higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL TECHNICAL CERTIFICATE

ENGINEERING SCIENCE N3

NOVEMBER 2014

(15070413)

20 November (Y-Paper)
13:00 – 16:00

REQUIREMENTS: Steam tables

Calculators may be used.

This question paper consists of 7 pages and a formula sheet of 2 pages and 1 information sheet.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N3
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Write neatly and legibly.
5. All the calculations should consist of at least the THREE steps:
   - 5.1 The formula used or manipulation thereof
   - 5.2 Substitution of the given data in the formula
   - 5.3 The answer with the correct SI unit
6. Drawing instruments must be used for all drawings/diagrams. All drawings/diagram must be fully labelled
7. The constant values, as they appear on the attachment information sheet, must be used were ever possible.
8. Keep subsections of Questions together
9. Rule off on completion of each Question
10. Use $g = 9,8\ m/s^2$
11. Answers must be rounded off to THREE decimal places.

QUESTION 1: MOTION, POWER AND ENERGY

1.1 Define the term 'velocity' of an object (2)

1.2 Sketch and describe the difference between initial velocity and final velocity (2)

1.3 A racing car move from rest and accelerates for 15 seconds with a uniformly acceleration of 4 m/s^2. Determine the displacement after 15 seconds (3)

1.4 A truck with a mass of 8 tons travels at a velocity of 60 km/h and collides with a minibus with a mass of 5 tons travelling in the same direction at 40 km/h. After the collision the two objects move together in the same direction.

Calculate the final common velocity of the **TWO** trucks in m/s^2 after the collision. (4)

1.5 A pulley with a diameter of 40 cm is driven by a belt with a thickness of 12 mm. The tension in the tight-side is 1320 N and that of the slack side is 123.154 N. The belt velocity is 12 m/s.

Consider the belt thickness and calculate the following:

1.5.1 The rotational frequency of the pulley. (2)

1.5.2 The power transmitted by the belt in kW. (2)
[15]

QUESTION 2: MOMENTS

2.1 Explain the difference of a concentrated load and a uniformly distributed load (2)

2.2 **FIGURE 1** below shows a light horizontal beam ABCDEF of a uniform cross-section, loaded as shown in figure 1.

