higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

07 February 2022

This marking guideline consists of 11 pages.

SECTION A

QUESTION 1: GENERAL

1.1 The rate of change in momentum of an object✓ is proportional to and in the direction of the applied force.✓

1.2 The bending moment at any section of a beam is the algebraic sum of all the moments of forces✓ about the section.✓

1.3 It is the deformation of an object✓ due to an internal state of stress.✓

1.4 The strain is proportional to the stress✓ producing it in an elastic object.✓

1.5 It is the change in volume✓ of a material per unit change in temperature.✓

(5 × 2) **[10]**

TOTAL SECTION A: 10

SECTION B

QUESTION 2: KINEMATICS

2.1 2.1.1

$$F_v = F\sin\theta$$
$$F_v = 8 + 5,6\sin 45$$
$$\underline{F_v = 11,960m/s(South)} \checkmark$$

$$F_h = F\cos\theta$$
$$F_h = 0 + 5,6\cos 45$$
$$\underline{F_h = 3,960m/s(East)} \checkmark$$

$$\mathrm{R} = \sqrt{F_v^{\,2} + F_h^{\,2}}$$
$$\mathrm{R} = \sqrt{11,96^2 + 3,96^2}$$
$$\underline{R = 12,599m/s} \checkmark$$

$$\theta = \tan^{-1}\frac{F_v}{F_h}$$
$$\theta = \tan^{-1}\frac{11,960}{3,960}$$
$$\underline{\theta = 71,68^\circ} \checkmark$$

R = 12,599 m/s east 71,68° south (4)

2.1.2

$$t = \frac{s}{v}$$

$$t = \frac{1200}{12,599} \checkmark$$

$$\underline{t = 95,246 \sec} \checkmark$$

(2)

2.2

$$F_v = F_a \sin\theta + F_b \sin\theta$$

$$F_v = 6\sin 25 + 2,5\sin 40$$

$$\underline{F_v = 4,143 m/s(South)} \checkmark$$

$$F_h = F_a \cos\theta + F_b \cos\theta$$

$$F_h = 6\cos 25 + 2,5\cos 40$$

$$\underline{F_h = 7,353 m/s(West)} \checkmark$$

$$\mathrm{R} = \sqrt{F_v^{\,2} + F_h^{\,2}}$$

$$\mathrm{R} = \sqrt{4,143^2 + 7,353^2}$$

$$\underline{R = 8,440 m/s} \checkmark$$

$$\theta = \tan^{-1}\frac{F_v}{F_h}$$

$$\theta = \tan^{-1}\frac{4,143}{7,353}$$

$$\underline{\theta = 29,399°} \checkmark$$

Thuso's velocity relative to Bakang:
8,440 m/s; west 29,399° south ✓

(5)
[11]

QUESTION 3: ANGULAR MOTION

3.1 3.1.1

$$\omega_1 = 750 \times \tfrac{2\pi}{60} = 78,540 rad/s$$

$$\omega_2 = 500 \times \tfrac{2\pi}{60} = 52,360 rad/s$$

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

$$\alpha = \frac{52,360 - 78,540}{45} \checkmark$$

$$\underline{\alpha = -0,576 rad/s^2} \checkmark$$

3.1.2 $\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

$\theta = (78,540 \times 45) + \frac{1}{2}(-0,576)(45)^2$ ✓

$\underline{\theta = 2951.1 revolutions}$ ✓

(2 × 2) (4)

3.2 3.2.1 $W = m(g + a) \times s$

$W = 500(9,8 + 1,3) \times 3,5$ ✓

$W = 19425J$ ✓

$\underline{W = 19,425kJ}$

3.2.2 $s = ut + \frac{1}{2}at^2$

$3.5 = 0 + \frac{1}{2}1,3.t^2$

$t = \sqrt{\frac{3.5}{0.65}}$

$t = 2,32s$ ✓

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

$P = \frac{19425}{2,32}$

$P = 8372,845W$

$\underline{P = 8,373kW}$ ✓

(2 × 2) (4)
[8]

QUESTION 4: DYNAMICS

4.1 4.1.1 $v_2 = \frac{95}{3,6} = 26,389m/s$

$a = \frac{v_2 - v_1}{t}$

$a = \frac{26,389 - 0}{85}$ ✓

$\underline{a = 0,310m/s^2}$ ✓

OR

$v = u + at$

$26,389 = 0 + a(85)$

$a = \frac{26,389}{85}$

$\underline{a = 0,310m/s^2}$

4.1.2 $E_k = \frac{1}{2}m.v^2$

$E_k = \frac{1}{2}1100 \times 26,389^2$ ✓

$E_k = 383008,627J$

$\underline{E_k = 383,009kJ}$ ✓

(2 × 2) (4)

