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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

22 NOVEMBER 2017

This marking guideline consists of 17 pages.

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QUESTION 1: GENERAL

1.1 1.1.1 The motion from one point to the other in a circular path, measured in radians

1.1.2 The deformation of a material due to internal state of stress

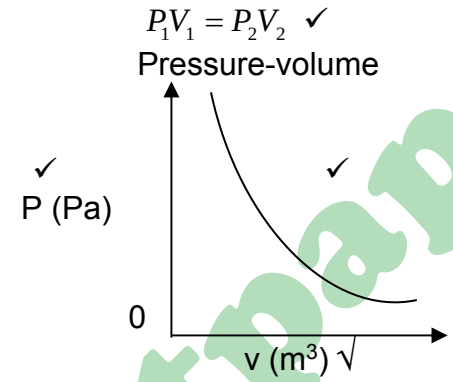
(2 × 1) (2)

1.2 1.2.1 In an enclosed system, when pressure is exerted it will be the same throughout in all directions. (1)

1.2.2 An object will remain in a state of rest or state of motion unless acted upon by an external force. (2)

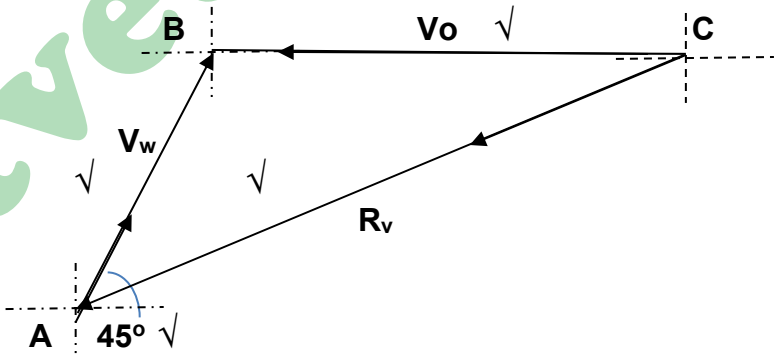
1.2.3 For an elastic limit, strain is directly proportional to the strain producing it. (2)

1.3 In a constant temperature, the pressure in a gas is inversely proportional to the volume.



(4)

1.4



(2)

1.5 1.5.1
- Liquid takes the shape of its container.
- Liquid has a definite volume.
- Liquid such as water and hydraulic fluid can be used to do work.

(Any 2 × 1) (2)

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1.5.2
- Air or gas accumulator
- Spring-loaded accumulator
- Mass = loaded accumulator (Any 2 × 1) (2)

1.6 South 45° West (1)

1.7 1.7.1 The thicker the liquid (viscosity) the higher the pressure.

1.7.2 The braking pads of the wheel is applied a force of 350 N.
OR
The motorcar brakes at a force of 350 N.
(2 × 1) (2)
[20]

QUESTION 2: KINEMATICS

2.1 $V_o = \ldots\ldots\ldots\ldots \quad \ldots\ldots\ldots\ldots\ldots\ldots$

$V_w = 90\ km/h\ N45^0E$

$R_v = ?\ \ N35^0W$

$\bar{S} = 280\ km\ \ N35^0W$

t = 1h35

2.1.1
$$R_v = \frac{\bar{S}}{t}$$
$$= \frac{280\ km}{1{,}583\ h} \checkmark$$
$$= 176{,}879\ km/h \ \checkmark\ N40^0W$$ (2)

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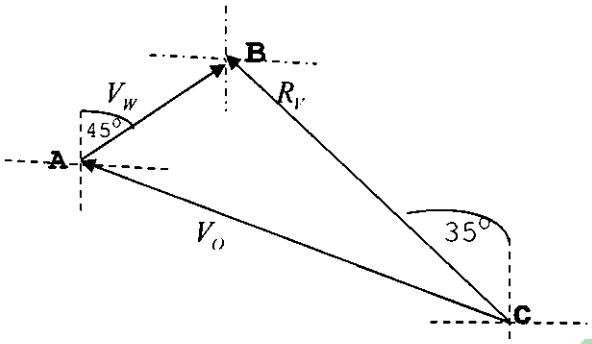
2.1.2