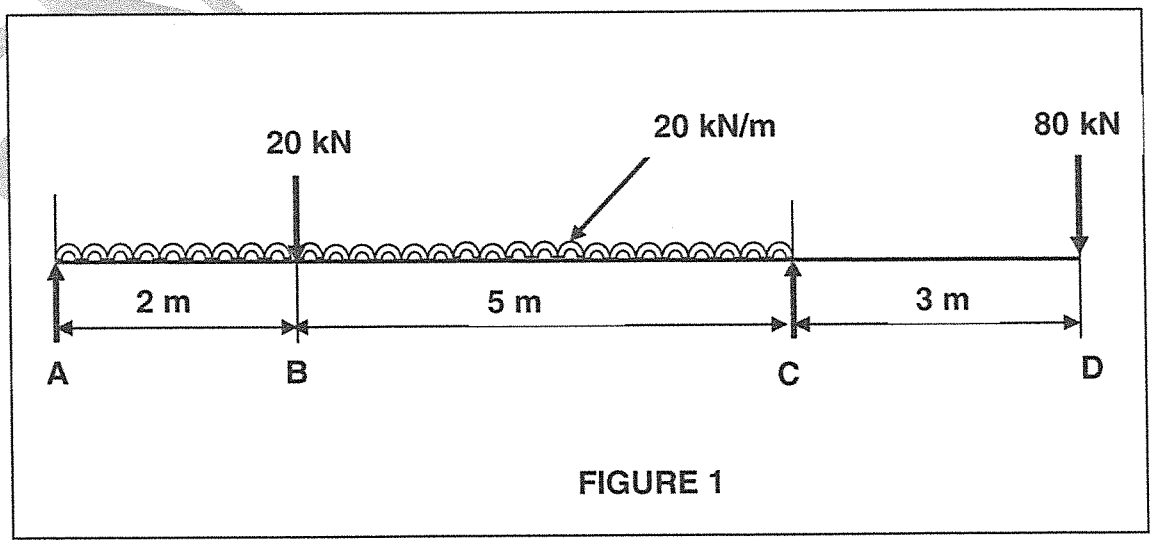


FIGURE 1

2.2.1 Calculate the reactions at the supports (6)

2.2.2 Draw a shear-force diagram, using a suitable scale. Show ALL the main values on the diagram. (3)

2.2.3 Determine from the diagram the maximum and minimum shear forces (2)
[13]

QUESTION 3: FORCES

3.1 Define the term 'parallelogram of forces' (2)

3.2 The FOUR forces in FIGURE 2 show a system of forces.

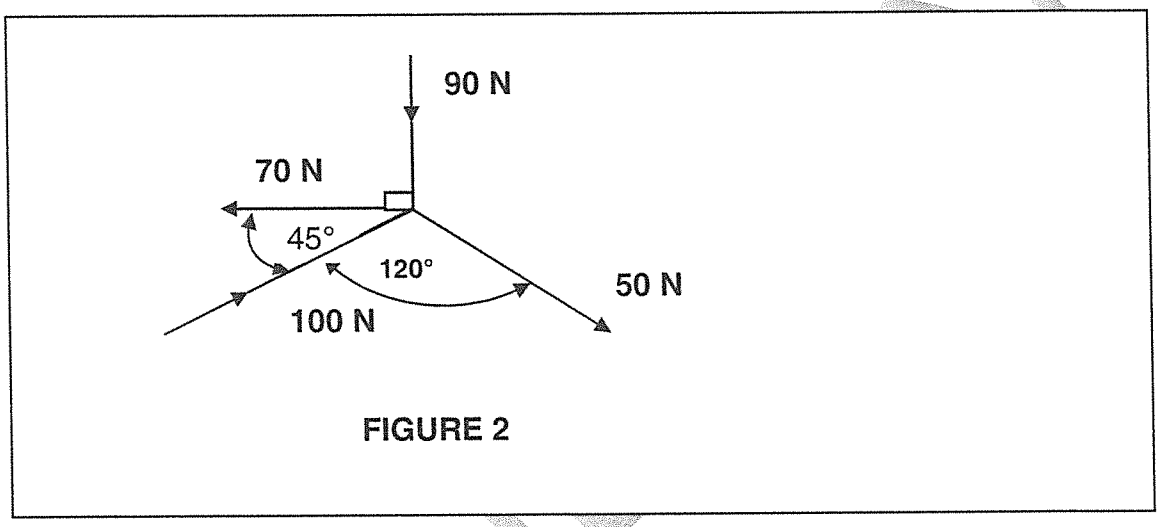


FIGURE 2

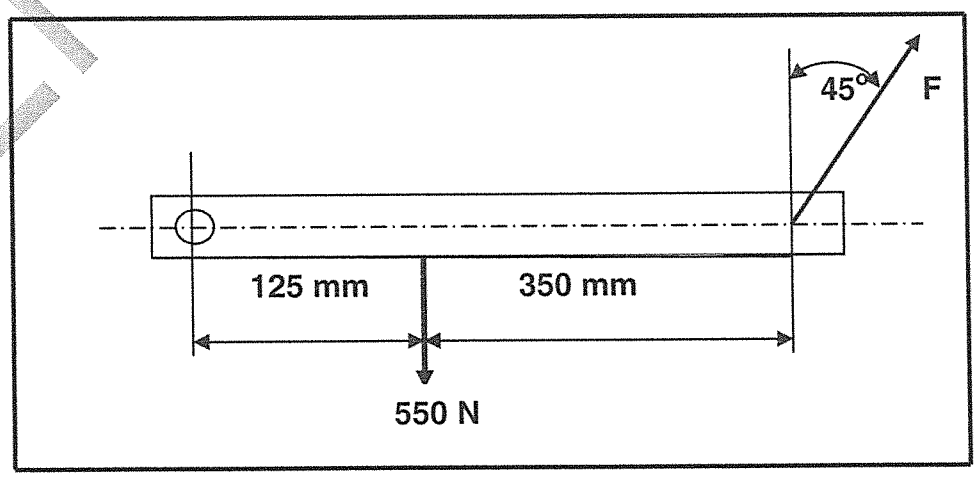
Calculate the following:

