higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

6 April 2020

This marking guideline consists of 12 pages.

SECTION A: GENERAL

QUESTION 1

1.1 In a frictionless open environment, when a baseball is hit or is moving at 20 m/s, it will keep on moving at 20 m/s for ever, unless it hits an object on its path and then reduces its velocity or ricochets back.

OR

When a ball hits a stationery object on a table, it will never change its position unless something moves it.

OR

A motional marble comes to rest because of the friction which opposes its motion/If the friction is completely eliminated then the marble will preserve its state of motion.

OR

An object thrown vertically upwards gets retarded and momentarily comes to rest at a certain height above the ground due to the force of gravity which opposes its motion. If the gravity is eliminated then the body preserves its state of uniform motion. (Any 1 × 2) (2)

1.2 1.2.1 Rate of angular velocity measured in rad/s

1.2.2 Reaction on a material due to external force

(2 × 2) (4)

1.3 1.3.1 $\beta = 2\alpha$
$\gamma = 3\alpha$ (2)

1.3.2 $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ (1)

1.4 At a constant temperature the pressure of gas is inversely proportional to the volume. (1)

[10]

QUESTION 2

2.1 D (1)
2.2 2.2.1 A (2)
2.2.2 A (2)
2.3 A (1)
2.4 D (1)
2.5 C (1)
2.6 D (1)
2.7 D (1)
2.8 C (2)
2.9 B (2)

[14]

TOTAL SECTION A: 24

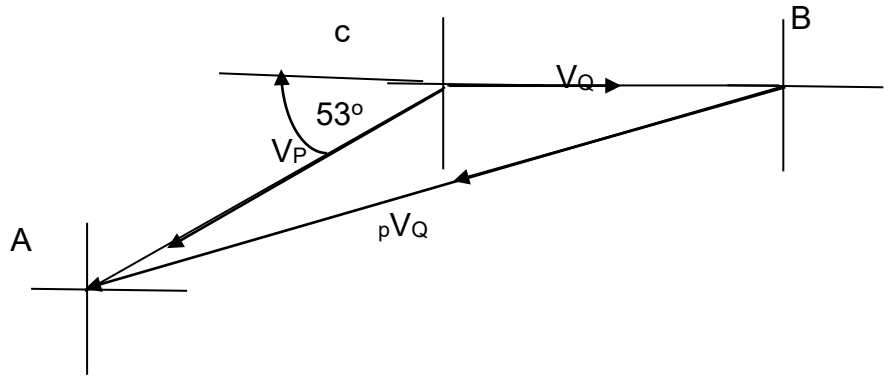
SECTION B

QUESTION 3

3.1 S_h = 55 km
U = 520 km/h
$\theta = 50°$
$u = 520km/h$
=144,444 m/s ✓
$\theta = 50°$
$S_h = u.t\cos\theta$
$t = \frac{S_h}{u.\cos\theta}$

$= \frac{55\ 000}{144{,}444.\cos 50}$ ✓
$= 592{,}375s$ ✓
$= 9{,}873\ minutes$ ✓ (4)

3.2 $V_p = 250\ km/h$ E
$V_Q = 210\ km/h$ W53°S



$C = 37° + 90°$
$= 127°$
$c = \sqrt{210^2 + 250^2 - 2(210).(250)\cos 127}$ ✓
$= 412{,}057km/h$ ✓
$\frac{\sin B}{b} = \frac{\sin C}{c}$

$B = \sin^{-1}\frac{b.\sin C}{c}$

$= \sin^{-1}\frac{(210).\sin 127°}{412{,}057}$ ✓
$= 24{,}018°$ ✓
✓
$_pV_Q = 412{,}057km/h\ \ W24{,}018°S$ (5)
[9]

QUESTION 4

4.1 V 280 km/h
d = 720 mm

$$v = \pi D n$$
$$n = \frac{v}{\pi D}$$
$$n = \frac{77,7778 m/s}{\pi(0,72)}$$

$$= 34,385 \quad \checkmark$$

N= $2063,12 rev/min$ ✓

ALTERNATIVE

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

$$\omega = \frac{77,7778 m/s}{0.36 m}$$

$$= 216,0493833\ rad/s \checkmark$$
$$N = \frac{216,0493}{2\pi}$$
N= $2063,12 rev/min$ ✓ (2)