$B = 35^o + 45^o$

$= 80^o \surd$

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

$= \sqrt{176{,}879^2 + 90^2 - 2(176{,}879)(90)\cos 80^\circ}$

$= 184{,}004\ Km/h \surd$

Vo $= 184{,}004\ Km/h \quad W\,26{,}204^\circ\ N$

$\frac{SinC}{C} = \frac{SinB}{b}$

$C = \sin^{-1}(\frac{CSinB}{b})$

$= \sin^{-1}(\frac{90Sin80}{184.004})$

$= 28{,}796^0 \surd$

$\theta = 55 - 28{,}796^0$

$= 26{,}204^0$

$= W\,26{,}204^0\ N$

DIRECTION $= W\,26{,}204^0\ N \surd$

Or

$= N\,63{,}796^0\ N$

(4)

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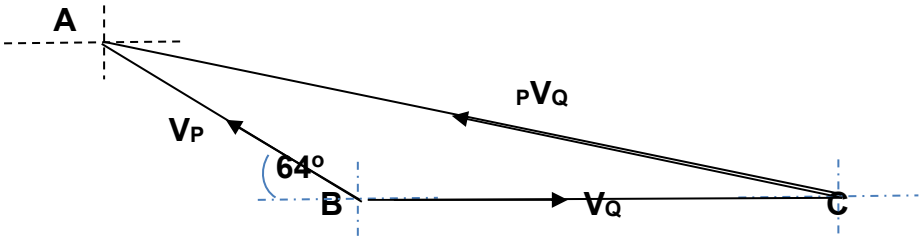
2.2



$$B = 180^o - 64^o$$
$$= 116^o$$
$$b = \sqrt{a^2 + c^2 - 2ac\cos B}$$
$$= \sqrt{200^2 + 270^2 - 2(200)(270)\cos 116^o}\ \surd$$

$$= 400{,}305\ Km/h\surd$$
$$\frac{SinC}{C} = \frac{SinB}{b}$$
$$C = \sin^{-1}(\frac{CSinB}{b})$$
$$= \sin^{-1}(\frac{270Sin116}{400{,}305})$$
$$= 37{,}317^0\surd$$
$${}_PV_Q = 400{,}305\ km/h\ W37{,}317^0\ N\surd$$ (4)

2.3 2.3.1

$$h_{\max} = \frac{u^2}{2.g}\sin^2\theta\ \surd$$
$$= \frac{12{,}4^2}{2.(9{,}8\ m/s)}(\sin 40)^2\ \surd$$
$$= 3{,}241\ m\ \surd$$

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2.3.2 V

$$h_{max} = \frac{u^2}{2.g}\sin^2\theta \surd$$

$$u^2 = \frac{h_{max}(2.g)}{\sin^2\theta}$$

$$u = \sqrt{\frac{h_{max}(2.g)}{\sin^2\theta}}$$

$$= \sqrt{\frac{4.21.(2..(9,8))}{(\sin 40)^2}} \surd$$

$$= 14{,}132\ m/s \surd$$

(2 × 2) (4)
[14]

QUESTION 3: ANGULAR MOTION

3.1 3.1.1 D
3.1.2 D

(2 × 2) (4)

3.2 3.2.1 D
3.2.2 C

(2 × 2) (4)
[8]

QUESTION 4: DYNAMICS

$m = 880\ kg$
$u = 30\ m/s$
$v = 0\ m/s$
$S = 50\ m$
$f_u = 295\ N$

4.1 4.1.1 $V^2 = U^2 + 2aS$

$$a = \frac{V^2 - U^2}{2S}$$

$$= \frac{0^2 - (30\ m/s)^2}{2(50\ m)} \surd$$

$$= -9\ m/s^2 \surd$$

(2)

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4.1.2 $f_{app} = -(f_B + f_u)\surd$

$f_{app} = ma$

$f_{app} = 880\ kg(-9\ m/s^2)$

$= -7920\ \ N\surd$

$\therefore f_B = -f_{app} - f_u$

$= -(-7920\ N) - 295\ N\surd$

$= -7625\ N\surd$ (4)

