higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

4 APRIL 2018

This marking guideline consists of 17 pages.

QUESTION 1: GENERAL

1.1 1.1.1 Angular displacement: the angle formed during rotation, and it is measured in radians.

1.1.2 Elasticity: the property that allows an object to regain its original shape or size when the force producing a state of stress is removed.

(2 × 1) (2)

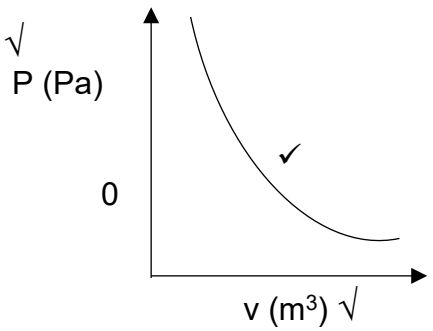
1.2
- Liquid has a definite shape.
- Liquid takes the shape of its container.
- Water and hydraulic fluids can be used to do work and can be used repeatedly. (Any 2 × 1) (2)

1.3
- Mass-loaded accumulator
- Spring-loaded accumulator
- Air- or gas-type accumulator (3)

1.4 Boyle's law: In a constant temperature, the pressure in a gas is inversely proportional to the volume.✓

$P_1V_1 = P_2V_2$ √ OR PV = K

Pressure-volume



(4)

1.5 1.5.1 Pascal's law: In an enclosed system, when pressure is exerted it will be the same throughout in all directions. ✓ (1)

1.5.2 Newton's second law of motion: The rate of momentum is directly✓ proportional and is in the same direction as the applied force. ✓ (2)

1.6 The hydraulic press retains 95% of fluid in the ram. ✓

OR

5% of fluid slips from the hydraulic press. ✓ (1)

1.7 $\bar{F} = m.a$ ✓ (1)

1.8 $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ✓ (1)

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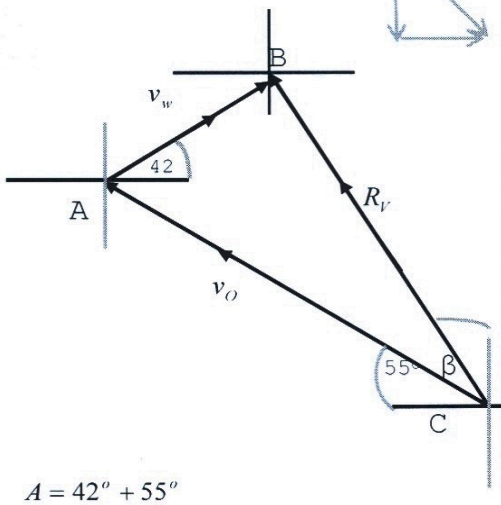
QUESTION 2: KINEMATICS

2.1 $V_o = 330Km/h\ N35^0W$

$V_w = 90Km/h\ E42^0N$

$R_v = ?$



$A = 42^o + 55^o$

$= 97^o$ √

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

$a = \sqrt{90^2 + 330^2 - 2(90)(350)\cos 97^0}$

$a = 352,476Km/h$ √

$\frac{SinC}{c} = \frac{SinA}{a}$

$C = \sin^{-1}(\frac{cSinA}{a})$

$= \sin^{-1}(\frac{90Sin97}{352,476})$

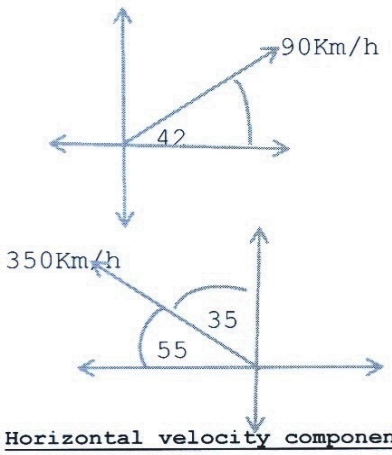
$= 14,681^0$ √

$\beta \Rightarrow 35^0 - 14,681^0 = 20,319^o$ √

√

$R_v = 352,476Km/h\ N20,319^0W$ (5)

