ (4)

2.3 $S_h = 1295\ m$

$U = 420\ m/s$

$t = 6s$

$S_h = u.t.Cos\theta$

$\theta = Cos^{-1}(\frac{S_h}{u.t.})$ ✓

$= Cos^{-1}(\frac{1\ 295\ m}{420\ m/s(6s).})$ ✓✓

$= 59{,}077^\circ$ ✓ (4)

[12]

QUESTION 3

3.1 3.1.1 B
3.1.2 C

(2 × 2) (4)

3.2 3.2.1 C
3.2.1 B

(2 × 2) (4)

[8]

QUESTION 4

4.1 $m = 1\,200\ kg$
$S_h = 30\ m$
$U = 120\ km/h$
$V = 60\ km/h$
$f_u = 0{,}311\ N/kg$

4.1.1 a

$$v^2 = u^2 + 2aS$$
$$a = \frac{v^2 - u^2}{2S}$$
$$= \frac{(16{,}667)^2 - (33{,}333)^2}{2(30)} \checkmark$$
$$= -13{,}888\ \ m/s \checkmark \quad (2)$$

4.1.2 Braking force

$$f_a = -(f_B + f_u)$$
$$f_B = -f_a - f_u \surd$$
$$f_u = 0.,311\ N/kg \times (1\,200\ kg)$$
$$= 373{,}2\ N \surd$$
$$f_a = m.a$$
$$= 1\,200\ kg \times (-13{,}888\ m/s^2)$$
$$= -16665{,}6\ N \surd$$

$$f_B = -f_a - f_u$$
$$= -(-16665{,}6\ N) - 373{,}2\ N \surd$$
$$= 16292{,}4\ N \checkmark \quad (3)$$

4.1.3 $v = u + at$

$$t = \frac{v - u}{a}$$
$$= \frac{16{,}667\ m/s - 3{,}333\ m/s}{-13{,}888\ m/s^2} \checkmark$$
$$= 12s \checkmark \quad (2)$$

4.1.4

$$E_K = \frac{1}{2}mv^2$$

$$= \frac{1}{2}(1\,200\ kg).(16{,}667\ m/s)^2 \checkmark$$

$$= 166673{,}333\ J \checkmark$$

(2)
[9]

QUESTION 5: STATICS

5.1 5.1.1

$\Delta \cong A$

$$\sum F_\perp .S(ac) = \sum F_\perp .(c)$$

$$B(7m) + 20\ N(3m) = 193\ N(2m)$$

$$B \Rightarrow \frac{1332\ NMm}{7\ m} = 47{,}429\ N \checkmark$$

$\Delta \cong B$

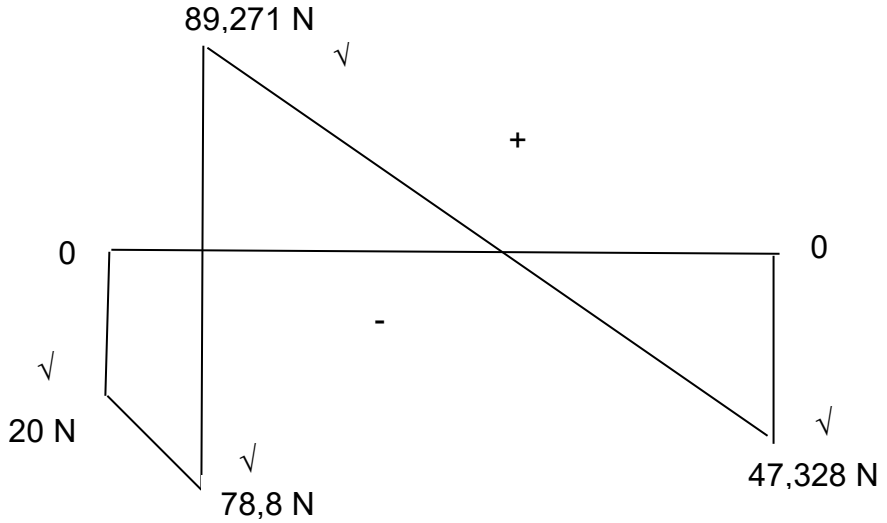
$$\sum F_\perp .S(ac) = \sum F_\perp .(c)$$

$$20\ N(10\ m) + 196\ \ N(5\ m) = A(7\ m)$$

$$A \Rightarrow \frac{1180\ Nm}{7\ m} = 168{,}571\ N \checkmark$$

(2)