4.2 $m = 280\ \ ton$

$f_{TOT} = 40\ 000\ N$

$m = 280\ \ ton$

$slope = 1:150$

$f_u = 80\ N/ton$

$\theta = \sin^{-1}(\frac{1}{150})$

$= 0{,}382^o\ \surd$

$f_u = 80\ N/ton(280n)$

$= 22\ 400\ N\ \surd$

$f_p = (280\ 000\ N)\sin(0{,}382^o)$

$= 1866{,}790\ N\ \surd$

$f_{TOT} = f_{app} + f_p + f_u\ \surd$

$f_{app} = f_{TOT} - (+f_p + f_u)$

$= 40\ 000\ N - (1866{,}790\ N + 2\ 240\ N)$

$= 35893{,}210N\ \surd$

$f_{app} = m.a$

$a = \frac{f_{app}}{m}$

$a = \frac{35893{,}210\ N}{280\ 000\ kg}\ \surd$

$= 0{,}128\ m/s^2\surd$ (3)

[9]

QUESTION 5: STATICS

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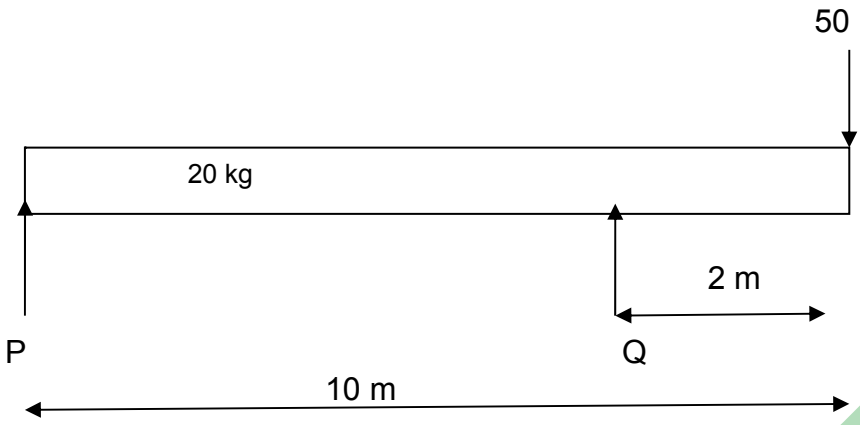
5.1



5.1.1

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

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

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

$\Delta \cong A$

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

$$B(8\ m) = 196\ N(5\ m) + 20\ N(10\ m)\ B \Rightarrow \frac{1180Nm}{8\ m} = 147{,}5\ N\surd$$

$\Delta \cong B$

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

$$196\ N(3m) = 20N(2\ m) + A(8m)$$

$$A \Rightarrow \frac{784Nm}{13m} = 68{,}5\ N$$

(2)

5.1.2

20 N

(2)