ALTERNATIVE



Horizontal velocity components

- 90cos42= 66,883Km/h E
- 330cos55=189,280Km/h W

$\sum V_{Horizontal} = 66,883Km/h - 189Km/h$

$= -122,397Km/h$ √ **Or**

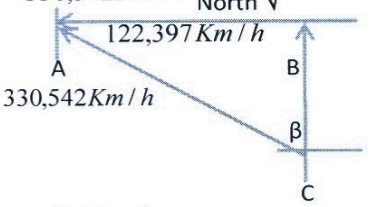
$= 122,397Km/h$ West√

Vertical velocity components

- 90sin42= 60,222Km/h N
- 330sin55=270,320Km/h N

$\sum V_{Horizontal} = 270,320Km/h + 60,222Km/h$

$= 330,542Km/h$ North √



$b = \sqrt{a^2 + c^2}$

$b = \sqrt{(330,542Km/h)^2 + (122,397Km/h)^2}$

$= 352,476Km/h$ √

$\tan\beta = (\frac{122,397Km/h}{330,542Km/h})$

$= 20,319^o$ √√ (5)

$R_v = 352,476Km/h\ N20,319^0W$

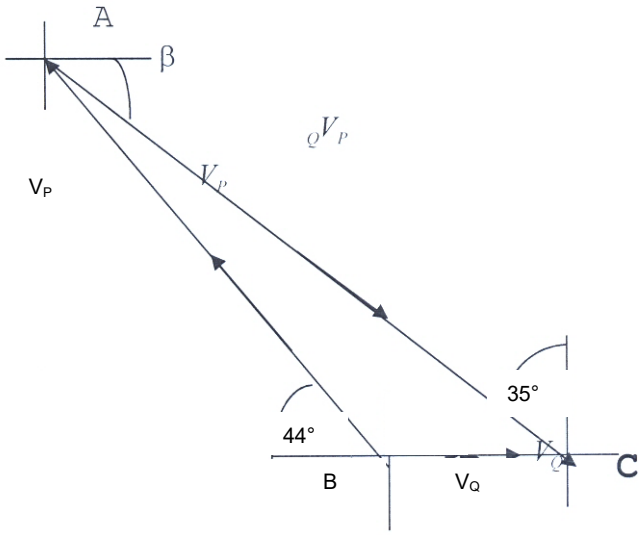
Rv = 352,476 km/h N 20,319°W

(5)

2.2 $V_o = 200\ km/h\ W44^o N$

$V_Q = 200\ km/h\ E$

${}_QV_P = ?$



$B = 46^o + 90^o \surd$

$= 136^o$

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

$b = \sqrt{200^2 + 200^2 - 2(200)(200)\cos 136^o}\ \surd$

$b = 370{,}874\ km/h \surd$

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

$A = \sin^{-1}(\frac{aSinB}{b})$

$A = \sin^{-1}(\frac{200Sin136}{370{,}874})$

$= 22^0 \surd$

$\beta \Rightarrow 44 - 22^0 = 22^o \surd$

${}_QV_P = 370{,}874\ km/h\ E22^0 S$ ✓ (5)

2.3 $h_{max} = \frac{2}{3}L$ √

$$\frac{u^2}{2g}\sin^2\theta = \frac{2}{3}\frac{u^2}{g}\sin 2\theta$$

$$\frac{1}{2}\sin^2\theta = \frac{2}{3}\sin 2\theta \text{ √}$$

$$\frac{\sin^2\theta}{\sin 2\theta} = \frac{2.2}{3}$$

$$\frac{\sin^2\theta}{\sin 2\theta} = \frac{4}{3}$$

$$\frac{\sin^2\theta}{2\sin\theta\cos\theta} = \frac{4}{3} \text{ ✓}$$

$$\frac{\sin\theta}{\cos\theta} = \frac{8}{3} \text{ √}$$

$$\tan\theta = \frac{8}{3}$$

$$\theta = \tan^{-1}(\frac{8}{3})$$

$$\theta = 69{,}444^o \text{ √}$$

(5)
[15]

QUESTION 3: ANGULAR MOTION

3.1 3.1.1 D (2)