4.2 4.2.1
$$N_1 = 444 rev/min$$
$$N_2 = 2840 rev/min$$
$$t = 0,58 min$$
$$\omega_1 = 444 rev/min \frac{2\pi}{60}$$
$$= 46,49558\ rad/s \quad \checkmark$$

$$\omega_2 = 2840 rev/min \frac{2\pi}{60}$$
$$= 297,40410445\ rad/s \quad \checkmark$$
$$\omega_2 = \omega_1 + \alpha . t$$
$$\alpha = \frac{\omega_2 - \omega_1}{t}$$
$$= \frac{297,40410 - 47,9558}{34,8}$$
$$= 7,210\ rad/s^2 \checkmark$$ (3)

4.2.2 n

$$\omega_2{}^2 = \omega_1{}^2 + 2\alpha\theta$$

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

$$\theta = \frac{297{,}4041^2 - 46{,}49558^2}{2(7{,}21)} \checkmark$$

$$= 17{,}400\ rad \checkmark$$

$$n = \frac{\theta}{2\pi}$$

$$n = \frac{\theta 17{,}400}{2\pi}$$

$$= 2{,}769 \checkmark$$ (3)

[8]

QUESTION 5

5.1 m = 980 kg
slope 1:45
u = 6 m/s
v = 21 m/s
f_u = 0,459 N/kg
t = 35 s

$$f_u = 0{,}459\ N/kg$$

A

$$v = u + a.t$$

$$a = \frac{v - u}{t}$$

$$= \frac{21-6}{35} \checkmark$$

$$= 0{,}42857 m/s^2 \checkmark$$ (2)

5.2

$$f_a = ma$$

$$= 980(0{,}42857) \checkmark$$

$$= 420\ N \checkmark$$ (2)

5.3

$$f_a = 420N$$

$$f_u = 0{,}459(980)$$

$$= 449{,}82N \checkmark$$

$$\theta = \sin^{-1}(\tfrac{1}{45})$$

$$= 1{,}2739°$$

$$f_p = 980(9{,}8)\sin 1{,}2739°$$

$$= 213{,}4222N \checkmark$$

$$f_{tot} = f_p + f_u + f_a$$

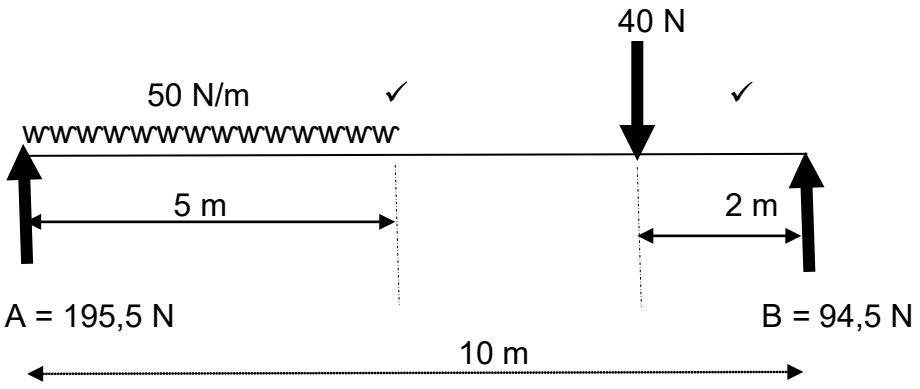
$$f_{tot} = 213{,}4222N + 449{,}82N + 420N \checkmark$$

$$= 1083{,}242N \checkmark$$ (4)

[8]