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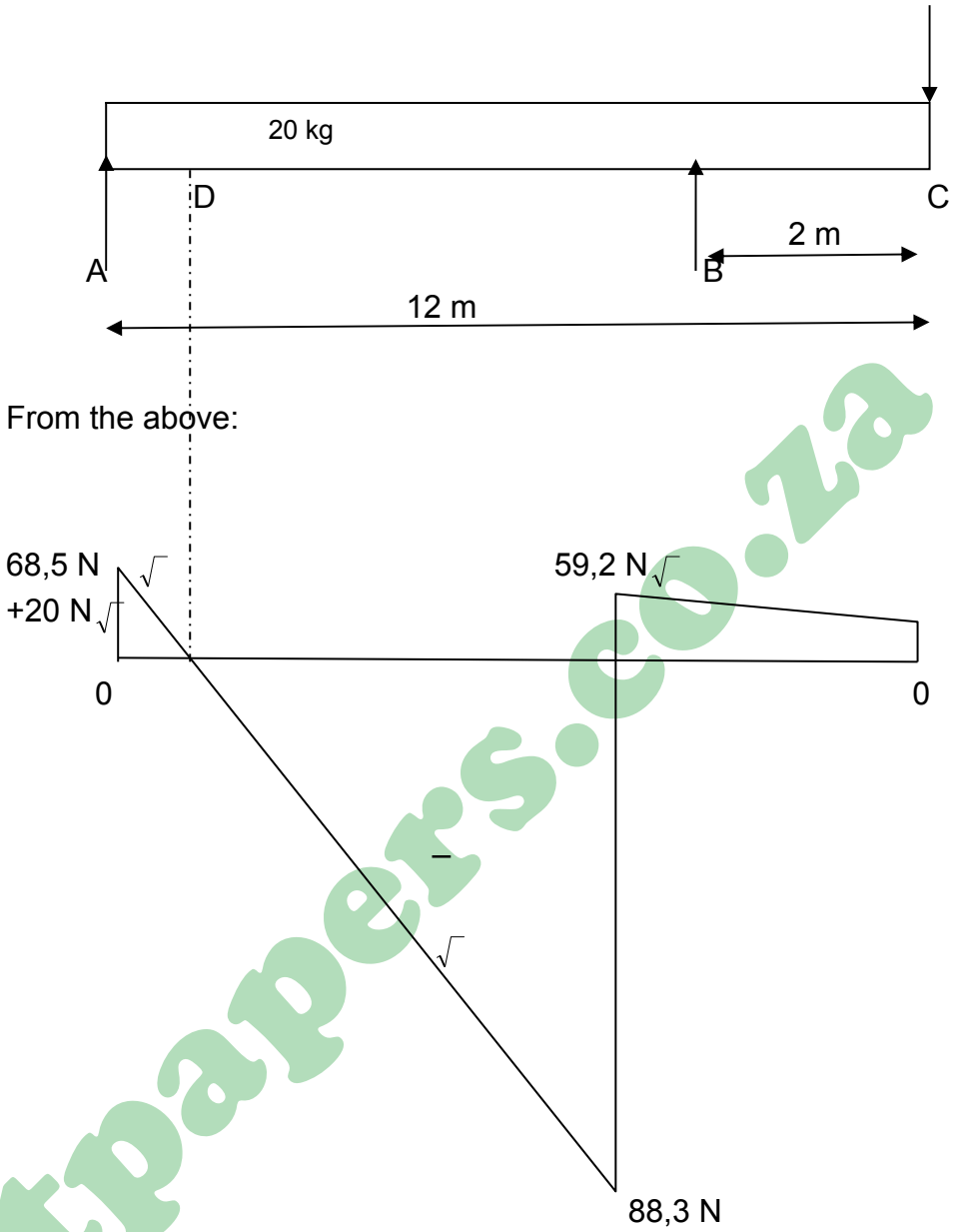

From the above:

5.1.3 $Bm_A \Rightarrow 68{,}5.(0\ m) = 0$

√ (3)

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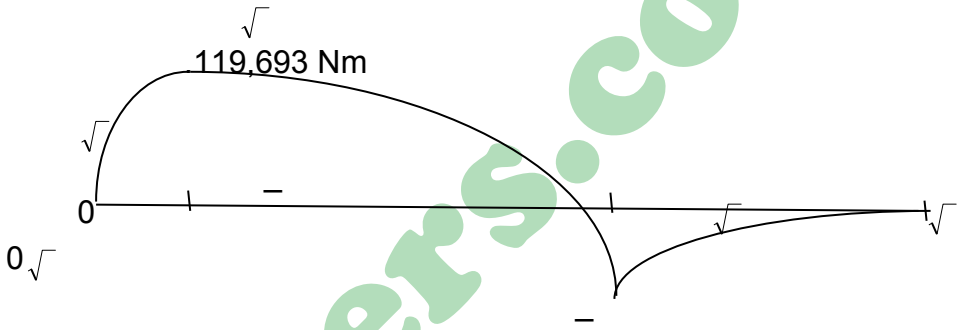
$Bm_C \Rightarrow 68{,}5.(10\,m) - 196\,N/m(5\,m.) + 88{,}3N.(2\,m)$
$= 0\,Nm$

$Bm_a \Rightarrow 68{,}5.(0\,m) = 0$
$\sum F_E = 0$
$68{,}5\,N - 196\,N/m(x) = 0$
$-196\,N/m(x) = -68{,}5\,N$
$x = \dfrac{-68{,}5N}{-196N/m}$
$= 3{,}495m$ √

$Bm_D \Rightarrow 68{,}5.(3{,}495\,m) - 19{,}6N/m.(3{,}495\,m).(\dfrac{3{,}495}{2})$ √
$= 119{,}693\,N$

5.1.4



(3)

5.2

Shape	Area (mm²)	Centroid (mm)	AC (mm³)

(5)