3.1.2 D (2)

3.2 3.2.1 D (2)

3.2.2 C (2)

3.2.3 A (1)
[9]

QUESTION 4: DYNAMICS

4.1 m = 1 ton
E_{k1} = 4,8 kJ
E_{k2} = 9,3 kJ
plane = horizontal
s = 200 m

4.1.1 Acceleration (horizontal road)

$$u = \sqrt{\frac{2(4900\ J)}{1\,000\ kg}}$$

=3,130 m/s √

$$V = \sqrt{\frac{2(9\,300\ J)}{1\,000\ kg}}$$

=4,313m/s √

$$(v_2)^2 = (v_1)^2 + 2.a.S$$

$$a = \frac{(v)^2 - (u)^2}{2(200)}$$

$$= \frac{(4{,}313)^2 - (3{,}130)^2}{2(200)}$$

= 0,022 m/s²√ (2)

4.1.2 Ek, S = 140 m

Velocity after 140 m

$V^2 = U^2 + 2as$ ✓

$V = \sqrt{V^2 + 2as}$

$= \sqrt{(3{,}130)^2 + 2(0{,}022)140}$
= 3,994 m/s ✓

$$\therefore Ek = \frac{1}{2}.mv^2$$

$$= \frac{1}{2}.1\,000\,.\,(3{,}9946)^2$$

$$= 7\,978{,}415\ J$$

$$= 7{,}978\ kJ$$ ✓ (3)

4.2 m = 880 kg
u = 30 m/s
v = 0
s = 50 m
f_u = 295 N
plane: horizontal

4.2.1 Deceleration

$$a = \frac{(v)^2 - (u)^2}{2.(S)}$$
$$= \frac{(0)^2 - (30)^2}{2.(50)} \checkmark$$

=-9 m/s^2✓ (2)

4.2.2 Braking force

$f_a = -(f_B + f_u)$ ✓
$f_B = -f_a - f_u)$
$= -m.a - 295N$ ✓
√
$= -880\ kg\ (-9\ m/s^2) - 295\ N$
$= 7920\ N - 295\ N$ √
$= 7625\ N$ ✓ (4)
[11]

QUESTION 5: STATICS

5.1 5.1.1

$$spring = (20\ Kg)(98\ m/s^2)$$

$$f_{spring} = \frac{(20\ Kg)(98\ m/s^2)}{10\ m}$$

$$= 19{,}6\ N/m$$

$\Delta \cong A$

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

$$B(13\ m) = 196\ N(5\ m) + 300\ N(12\ m) + 150\ N(15\ m)$$

$$B \Rightarrow \frac{6830\ Nm}{13\ m} = 525{,}385\ N\ \surd$$

= 525,385 N✓

$\Delta \cong B$

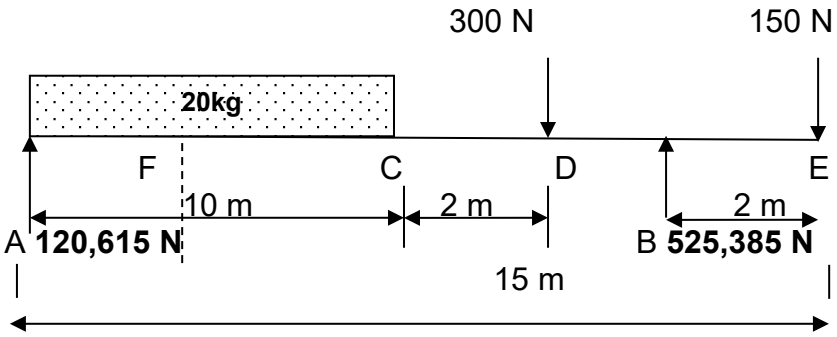
$$\sum F_{\perp}.S(ac) = \sum F_{\perp}.(c)$$