5.1.2



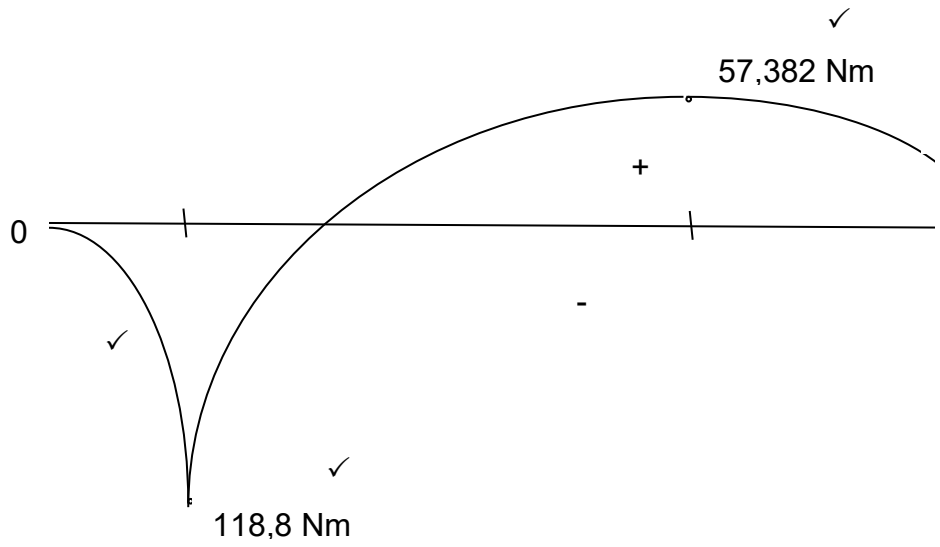
(2)

5.1.3 $BM_{A\rightarrow}$(-20 N).(3 m) – 19,6 N(3 m).(0,5)(3) =-148,2 Nm✓

$$\sum f_s = 0$$
$$-20\ N + (168{,}571\ N) - 19{,}6\ N/m.x = 0$$
$$x = \frac{-148{,}571\ N}{-19{,}6\ N/m}$$
$$= 7{,}580\ m\ \checkmark$$

$BM_{D\rightarrow}$(-20 N).(7,58 m)- (168,571 N(4.5847N)-
19,6 N/m(7,58 m)(0,5)(7,580)
= 57,382 Nm✓ (3)

5.1.4



(3)

5.2

Shape	Area (mm^2)	Centroid, C (mm)	AC
Triangle	$\frac{1}{2}.b.h = \frac{1}{2}.95(77.942)$ $= 3507{,}39$ √	$\frac{1}{3}.h = \frac{1}{3}.77{,}942$ $= 29.981$ √	(3507,39). (29,981) $= 105155{,}06$ √
Circle	$\frac{\pi.d^2}{4} = \frac{\pi.(20)^2}{4}$ $= 314{,}159$ √	h_2+ r $45 + 10$ $= 55$ √	(314,159). (55) $= 17278{,}745$ √
	$\sum A = \sum A_1 - \sum A_2$ $= 3507.39 - 314.159$ $= 3193{,}231$ √		$\sum AC = \sum AC_1 - \sum AC_2$ $= 105155{,}06 - 17278{,}745$ $= 87876{,}315$ √
		$y = \frac{87876{,}315}{3193{,}231}$ $= 27{,}52\ mm$ √√	

(5)
[15]

QUESTION 6: HYDRAULICS

6.1 $f_{eff} = 210\ N$

$S_l = 120mm$

$d = 110mm$ $D = 290mm$

$MA = 18$

6.1.1 W_R , $\eta = 93\%$

$$\frac{W_R}{f_p} = \frac{D^2}{d^2} \qquad MA = \frac{f_p}{f_h}.\frac{100}{\eta} \checkmark$$

$$f_p = \frac{f_h MA.\eta}{100}$$

$$= \frac{210\ N.(18).(93)}{100} \checkmark$$

$$= 38.73N \checkmark$$

$$W_R = \frac{D^2.f_p}{d^2}$$

$$= \frac{(0{,}29\ m)^2.(38{,}73\ N)}{(0{,}11)^2} \checkmark$$

$$= 269{,}19\ \ N \checkmark$$ (5)

6.1.2 n , $S_L = 480\ mm$ $\eta = 93\%$

$$V_a = \frac{\pi.D^2}{4}.S_L$$

$$= \frac{\pi(0{,}29\ m)^2}{4}.(0{,}41\ m)$$

$$= 0.027081314\ m^3 \checkmark$$

$$V_S = V_a \frac{100}{\eta}$$

$$= 0.027081314\ m^3 \frac{100}{93}$$

$$= 0.029119692\ m^3 \checkmark$$

$$\therefore \frac{\pi.d^2.S_l.n}{4} = 0{,}029119692\ m^3$$

$$\frac{\pi.(0{,}11\ m)^2.(0{,}12\ m)n}{4} = 0{,}038541326\ m^3$$

$$\therefore n = \frac{0{,}029119692\ m^3}{0{,}001140398\ m^3}$$

$$= 25{,}535 \Rightarrow 26 \checkmark$$ (3)

6.2 $n = 1$
$S_l = ...$
$d = 210 \quad mm$
$V_a = 0{,}042\ m^3$

6.2.1 S_l

$V_s = V_a$ since efficiency s 100%
$= 0{,}042\ m^3$ √

$V_s = \frac{\pi.d^2.}{4} S_l n$

$= \frac{\pi(0{,}21\ m)^2.(S_l).1}{4} = 0{,}042\ m$ √

$S_l = \frac{4(0{,}042\ m^3)}{\pi.(0{,}21\ m)^2}$ ✓

$= 1{,}213\ m$ ✓ (3)