3.2.1 The sum of the horizontal components and give the direction (3)

3.2.2 The sum of the vertical component and give the direction (3)

3.2.1 The magnitude and direction of the resultant (3)

3.3 Calculate the magnitude of the unknown force F in FIGURE 3 below:



(4)
[15]

FIGURE 3

QUESTION 4: FRICTION

4.1 Name TWO advantages and TWO disadvantages of friction. (4)

4.2 An iron block with a mass of 45 000 g rests on an inclined plane of 16° to the horizontal. Take the coefficient friction as 0,25

Calculate the following:

4.2.1 The weight component perpendicular to the inclined plane. (2)

4.2.2 The weight component parallel to the inclined plane (2)

4.2.3 The friction force (1)

4.2.4 The minimum force required the pull the block up the inclined plane (2)
[11]

QUESTION 5: HEAT

5.1 Water is heated from 18 °C to 80 °C within 1 hour. 13 kg fuel with a heat value of 30 MJ/kg is used. Take the specific heat capacity of water as 4,2 kJ/kg°C. Suppose that no heat energy is lost.

Calculate the following:

5.1.1 The temperature change. (1)

5.1.2 The heat energy given off by the fuel. (2)

5.1.3 The amount of water heated. (2)

5.2 An aluminium rectangular plate at 23 °C with dimension of 25 cm by 10 cm is heated and the temperature increases to 65 °C. Calculate the change in the area of the plate. (2)

5.3 Steam is generated in a boiler at a pressure of 270 kPa to a dryness fraction of 0.94.

Calculate the following:

5.3.1 The enthalpy of the dry saturated steam. (1)

5.3.2 The enthalpy required to convert 2 kg of water into wet steam. (2)

5.4 Define heat capacity (2)

5.5 Define the term specific heat capacity (2)
[14]

QUESTION 6: HYDRAULICS

6.1 A diesel generator with an output power of 5 kW drives a single - acting pump. The pump delivers 80 000 litres of water per hour. The tank is 20 m vertically above the pump.

Calculate the following:

6.1.1 The pressure exerted by the pump in kPa (2)

6.1.2 The work done by the pump per hour. (2)

6.1.3 The efficiency of the pump. (2)

6.2 The following data refers to a maintenance test with an hydraulic press:

Diameter of the plunger	=50 mm
Diameter of ram	= 0.2 m
Stroke length of plunger	= 70 cm
Effort on the plunger	= 310 kN

Determine the following:

6.2.1 The force exerted by the ram. (2)

6.2.2 The distance moved by the ram per stroke of the plunger. (2)

6.2.3 The number of pumping strokes required by the plunger to lift the load to a height of 46 m. (3)
[13]

QUESTION 7: ELECTRICITY

7.1 Ref to FIGURE 4 below where a circuit was tested with the following readings $R_1 = 1{,}2\ k\Omega$, $E_T = 90$ V, $I_T = 0{,}05$ A $I_2 = 0{,}02$ A and R2 = 1 kΩ