196 N (8 m) +300 N(1 m) = 150 N(2 m) + A(13 m)

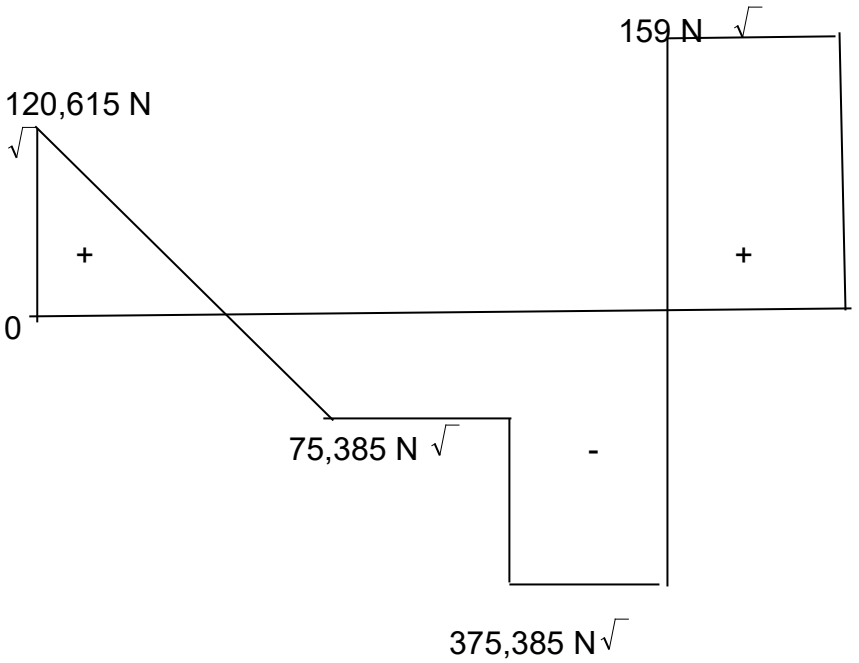
$$A \Rightarrow \frac{1568\ Nm}{13\ m} = 120{,}615\ N\ \surd$$

= 120,615 N✓ (2)

5.1.2



Calculate:



(2)

5.1.3 $BM_{A\rightarrow}$(120,615 N).(o m) = 0

$BM_{C\rightarrow}$(120,615 N).(10 m)-(196 N).(5 m) = 226,15 Nm ✓

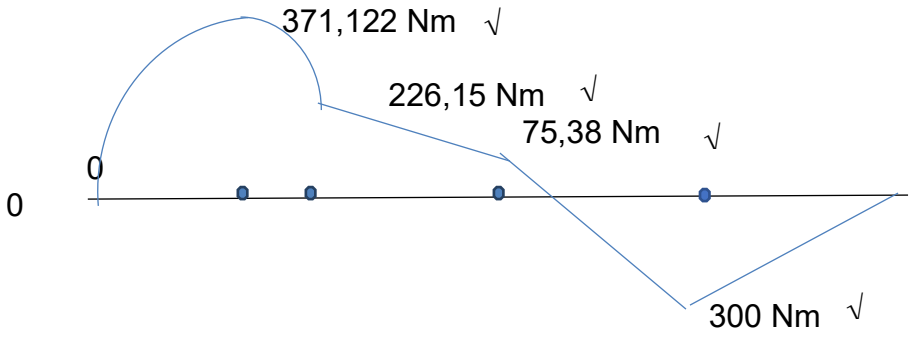
$BM_{D\rightarrow}$(120,615 N).(12 m)-(196 N).(7 m) = 75,38 Nm ✓
$BM_{B\rightarrow}$(120,615 N).(13 m)-(196 N).(8 m) – 300 N(1 m) =-300,005 Nm✓

$BM_{E\rightarrow}$(120,615 N).(15 m)-(196 N).(10 m)- (300 N).(3 m)-(130 N).(0 m) = 0

$$\sum f_s = 0$$
$$120{,}615\ N - (19{,}6\ N/m).x = 0$$
$$x = \frac{-120{,}615\ N}{-19{,}6\ N/m}$$
$$= 6{,}154\ m \checkmark$$

$BM_{F\rightarrow}$(120.615 N).(6.154 m) – (19,6 N).(6,154 m)(0,5)(2,333 m)
= 371,122 Nm ✓ (5)

5.1.4



(2)