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	L, b = 35(110) = 3850 √	$C = \frac{L}{2}$ $= \frac{110}{2}$ = 55 √	3850 (55) = 211750 √
	L, b = 80(150) = 12000 √	$C = L_1 + \frac{L_2}{2}$ $= 110 + \frac{80_2}{2}$ = 150 √	12000 (150) = 1 800000 √
	$\sum A = 3850 + 12000$ = 15850 √		$\sum AC = 211750 + 1800000$ = 2011750 √

$$y = \frac{\sum AC}{\sum A} = \frac{2011750}{15850}$$

= 126,924 mm√

[15]

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QUESTION 6: HYDRAULICS

6.1 d = 100 mm D = 440 mm

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MA = 22
SI = 130 mm

6.1.1 f_{effort} , m = 4,8 Mg Ƞ = 92% note $f_{effort} = f_h$

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

$$\therefore W_R = m.g$$
$$= 4{,}8 \times 10^3 kg(9{,}8\ m/s^2)$$
$$= 47\ 040\ \text{N}\surd$$

$$f_p = \frac{d^2.W_R}{D^2}$$
$$f_p = \frac{(0{,}1)^2..(47040\ N)}{(0{,}440\ m)^2}\surd$$
$$= 2429{,}752\ N\surd$$
$$f_h = \frac{f_p}{MA}.\frac{100}{\eta}$$
$$= \frac{2429{,}752\ N}{22}.\frac{100}{92}\surd$$
$$= 120{,}047\ \text{N}\surd$$

(5)

6.1.2 SL, m = 4,8 Mg n = 150 Ƞ = 92%

V_a (Actual volume in l/s), $S_L = 300mm$

(4)

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

$$= \frac{\pi.(0{,}10\ m)^2.0{,}13\ m.150}{4}$$

$$= 0{,}153153\ m^3\ \surd$$

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

$$= 0{,}153153\ m^3\ \frac{92}{100}$$

$$= 0{,}140900\ m^3\ \surd$$

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

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

$$= \frac{4(0{,}14090043\ m^3)}{\pi(0{,}44\ m^3)^2}\surd$$

= 0,927 m √

6.2 N = 240 r/min
d = 90 mm
S_l = 590 mm
C = 3

V_a (Actual volume in l/s), $Slip\% = 1.8\%$ η=100-slip%

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

$$= \frac{\pi.(0{,}09\ m)^2.0{,}59\ m.1.(3)}{4}.\frac{240\ r/\min}{60}\ \surd$$

$$= 0{,}045041\ m^3\ \surd$$

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

$$= 0{,}045041\ m^3/s.\frac{98.2}{100}\ \surd$$

$$= 0{,}044230275 m^3/s(1000 l/m^3)$$

$$= 44{,}230\ l/s\ \surd$$

(3)

6.3 H = 65 m
V_a = 320l/min
η_l = 75%

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$$P_{rr}. = \rho.g.h$$
$$= 1\,000\,kg/m^3(9{,}8\,m/s^2).65\,m$$
$$= 637\,kPa\ \surd$$

$$Va = 320\,000\,m^3/\min$$
$$= 320\,000\,m^3/\min.\frac{1\min}{60s}$$
$$= 5333.333m^3/s\ \surd$$

$$P_{out} = (637000\,Pa)5333.333m^3/.s$$
$$= 3397333333W\ \surd$$
$$\eta = .\frac{P_{out}}{P_{in}}.100$$
$$P_{in} = .\frac{P_{out}}{\eta}.100$$
$$= \frac{3397333.333kW}{75}.100$$
$$= 4529777.778\ \ kW\ \surd$$

(3)
[15]

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

$1\frac{1}{2}$ mark for any 4 correct answers per row

7.1

$\sigma = MPa$ Load	0	25,06	98,94	173,1	27,6	321,8
ε (X10^{-4})	0	1.0	4.4	8.1	11.9	16

½ mark for correct stress y-axis
½ mark for correct strain x-axis
1 mark for straight line
1 mark for more dots (3)