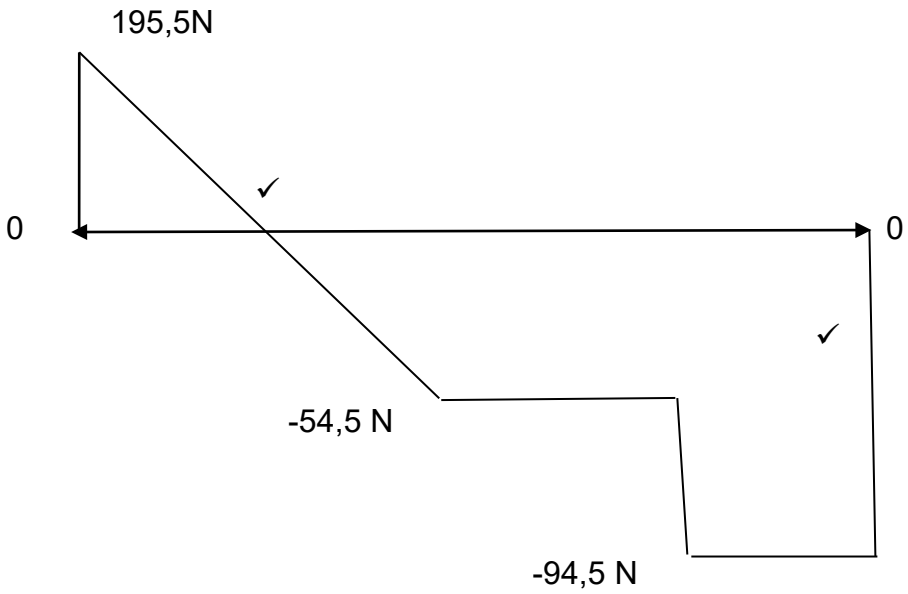
QUESTION 6

6.1 6.1.1



(2)

6.1.2



(2)

6.1.3 $BM_C \approx 195{,}5(5) - 50(5).\frac{5}{2} = 350Nm$ ✓

$BM_D \approx 195{,}5(8) - 50(5)(5{,}5) - 40(0) = 189Mm$ ✓

$$\sum F._E = 0$$

$$195{,}5N - 50N/m.x = 0$$

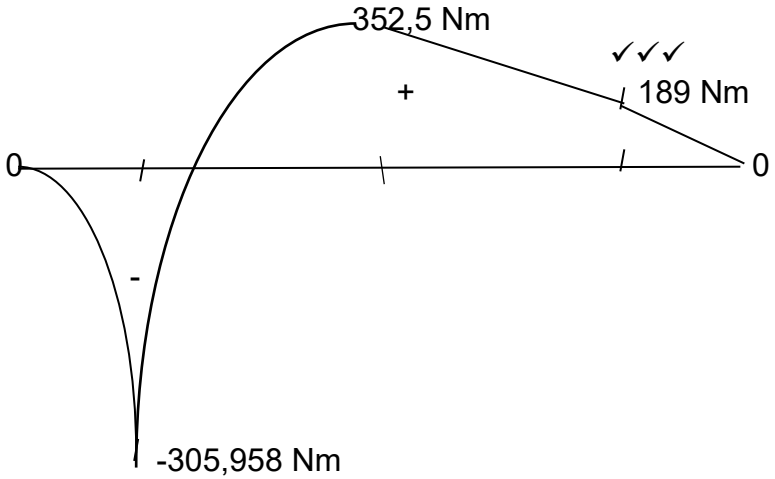
$$x = \frac{-195{,}5N}{-50N/m}$$

$= 3{,}91m$ ✓

$BM_E \approx 195{,}5(3{,}91) - 50(3{,}91).\frac{3{,}91}{2} = -305{,}958Nm$ ✓

(3)

6.1.4



(3)

6.2

Shape	Area (cm²)	Centroid (cm)	AC (cm³)
Rectangle	L(b)= 60(50) =3 000 √	60/2= 30 √	3000 (30) =90 000 √
triangle/ hole	0,5(12)18 =108 √	23+12/3 =27 √	108 (27) = 2916 √
	$\sum A_1 - \sum A_2$ 3 000-108 2892 √		$\sum AC_1 - \sum AC_2$ 90 000-2916 =87084 √
		$y = \frac{87084}{2892}$ $= 30{,}112cm$✓	

(5)
[15]

TOTAL SECTION B: 40

SECTION C

QUESTION 7

7.1 D = 50 m
h = 28 m
P = 250 kPa

7.1.1 W

$$V = \pi \frac{D^2}{4}.h$$
$$= \pi \frac{50^2}{4}.28$$
$$= 54977,87144m^3 \checkmark$$

W= (250 000) 54977,87144m^3 ✓

$$= 1,374446786 \times 10^{10} J$$

$$= 13744,468MJ \checkmark$$ (3)

7.1.2 t, P =8 40 kW

$$P = \frac{W}{t}$$
$$t = \frac{W}{P}$$
$$t = \frac{13744,46787 \times 10^6 W}{840\ 000Pa} \checkmark$$
$$= 16362,46174s$$
$$= 4,545hours \checkmark$$ (2)

7.2 3d
= D
S_l = 110 mm
MA = 22

F_h, m = 2,2 Mg $\eta = 91\%$

$W_R = (2200).(9.8)$
=21560N ✓

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

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

$f_p = \frac{21560(d^2)}{(3d)^2}$ ✓

$= 2395.556N$ ✓

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

$f_h = \frac{2395.556}{22}.\frac{100}{91}$ ✓
$= 119.658N$✓ (5)