4.2 4.2.1

$E_P = mgh$

$E_P = 250 \times 9,8 \times 12$ ✓

$E_P = 29,4kJ$ ✓

4.2.2

$P = \frac{F.s}{t}$

$P = \frac{(250 \times 9,8) \times 12}{10}$ ✓

$P = 2940W$

$P = 2,94kW$ ✓

(2 × 2) (4)

4.3 (Work done in one second = force x distance in one second)

$m = 85kg$

$\mu = 0,5$

$v = 1,8m.s^{-1}$

$F_\mu = \mu.W$ ✓

$F_\mu = 0.5 \times (85 \times 9,8)$

$F_\mu = 416,5N$ ✓

$P = F.s$

$P = 416,5 \times 1,8$

$P = 749,7W$ ✓

(3)
[11]

QUESTION 5: STATICS

5.1 5.1.1

$\Sigma M_A = 0$

$(55000 \times 3)(1,5) + (15000 \times 3)(4,5) + (120000)(7,5) - R_C(6) = 0$

$247500 + 202500 + 900000 - R_C(6) = 0$

$R_C = \frac{1350000}{6}$ ✓

$R_C = 225000N$ ✓

$\Sigma F_{UP} = \Sigma F_{DOWN}$

$R_A - 165000 + 45000 + 120000 - 225000 = 0$ ✓

$R_A = 105000N$ ✓

(4)

5.1.2 $BMB = (105000 \times 3) - [(55000 \times 3) \times 0.5]$

$BMB = 315000 - 82500$ ✓

$BMB = 232,5kN.m$ ✓

$BMC = (105000 \times 6) - [(55000 \times 3) \times \frac{6}{2}]$

$BMC = 630000 - 495000$ ✓

$BMC = 135kN.m$ ✓ (4)

5.2

FIGURE	AREA	CENTROID	MOMENT
Rectangle	$Area = L \times B$ $Area = 50 \times 75$ $\underline{Area = 3750mm^2}$	$Cent = \frac{1}{2}h$ $Cent = \frac{1}{2} \times 50$ $\underline{Cent = 25mm}$	$Moment = F.s$ $Moment = 3750 \times 25$ ✓ $\underline{Moment = 93750N.mm}$
½ Circle	$Area = \frac{1}{2}\pi r^2$ $Area = \frac{1}{2}\pi(25)^2$ $\underline{Area = 981.748mm^2}$	$Cent = \frac{4r}{3\pi}$ $Cent = \frac{4(25)}{3\pi}$ $\underline{Cent = 10,61mm}$	$Moment = F.s$ $Moment = 981,748 \times 10,61$ ✓ $\underline{Moment = 10416,346N.mm}$
Total	$Area = 4731,748mm^2$	$Cent = y$	$Moment = 104166,346N.mm$ ✓
$Total\_moment = moment\_in\_seperate\_parts$ $4731,748.y = 104166,346$ $y = \frac{104166,346}{4731,748}$ ✓ $\underline{y = 22,014mm}$ ✓			

(5)
[13]

QUESTION 6: HYDRAULICS

6.1 6.1.1

$$Vol/stroke = \frac{\pi d^2}{4} \times L$$

$$Vol/stroke = \frac{\pi(0.225)^2}{4} \times 0,25$$

$$Vol/stroke = 9,94 \times 10^{-3} m^3 \quad ✓$$

$$r/s = \frac{r/\min}{60}$$

$$r/s = \frac{175}{60}$$

$$r/s = 2,917 r/s$$

$$Vol/s = r/s \times Vol/stroke$$

$$Vol/s = 2,917 \times 9,94 \times 10^{-3}$$

$$Vol/s = 0,029 m^3/s \quad ✓$$

$$2\_Cyl:$$

$$Vol/s = 0,029 \times 2$$

$$Vol/s = 0,056 m^3/s \quad ✓$$

$$Power = \eta \times \rho \times Vol/s$$

$$Power = 0,75 \times 575000 \times 0,056$$

$$Power = 24,14 kW \quad ✓$$

(4)

6.1.2

$$Vol/\min = Vol/stroke \times r/\min \times cyl. \times slip$$

$$Vol/\min = 9,94 \times 10^{-3} \times 175 \times 2 \times \tfrac{94}{100} \quad ✓$$

$$Vol/\min = 3,27 m^3/\min \quad ✓$$

(2)

6.2 6.2.1

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

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

$$F=\frac{0,02^2\times(1500\times 9,8)}{0,09^2}\ \checkmark$$

$$\underline{F=725,926N}\ \checkmark$$

$$Effort=\left(\frac{F}{MA}\right)\times\eta$$

$$Effort=\left(\frac{725,926}{14}\right)\times\eta\ \checkmark$$

$$\underline{Effort=38,889N}\ \checkmark$$ (4)