5.2

Shape	V (mm³)	G (mm)	VG (mm⁴)
Cylinder A	$V_A = \frac{\pi D^2}{4} H$ $= \frac{\pi 50^2}{4} 20$ =39269,908√	$G = \frac{H}{2}$ $= \frac{20}{2}$ =10√	39269,908(10) =392699,08√
Cylinder B	$V_B = \frac{\pi d^2}{4} h$ $= \frac{\pi 30^2}{4} 80$ =56548.668√	$G = H + \frac{h}{2}$ $= 20 + \frac{80}{2}$ =60√	56548.668(60) =3392920.066√
	$\sum v. = 39269.908 + 56548.668$ =95818,576	$y = \frac{\sum v.G}{\sum V}$ =39.508 mm✓	$\sum v.G = 392699.08 + 3392920.066$ =3785619,146

(4)
[15]

QUESTION 6: HYDRAULICS

6.1 D = 120 mm
= 0,12 m

D = 220 mm
= 0,22 m

SI = 380 mm
n = 80
m = 2,1 tons
$\eta = 94{,}6\%$

6.1.1 MA , f_h =311.4N

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

$$W_R = 2{,}1 \times 10^3 kg\ (9{,}8\ m/s^2)$$
$$= 20580\ N \surd$$

$$f_p = \frac{d^2 W_R}{D^2}$$
$$f_p = \frac{(0{,}12\ m)^2\ 20580 \cdots N}{(0.22\ m)^2} \surd$$
$$= 6122.975N \surd$$

$$MA = \frac{f_p}{f_h}.\frac{100}{\eta}$$
$$= \frac{6122{,}975\ N}{311{,}4\ N}.\frac{100}{94{,}6} \surd$$
$$= 20{,}785 \surd \qquad (5)$$

6.1.2 SL,

$$V_a = V_s.\frac{\eta.}{100}$$
$$= \frac{\pi.d^2.sl.n}{4}.\frac{\eta.}{100}$$
$$= \frac{\pi.(0{,}120\ m)^2.0380\ m.(80)}{4}.\frac{94{,}6}{100} \surd$$
$$= 0{,}496\ m^3 \surd \qquad (2)$$

6.2 C = 3
d = 280 mm
S_l= 390 mm
N = 333,33 r/min
Slip = 4,8%

V_a

$$Slip.\% = \frac{V_s - V_a}{V_s}.100$$

$$V_s = \frac{\pi.d^2 sl.n.C.}{4}.N.60$$

$$= \frac{\pi.(0.28\ m)^2.(0.39\ m).3.(333.33).}{4.}.\frac{60}{h}$$

$$= 1440.8456\ m^3/h \surd$$

$$\therefore Slip.\% = \frac{V_s - V_a}{V_s}.100$$

$$4.8 = \frac{1440.8456\ m^3 - V_a}{1440.8456\ m^3}.100 \surd$$

$$0.048(1440.8456\ m^3) = 1440.8456\ m^3 - V_a$$

$$V_a = 1.372\ kl/h \surd$$

Alternative

$$\eta = 100 - Slip\%$$

$$= 95{,}2\% \ \surd$$

$$V_a = V_s.\frac{\eta}{100}$$

$$V_s = \frac{\pi.d^2 sl.n.C.}{4}.N.60$$

$$= \frac{\pi.(0.28m)^2.(0.39m).3.333.33.}{4.}.\frac{60}{h}$$

$$= 1440.8456\ m^3\ /h \surd$$

$$\therefore V_a = 1440.8456.(1000l).\frac{95.2}{100} \surd$$

$$V_a = 1.372\ kl/h \surd$$

(3)

6.3 D = 444 mm
= 0,444 m
P = 1200 000 Pa

6.3.1 Work done

$$V = \frac{\pi.d^2}{4}h$$

$$= \frac{\pi(0{,}44\ m)^2}{4}18\ m \surd$$

$$= 11083{,}539\ m^3$$

$$W = P.V$$

$$= 1\,200\ Pa.(11083{,}539\ m^3) \surd$$

$$= 13300606.8J$$

$$= 13.301\ MJ \checkmark$$ (2)