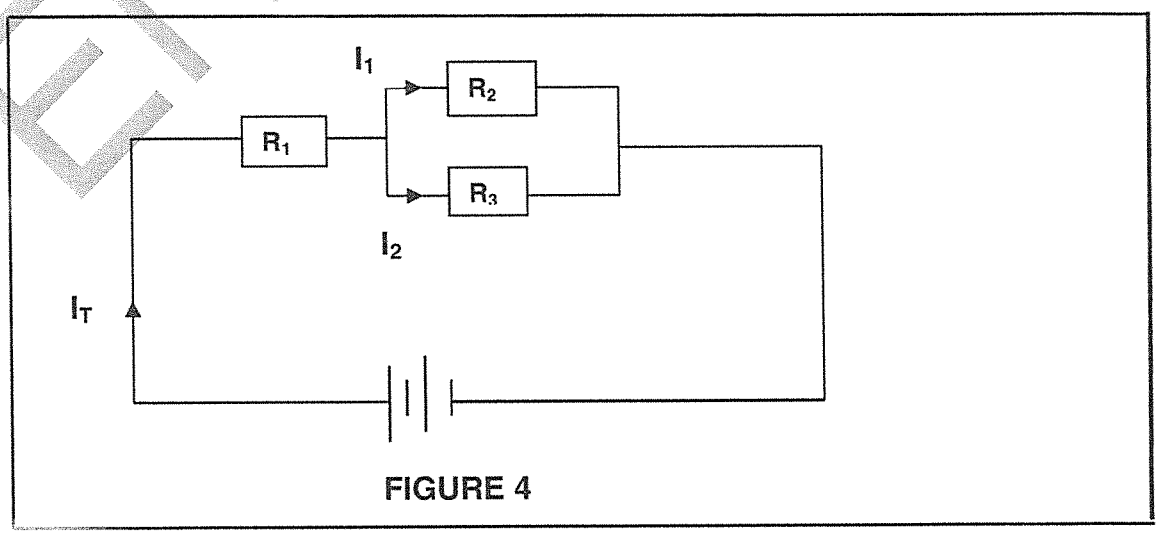


FIGURE 4

Determine the values of:

7.1.1 The total voltage across R_1 (V_{R1}) (2)

7.1.2 The total resistance of the circuit. (R_T), but first calculate the value of R3 (5)

7.1.3 Power consumed by R_2 (2)

7.2 A single-phase transformer has a supply voltage of 240 V and a primary current of 20 A at full load. There are 50 primary turns and 300 secondary turns on the transformer

Calculate the following:

7.2.1 The secondary voltage. (2)

7.2.2 The secondary current. (2)
[13]

QUESTION 8: CHEMISTRY

8.1 Fill in the missing words. Write only the answers next to the numbers (8.1.1–8.1.6) in the ANSWER BOOK.

Electrolysis involves passing an .....8.1.1..... through a liquid or solution by means of ..... 8.1.2 .....in the solutions

..... 8.1.3 ..... is an alloy of copper, tin and ..... 8.1.4 .....

Tungsten increases the hardness and ....8.1.5 .... of steel, a ductile material with very .....8.1.6 .....point. (6)
[6]

TOTAL: 100

ENGINEERING SCIENCE N3
FORMULA SHEET

All the formulae needed are not necessarily included.
Any applicable formula may also be used.

$W = F.s$

$W = \rho.V$

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

$\eta = \frac{Uitset/Output}{Inset/Input}\ 100\%$

$F = m.a$

$\mu = \frac{F_\mu}{N_R}$

$\mu = \tan\Phi$

$N_R = F_C \pm F_T sin\alpha \ ... \ a = 0$

$F_S = wsin\theta$

$F_C = wcos\theta$

$F_T cos\alpha = F_\mu \pm F_S \ ... \ a = 0$

$F_e = T_1 - T_2$

$\frac{T_1}{T_2} = tension\ ratio$

$P = F_e \ . \ v$

$v = \pi \ . \ d \ . \ n \ ... \ n = \frac{N}{60}$

$W_\mu = F_\mu \ . \ s$

$\Delta E_p = m.g.\Delta h$

$\Delta E_K = \frac{1}{2}.m.\Delta v^2$

$Q = I^2 \ . \ R \ . \ t$

$m = I \ . \ z \ . \ t$

$\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$

$m_1.u_1 \pm m_2.u_2 = m_1.v_1 \pm m_2.v_2$

$D_e = (D + t)$

$h_{nat/wet} = h_f + x.h_{fg}$

$P = 2.\pi.T.n \ ... \ T = F.r$

$P = \frac{F_{RAM}}{A_{RAM}} = \frac{F_{PL}}{A_{PL}} \ ... \ A = \frac{\pi D^2}{4}$