6.2.2 W

$W = f_h.(S_l)$
$= 7\ 500\ N.(1{,}213\ m)$ ✓

$= 9094{,}568\ J$ ✓ (2)

6.3 $W = 250{,}248\ kJ$
$d = 20\ m$
$P = 860kPa$

h
$a = \frac{\pi}{4}d^2 = \frac{\pi}{4}(20m)^2$
$= 314{,}159\ m^2$ ✓

$W = P.V$
$V = \frac{W}{P}$

$V = \frac{250248\ J}{380\ P_a}$
$= 658{,}54737\ m^3$ ✓
$V = a.h$
$h = \frac{V}{a}$
$h = \frac{658{,}5737\ m^3}{314{,}159\ m^2}$
$= 2{,}096\ m$ ✓ (3)
[16]

QUESTION 7: STRESS AND STRAIN

7.1 $d_o = 20\ mm$ $d_f = 49{,}22\ mm$
$l_o = 196\ mm$ $l_g = 211{,}310\ mm$

$E = 230GPa$

7.1.1 % Extension

$\%Extension = \frac{l_g - l_o}{l_o}.100$ ✓
$= \frac{211{,}310\ mm - 196\ mm}{196\ mm}.10($ ✓

$= 7{,}811\%$ ✓ (3)

7.1.2 % area reduction

$$\%area_{reduction}\ \frac{a_o - a_g}{a_g}.100 \checkmark$$

$$= \frac{\frac{\pi}{4}(d_o{}^2 - d_n{}^2)}{\frac{\pi}{4}d_o{}^2}.100$$

$$= \frac{\frac{\pi}{4}([0{,}02\ m]^2 - [0{,}01313\ m]^2)}{\frac{\pi}{4}(0{,}02\ m)^2}.100 \checkmark$$

$$= 63{,}336\% \checkmark$$ (3)

7.2 $F = 90\ kN$
$d = 80\ mm$
$\Delta l = 0{,}1181\ \ mm$
$l = 981\ \ mm$
$E = 230\ \ GPa$

7.2.1 Stress

$$\delta = \frac{f}{a}$$

$$= \frac{4(90\ 000\ N)}{\pi.(0{,}08\ m)^2} \checkmark$$

$$= 17904931{,}1\ Pa \checkmark$$

7.2.2 Strain

$$\varepsilon = \frac{\Delta l}{l}.$$

$$= \frac{0{,}1181\ mm}{981\ mm} \checkmark$$

$$= 1{,}204 \times 10^{-4} \checkmark$$

7.2.3 E

$$E = \frac{\delta}{\varepsilon}.$$
$$= \frac{17904931.1Pa}{1.204\times10^{-4}} \checkmark$$

$$= 1.4871205\times10^{11}$$
$$= 148.712GPa \checkmark$$

(3 × 2) (6)
[12]

QUESTION 8: HEAT

8.1 Dimensions = 500 m × 200 mm × 600 mm

$t = 20\ ^oC$

$\Delta t = 245\ ^oC$

$\alpha = 12{,}5\times10^{-6}/K$

$E = 230\ GPa$

8.1.1 Side extension

$$\Delta T = 245\ ^oC + 273$$
$$= 518K \surd$$
$$T_1 = 2\ ^oC + 273$$
$$= 293\ K \surd$$
$$\Delta l = l_o.\alpha.\Delta T$$
$$= 0{,}6\ m(12{,}5\times10^{-6}/K).518\ K \checkmark$$

$$= 0{,}03885\ m \checkmark$$ (3)

8.1.2 Side extension

$$V_o = (0.5m).(0.2m).(0.6m)$$
$$= 0.6m^3 \surd$$

$$\Delta V = 3V_o.\alpha.\Delta T$$
$$= 3(0.06m^3).12.5\times10^{-6}/K.(518K) \surd$$
$$= 0{,}0011655m^3 \checkmark$$ (2)

8.2 $V_1 = 0.208\ m^3$ $V_2 = ...$
$t_1 = 30\ ^oC$ $t_2 = 6\ ^oC$
$P = 185\ kPa$

8.2.1 V_2

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V_2 = \frac{T_2 V_1}{T_1}$$

$$= \frac{279\ K.(0{,}208\ m^3)}{303\ K} \checkmark$$

$$= 0{,}191\ m^3 \checkmark$$ (2)

8.2.2 V_2

$$\frac{V_1.P_1}{T_1} = \frac{V_2.P_2}{T_2}$$

$$P_2 = \frac{P_1 T_2 V_1}{T_1 V_2} \checkmark$$

$$= \frac{185\ kPa.(279\ K).(0{,}208\ m^3)}{303\ K.(0{,}089\ m^3)} \checkmark$$

$$= 389{,}113\ kPa \checkmark$$ (3)

8.3
- Combination of Boyle's and Charles's laws.
- None of the pressure, temperature or volume is constant. (2)

[12]

TOTAL: 100

Copyright reserved