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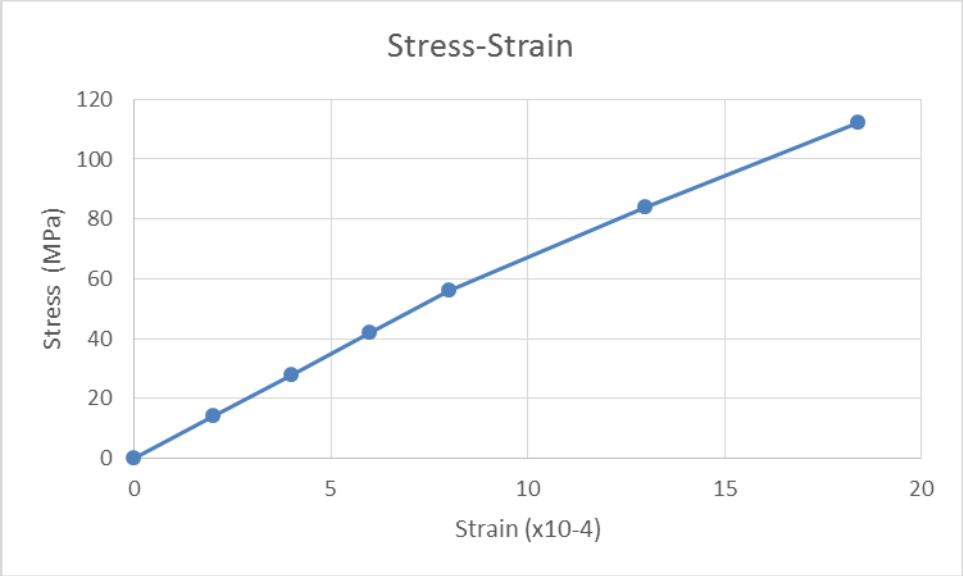
7.2 7.2.1



(3)

7.2.2

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

$$= \frac{\delta_2 - \delta_1}{\varepsilon_2 - \varepsilon_1}\surd$$

$$= \frac{42 \times 10^6 - 14 \times 10^6}{8 \times 10^{-4} - 2 \times 10^{-4}\varepsilon_1}\surd$$

$$= 4{,}6667 \times 10^{10} Pa$$

$$= 46{,}667 \times GPa\surd$$

(3)
[9]

QUESTION 8: HEAT

8.1 $V_1 = 90\ l$ $V_2 = ?$
$P_1 = 20{,}11$ kPa $P_2 = 11$ kPa

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1V_1}{P_2}$$

$$= \frac{20{,}11 \times 10^3\ Pa.(0{,}9\ m^3)}{11 \times 10^3\ Pa}\surd$$

$= 16{,}373\ m^3\surd$ (2)

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8.2 R = 0,44 m
t = 22 °C
α = 20 × 10^{-6}/°C
20,11 kPa

8.2.1 Δd , t_2 = 84 °C

$$\Delta t = t_2 - t_1$$
$$= 84\,^oC - 22\,^oC$$
$$= 62\,^oC$$

$$a_o = \frac{\pi(d_0)^2}{4}$$
$$= \frac{\pi(0.88m)^2}{4}$$
$$= 0{,}608212\,m \surd$$
$$\Delta a = 2a_o \alpha \Delta t$$
$$= 2(0{,}608212\,m^2)(20\times10^{-6}/^o\,C)(62\,^oC)$$
$$= 0{,}1508\times10^{-2}\,m^2 \surd$$

$$\Delta a = \frac{\pi \Delta d^2}{4}$$
$$\Delta d = \sqrt{\frac{4(0{,}1508\times10^{-2})}{\pi}}$$
$$= 0{,}044\,m \surd$$ (3)

8.2.2 Δa , t_2 = 140 °C

$$\Delta t = t_2 - t_1$$
$$= 140\,^oC - 22\,^oC$$
$$= 118\,^oC$$

$$\Delta a = 2a_o \alpha \Delta t$$
$$= 2(0{,}608212\,m^2)(20\times10^{-6}/^o\,C)(118\,^oC) \surd$$
$$= 0{,}287\times10^{-2}\,m^2 \surd$$ (2)

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8.3 m = 0,61 kg
P = 100 kPa
V = 521 litres
t = 27 °C

$$PV = mRT$$

$$R = \frac{PV}{mT}$$

$$= \frac{100 \times 10^3\ Pa.(0{,}521\ m^3)}{(0{,}61\ kg).(300\ K)}\ \surd\surd$$

= 284,699 J/kg.K √ (3)

[10]

TOTAL: 100

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