$V_{RAM} = V_{PL} \times n$

$A_{RAM} \ . \ H_{RAM} = A_{PL} \ . \ L_{PL}$

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

$\Sigma F_X = F_1 cos\theta_1 + ... + F_n cos\theta_n$

$\Sigma F_y = F_1 sin\theta_1 + ... + F_n sin\theta_n$

$R = \sqrt{\Sigma F_X^2 + \Sigma F_Y^2}$

$tan\varphi = \frac{\Sigma F_Y}{\Sigma F_X}$

$Q = m \ . \ c \ . \ \Delta t \ ... \ t_F = to \pm \Delta t$

$m.ww = Q = m.hv$

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

$\Delta L = Lo \ . \ \alpha \ . \ \Delta t \ ... \ L_f = Lo \pm \Delta L$

$\Delta A = A_0 \ . \ \beta \ . \ \Delta t \ ... \ A_f = A_0 \pm \Delta A$

$2.a.s = v^2 - u^2$

$s = u.t + \frac{1}{2}.a.t^2$

$v = u + a.t$

$\Sigma \uparrow F = \Sigma \downarrow F$

$M = F \ . \perp s$

$$\Sigma\ CWM = \Sigma ACWM$$

$$P_{ABS} = P_{ATM} + P_{MET}$$

$$P = \delta \times g \times h$$

$$\frac{1}{R_{PAR}} = \frac{1}{R_1} + \ldots + \frac{1}{R_n}$$

$$R_{SER} = R_1 + \ldots R_n$$

$$V_1 - V_2 = -e(U_1 - U_2)$$

$$V = I \times R$$

INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	CONSTANTS KONSTANTE	HOEVEELHEID
Atmospheric pressure	101,3 kPa	Atmosferiese druk
Density of copper	8 900 kg/m^3	Digtheid van koper
Density of aluminium	2 770 kg/m^3	Digtheid van aluminium
Density of gold	19 000 kg/m^3	Digtheid van goud
Density of alcohol (ethyl)	790 kg/m^3	Digtheid van alcohol (etiel)
Density of mercury	13 600 kg/m^3	Digtheid van kwik
Density of platinum	21 500 kg/m^3	Digtheid van platina
Density of water	1 000 kg/m^3	Digtheid van water
Density of mineral oil	920 kg/m^3	Digtheid van minerale olie
Density of air	1,05 kg/m^3	Digtheid van lug
Electrochemical equivalent of silver	1,118 mg/C	Elektrochemiese ekwivalent van silwer
Electrochemical equivalent of copper	0,329 mg/C	Elektrochemiese ekwivalent van koper
Gravitational acceleration	9,8 m/s^2	Swaartekragversnelling
Heat value of coal	30 MJ/kg	Warmtewaarde van steenkool
Heat value of anthracite	35 MJ/kg	Warmtewaarde van antrasiet
Heat value of petrol	45 MJ/kg	Warmtewaarde van petrol
Heat value of hydrogen	140 MJ/kg	Warmtewaarde van waterstof
Linear coefficient of expansion of copper	17 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van koper
Linear coefficient of expansion of aluminium	23 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van aluminium
Linear coefficient of expansion of steel	12 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van staal
Linear coefficient of expansion of lead	54 × 10^{-6}/°C	Lineêre uitsettingskoëffisiënt van lood
Specific heat capacity of steam	2 100 J/kg.°C	Spesifieke warmtekapasiteit van stoom
Specific heat capacity of water	4 187 J/kg.°C	Spesifieke warmtekapasiteit van water
Specific heat capacity of aluminium	900 J/kg.°C	Spesifieke warmtekapasiteit van aluminium
Specific heat capacity of oil	2 000 J/kg.°C	Spesifieke warmtekapasiteit van olie
Specific heat capacity of steel	500 J/kg.°C	Spesifieke warmtekapasiteit van staal
Specific heat capacity of copper	390 J/kg.°C	Spesifieke warmtekapasiteit van koper

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MARKING GUIDELINE

NATIONAL CERTIFICATE

NOVEMBER 2014

ENGINEERING SCIENCE N3

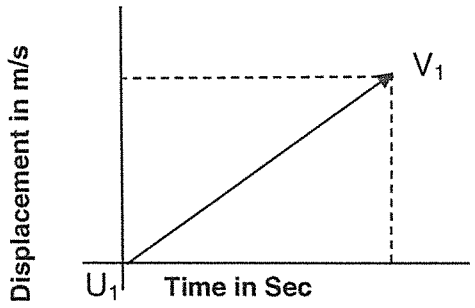
21 November 2014

This memorandum consists of 10 pages.