6.3.2 P, t = 12 hours

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

$$= \frac{13300606\ J}{12(3600\ s)} \checkmark$$

$$= 307.884\ W \checkmark$$ (2)

[14]

QUESTION 7: STRESS, STRAIN, AND YOUNG'S MODULUS OF ELASTICITY

7.1 F = 300 kN
S = 120 mm
l = 0,95 m
E = 110 GPa

7.1.1 δ

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

$$= \frac{300000\ N}{(0{,}12\ m)^2}$$

$$= 20833333.33Pa \surd$$

$$= 20{,}833\ MPa$$ (2)

7.1.2 Δl_{tot}

$$a = \frac{\pi}{4}(d^2)$$
$$\Delta l_{tot} = \frac{F.l}{A.E}$$
$$= \frac{300000N.(0{,}95\ m)}{(0{,}12\ m).(112\times10^9\ Pa)}\ ✓$$

$$= 1{,}799\times10^{-4}\ m\ ✓$$ (2)

7.2 d = 24,4 mm
E = 209 GPa
l_o = 31 m
m = 0,88 ton

Δl

$$F = m.g$$
$$= 880\ kg.(9{,}8\ m/s^2)$$
$$= 8624\ N$$
$$E = \frac{\delta}{\varepsilon}\ \varepsilon = \frac{\delta}{E}$$
$$\delta = \frac{F}{a}$$

$$= \frac{8624\ N}{\frac{\pi.(0.0244\ m)^2}{4}}\ ✓$$

$$= 18443324{,}77 Pa\ ✓$$

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

$$= \frac{18443324.77N}{209\times10^9\ Pa}.\ ✓$$

$$= 8.824\times10^{-5}\ ✓$$
$$\varepsilon = \frac{\Delta l}{l}$$
$$\Delta l = \varepsilon.l$$
$$= 8{,}824\times10^{-5}.(31\ m)$$

$$= 0{,}274\times10^{-3}\ m\ ✓$$ (5)

[9]

QUESTION 8: HEAT

8.1 $V = 0{,}77\ m^3$

$\gamma = 17 \times 10^{-7} / K$

$\Delta T = 233K$

$\Delta V = V_o.\gamma.\Delta T$

$\Delta V = 0{,}77m^3.17 \times 10^{-3} / K.(233K)$

$= 0.00304997\ m^3$ ✓

$\Delta V = V_2 - V_o.$

$V_2 = \Delta V + V_o.$ ✓

$= 0{,}00304997\ m^3 + 0{,}77\ m^3$

$= 0{,}773\ m^3$ ✓ (3)

8.2 A

$V_A = 2\ m^3$

$t_A = 25^o C$

$P_A = 580kPa$

R=287J/kg.K

$m_B = 6\ kg$

$V_B = ?$

$t_A = 35^o C$

$P_B = 580kPa$

$t_{eqil} = 20\ ^oC$

8.2.1 $T_A = 298\ K$ ✓ $T_{equi} = 293\ K$ $T_B = 308\ K$ ✓

$V_B = ?$

$P_B V_B = m_B R T_B$

$V_B = \dfrac{m_B R T_B}{P_B}$

$= \dfrac{6\ kg(287\ J/kg.K).(308\ K)}{580000\ Pa}$ ✓

$= 0{,}914\ m^3$ ✓ (3)

8.2.2 $P_{equi} = ?$

$P_{equi}V_{equi} = m_{equi}RT_{equi}$

$V_{equi} = V_A + V_B$

$= 2\ m^3 + 0{,}914\ m^3$

$= 2{,}914\ m^3$ √

$P_AV_A = m_ART_A$

$m_A = \dfrac{P_AV_A}{RT_A}$

$= \dfrac{580000Pa(2\ m^3)}{(287\ J/kg.K).(298\ K)}$ ✓

$= 13{,}563\ kg$ √

$P_{equi} \Rightarrow \dfrac{m_{equi}RT_{equi}}{V_{equi}} = \dfrac{13{,}563(287).(293\ K)}{2{,}914}$ ✓

$P_{equi} = 391{,}395\ kPa$ ✓

(4)
[10]

TOTAL: 100