7.3 C = 2

d = 70 mm
S_l = 150 mm

V_a= 0,027 *l*/s

$\eta = 94\%$

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

$V_s = 0.027.\frac{100}{94}$
$= 0.028723404\,l/s$ ✓

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

$\frac{\pi(d^2)S_l.n.c}{4}\frac{N}{60} = 0.028723404\,l/s$

$\frac{\pi(0.07^2).(0.15).1.2.}{4}\frac{N}{60} = 0.028723404\,l/s$ ✓

$N = \frac{0.028723404}{0.000019242}$

=1492,725 rev/s✓
=24,879 rev/min ✓ (4)
[14]

QUESTION 8: STRESS, STRAIN, AND YOUNG'S MODULUS OF ELASTICITY

8.1 d = 32 mm
l = 820 mm
F = 52,332 kN
$\Delta l = 0{,}621mm$

8.1.1
$$\delta = \frac{f}{a}$$
$$a = \frac{\pi d^2}{4}$$
$$= \frac{\pi 0{,}032^2}{4}$$
$$= 0{,}000804247m^2 \checkmark$$
$$\delta = \frac{52332J}{0{,}000804247} \checkmark$$
$$= 65{,}070MPa \checkmark \quad (3)$$

8.1.2
$$\epsilon = \frac{\Delta l}{l}$$
$$= \frac{0{,}621}{820} \checkmark$$
$$= 7{,}57317 \times 10^{-4}$$
$$= 7{,}573 \times 10^{-4} \checkmark \quad (2)$$

8.1.3
$$E = \frac{\delta}{\varepsilon}$$
$$= \frac{65{,}070 \times 10^6}{7{,}57317 \times 10^{-4}} \checkmark$$
$$= 8{,}592174 \times 10^{10}$$
$$= 85{,}922GPa \checkmark \quad (2)$$

8.2 m =1,8 ton
d = 5 mm
l = 50 m
$\Delta l = 8mm$

$$a = \frac{\pi d^2}{4}$$
$$= \frac{\pi 0{,}05^2}{4}$$

$$= 0{,}001963495 m^2 \checkmark$$

$$\delta = \frac{517640N}{0{,}001963495 m^2}$$
$$= 8983978{,}228\ Pa \checkmark$$
$$\epsilon = \frac{\Delta l}{l}$$
$$= \frac{0{,}08mm}{50}$$
$$= 0{,}0016$$

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

$$= \frac{8983978{,}228Pa}{0{,}0016}$$
$$= 5614986393Pa$$
$$= 5{,}615GPa \checkmark$$

ALTERNATIVE

$$E = \frac{f.L}{a.\Delta l}$$
$$E = \frac{17640N(50)}{0{,}001963495.(0{,}08)} \checkmark\checkmark$$
$$= 5{,}615GPa \checkmark$$ (3)

[10]

QUESTION 9

9.1 Dimensions: 500 mm x 200 mm x600 mm

$t = 20°C$
$\Delta t = 245°C$
$\alpha = 12{,}5 \times 10^{-6}/K$

9.1.1 Δl

$$\Delta l = l_o \alpha \Delta T$$
$$= 0{,}6(12{,}5 \times 10^{-6})518K \checkmark$$
$$= 0{,}003885m \checkmark$$ (2)

9.1.2 $\Delta V = 3.V_o.\propto \Delta t$

$V_o = 0{,}5(0{,}2).(0{,}6)$ ✓

$\Delta V = 3.V_o.\propto \Delta t$
$= 3(0{,}06).(12{,}5 \times 10^{-6})518K$ ✓
$= 0{,}0011655m^3$
$= 1{,}167 \times 10^{-3}m^3$ ✓ (3)

9.2 $V_1 = 0{,}208m^3$ $V_2 =$
$t_1 = 20^oC$ $t_2 = 2^oC$
$P_1 = 1850\ kPa$

$T_1 = 293^oK$

9.2.1 V_2

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
$V_2 = \frac{V_1.T_2}{T_1}$
$= \frac{0{,}208\,(275)}{293}$ ✓

$= 0{,}195m^3$ ✓ (2)

9.2.2 P_2

$P_2 = \frac{P_1.V_1.T_2}{T_1.V_2}$
$= \frac{185(0{,}208)(275)}{293\,(0{,}089)}$ ✓✓

$= 405{,}798kPa$ ✓ (3)

9.2.3 Combination of Boyles's and Charles's laws
There is no constant term/s (2)
[12]

TOTAL SECTION C: 36
GRAND TOTAL: 100