QUESTION 1: MOTION, POWER AND ENERGY

1.1 Velocity is the ***rate of displacement*** of a moving body in ***relation to time*** ✓ (2)

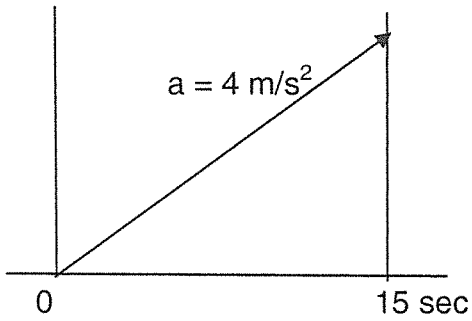
1.2



✓

Initial velocity (U_1) is where the object will start and the final velocity (V_1) is where the object will end in that particular face /period ✓ (2)

1.3



✓

$S = u \times t + ½ \times a \times t^2$

$S = 0 \times 15 + ½ \times 4 \times (15)^2$ ✓

$S = 450$ m ✓ (3)

1.4 $M_1 = 8$ tons $= 8000$ kg

$U_1 = 60$ km/h $= 16{,}667$ m/s
$M_2 = 5$ tons $= 5000$ kg
$U_2 = 40$ km/h $= 11{,}111$ m/s

$m_1 \times U_1 + m_2 \times U_2 = (m_1 + m_2)V$

$8000 \times 16{,}667 + 5000 \times 11{,}111$✓ $= (8000 + 5000)\ V$ ✓

$$V = \frac{133\ 336 + 55\ 555{,}556}{13\ 000}$$ ✓

$V = 14{,}53$ m/s ✓ (4)

1.5 D = 40 cm = 400 mm or 0,4 m
t = 1,2 mm
T_1 = 1320 N
T_2 = 123,154 N
V = 12 m/s

1.5.1 $$V = \frac{\pi \times d \times N}{60}$$

$$12 = \frac{\pi \times 0,4 \times N}{60} \quad \checkmark$$

$$N = 572,884 \text{ r/min} \quad \checkmark$$

(2)

1.5.2 $$P = (T_1 - T_2)\, V$$

$$P = (1320 - 123,154) \times 12 \quad \checkmark$$

$$P = 14\,362,152 \text{ W or } 14,4 \text{ kW} \quad \checkmark$$

(2)
[15]

QUESTION 2: MOMENTS

2.1 Concentrated Load = Load acting on a point or point load and normally act vertically downward ✓

Uniformly distributed Load = is a load that spread evenly over the length of a beam or a part of the length of a beam ✓ (2)

2.2

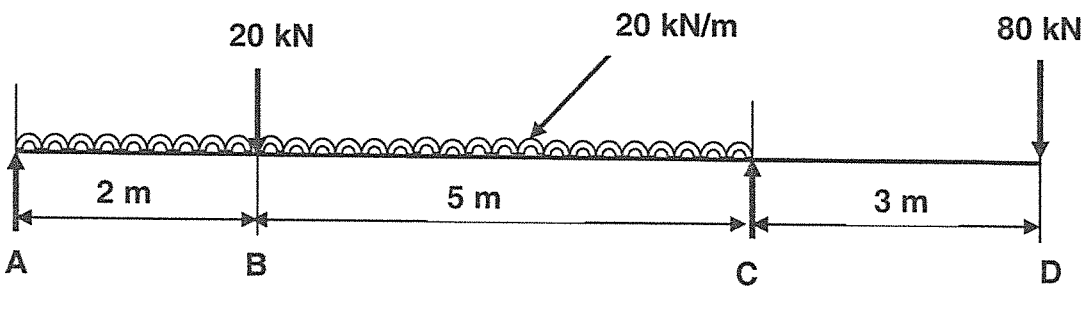


FIGURE 1

2.2.1 Taking moment about A

Sum of the anti-clockwise moment = sum of the clock wise moment

$C \times 7 = 20 \times 2 + 140 \times 3,5 + 80 \times 10$ ✓

$C \times 7 = 40 + 490 + 800$

$C \times 4 = 1330$

$C = \frac{1330}{7}$ ✓

$C = 190$ kN ✓ (3)

Taking moments about C

Sum of the anti-clock wise moments = sum of the clockwise moments.