6.2.2 $$Vol./stroke\times number\_of\_strokes=Vol.ram$$

$$\left(\frac{\pi d^2}{4}\times\ell\right)\times n=\left(\frac{\pi D^2}{4}\times L\right)$$

$$d^2\times\ell\times n=D^2\times L$$

$$n=\frac{D^2\times L}{d^2\times\ell}\ \checkmark$$

$$n=\frac{0,09^2\times 0,04225}{0,02^2\times 0,028}\ \checkmark$$

$$n=30,556$$

$$n=31\_strokes\ \checkmark$$ (3)

6.3 6.3.1

$$Vol/\sec=\frac{0,25m^3}{60}$$

$$Vol/\sec=4,167\times10^{-3}m^3$$

$$Vol\_in\_5\sec.=0,021m^3$$

$$Accumulator=0,25-0,021$$

$$Accumulator=0,229m^3\ \checkmark$$

$$V=\frac{\pi D^2}{4}\times h$$

$$h=\frac{V.4}{\pi.0,25^2}\ \checkmark$$

$$\underline{h=4,665m}\ \checkmark$$

6.3.2

$$Vol./\ stroke = \frac{\pi.D^2}{4} \times h$$

$$Vol./\ stroke = \frac{\pi.(072)^2}{4} \times 0.25$$

$$Vol./\ stroke = 0{,}102 m^3 \checkmark$$

$$n = \frac{Vol\ /\ \min}{\eta.Vol\ /\ stroke}$$

$$n = \frac{0{,}25}{0{,}96(0{,}102)} \checkmark$$

$$\underline{n = 2{,}553 r/m} \checkmark$$

(2 × 3) (6)

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QUESTION 7: STRESS, STRAIN AND YOUNG'S MODULES

7.1 7.1.1

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

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

$$A = \frac{120000}{28000000}$$

$$A = 4{,}286 \times 10^{-3} m^3 \checkmark$$

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

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

$$D = \sqrt{\frac{4{,}286 \times 10^{-3} \times 4}{\pi}} \checkmark$$

$$\underline{D = 0{,}0739 m} \checkmark$$

7.1.2

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

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

$$\varepsilon = \frac{28000000}{96000000000} \checkmark$$

$$\underline{\varepsilon = 291{,}667 \times 10^{-3}} \checkmark$$

(2 × 3) (6)

7.2 $A = L \times B$

$A = 0,22 \times 0,3$

$A = 0,66m^2$ ✓

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

$F = \sigma.A$ ✓

$F = 200 \times 10^9 \times 0,66$

$\underline{F = 13,2GPa}$ ✓ (3)

7.3 7.3.1 $A = L \times B$

$A = 0,006 \times 0,012$

$A = 72 \times 10^{-6} m^2$ ✓

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

$\sigma = \frac{32000}{72 \times 10^{-6}}$ ✓

$\sigma = 444,444MPa$ ✓

7.3.2 $\varepsilon = \frac{\Delta x}{L}$

$\varepsilon = \frac{0,37}{1800}$ ✓

✓

$\underline{\varepsilon = 194,444 \times 10^{-6}}$ ✓

(2 × 3) (6)

[15]

QUESTION 8: HEAT

8.1 $A_f = A_o + A_o.\beta.\Delta t$

$A_o = \frac{A_f}{1 + \beta.\Delta t}$ ✓

$A_o = \frac{50625}{1 + (2 \times 54 \times 10^{-6} \times 25)}$ ✓

$A_o = 50488,68mm^2$ ✓

$A_o = x^2$

$x = \sqrt{A_o}$

$x = \sqrt{50488,68}$

$\underline{x = 224,697mm}$ ✓ (4)

8.2 8.2.1

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

$$P_2 = \frac{P_1.T_2}{T_1} \quad ✓$$

$$P_2 = \frac{1,95 \times 32}{5} \quad ✓$$

$$P_2 = 12,48bar \quad ✓$$

8.2.2

$$P.V = m.R.T$$

$$m = \frac{P.V}{R.T} \quad ✓$$

$$m = \frac{195 \times 0,57}{297 \times 273} \quad ✓$$

$$m = 1,346 \times 10^{-3} kg$$

$$m = 1,346g \quad ✓$$

(2 × 3) (6)

8.3

$$V_f = V_o + V_o.\gamma.\Delta t$$

✓

$$V_f = 35 + 35 \times 950 \times 10^{-6} \times (38 - 25) \quad ✓$$

$$V_f = 35,432m^3 \quad ✓$$

(3)
[13]

TOTAL SECTION B: 90
GRAND TOTAL: 100