$3,5 \times 140 + 20 \times 5 = 80 \times 3 + A \times 7$ ✓

$490 + 100 = 240 + A \times 7$ ✓

$A = 50$ kN ✓ (3)

Test

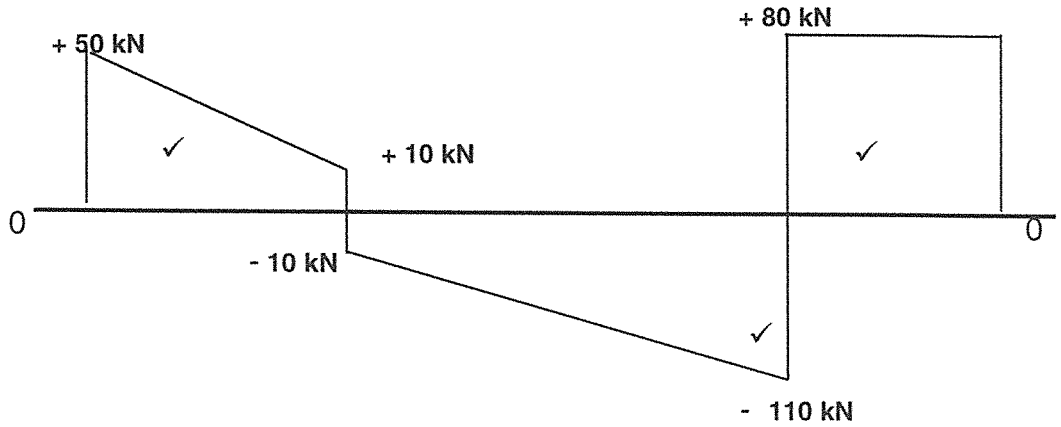
Upward force = Downward forces

$A + C = 20 + 80 + 140$

$50 + 190 = 240$ kN

240 kN $= 240$ kN

2.2.2



(3)

2.2.3 Maximum = -110 kN ✓

Minimum = + 80 kN ✓ (2)

[15]

QUESTION 3: FORCES

3.1 If TWO pulling forces, acting at a point, are represented in magnitude and direction by TWO adjacent side of a parallelogram, the resultant of the TWO forces is represented in magnitude and direction by the diagonal of the completed parallelogram✓ drawn from the point where the forces act ✓ (2)

3.2

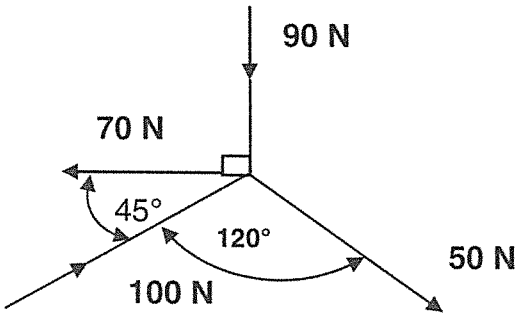


FIGURE 2

3.2.1 The sum of the horizontal components and give the direction

$$\sum HC = -70 + 100 \text{ Cos } 45^{\circ} + 50 \text{ x Cos}15^{\circ} \quad ✓$$

$$\sum HC = -70 + 70{,}711 + 48{,}2963 \quad ✓$$

$$\sum HC = 49 \text{ kN} \quad \text{EAST} \quad ✓$$ (3)

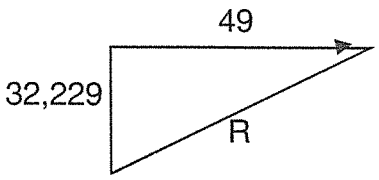
3.2.2 The sum of the Vertical components and give the direction

$$\sum VC = -90 - 50 \text{ Sin } 15 + 100 \text{ Sin } 45 \quad ✓$$

$$\sum VC = -90 - 12{,}94 + 70{,}7071 \quad ✓$$

$$\sum VC = -32{,}229 \text{ kN South} \quad ✓$$ (3)

3.2.3



$R = \sqrt{(32,229)^2 + (49)^2}$ ✓

$R = 1087,708$ kN ✓

$\text{Tan } \alpha = 32,229/49$

$\alpha = 33,33^{\circ}$ ✓ (3)

[11]

QUESTION 4: FRICTION

4.1 Braking of an object ✓
Transfer Power ✓
Wear between two objects in contact ✓
Cause objects like scissors to get blunt ✓ (4)

4.2 4.2.1 $W. \text{Cos } \theta = 45 \times 9,8 \times \cos 16^0$ ✓
$Fc = \underline{423,916 \text{ N}}$ ✓ (2)

4.2.2 $W. \text{Sin } \theta = 45 \times 9,8 \times \sin 16^0$ ✓
$Fs = 121,556$ N ✓ (2)

4.2.3 $F\mu = Fc \times \mu$
$F\mu = 105,979$ N ✓ (1)

4.2.4 $F_{up} = F\mu + Fs$
$F_{up} = 105,979 + 121,556$ ✓
$F_{up} = 227,535$ N ✓ (2)

[11]

QUESTION 5: HEAT

5.1 5.1.1 $\Delta T = t_2 - t_1$
$\Delta T = 80 - 18$
$\Delta T = 62\ ^{\circ}C$ ✓ (1)

5.1.2 Heat Energy = m x HV
$Q = 13 \times 390$ ✓
$Q = 390$ MJ ✓ (2)

5.1.3 $Q = m \times c \times \Delta T$

$m = \frac{Q}{c \times \Delta T}$

$, = \frac{390 \times 10^6}{4200 \times 62}$ ✓

M = 1497,696 Litres ✓ (2)

5.2 $\Delta A = Ao \times 2\alpha \times \Delta t$

$= (0,25 \times 0,1) \times 2 \times 25 \times 10^{-6} \times (65-23)$ ✓

$\Delta A = 5,25 \times 10^{-5}\ m^2$ ✓ (2)

5.3 5.3.1 $H_{dry} = hfg - hfg$

$= 2174 - (1 \times 2174)$

$= 2720$ kJ ✓ (1)

5.3.2 $H_{wet} = (hf + xhfg) \times 2$

$H_{wet} = (546 + (0.94 \times 2174) \times 2$ ✓

$H_{wet} = 5179,12$ kJ ✓ (2)

5.4 Is the quantity of het to raise a substance temperature by 1 °C ✓✓ (2)

5.5 The specific heat capacity of a substance is the quantity of energy required to raise the temperature of a unit mass of material✓ of a substance by 1 °C ✓ (2)
[14]

QUESTION 6: HYDRAULICS

6.1 Pin = 5 kW
Q = 80 000 l/h
H = 20 m

6.1.1 $P_r = p \times g \times h$
$P_r = 1000 \times 9,8 \times 20$ ✓
$P_r = 196000$ Pa or 196 kPa ✓ (2)

6.1.2 Work done (Wd) = Force x distance
Wd = m x g x s
Wd = 22,22 x 9,8 x 20 ✓
Wd = 4355,556J or 4,4 kJ ✓ (2)

6.1.3 $\eta = Wd/Pin \times 100$
$\eta = 4,4/5 \times 100$ ✓
$\eta = 88\ \%$ ✓ (2)

6.2 6.2.1 $d = 50$ mm
$D = 200$ mm
$h = 70$ cm $= 700$ mm
effort $= 310$ kN

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

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

$$W = \frac{310}{50^2} \times 200^2$$ ✓

$W = 4960$ kN ✓ (2)

6.2.2 $D^2 . h = d^2 . H$

$$H = \frac{D^2.h}{d^2}$$
$$= \frac{(50)^2 \times 700}{(200)^2}$$ ✓

h = 43,75 mm ✓ (2)

6.2.3 $$\text{No of strokes} = \frac{D^2 \times \text{height lifted}}{d^2 \times \text{stroke}}$$

$$\text{No of strokes} = \frac{(0,2)^2 \times 46}{(0,05)^2 \times 0,7}$$ ✓ ✓

No of strokes = 1051,428 strokes ✓ (3)
[13]

QUESTION 7: ELECTRICITY

7.1 7.1.1 $V_{r1} = I \times R$
$V_{r1} = 0,05 \times 1,2 \times 10^3$ ✓
$Vr_1 = 60$ Volts ✓ (2)

7.1.2

$V_P = V_T - V_{R1}$
$V_P = 90 - 60$
$V_P = 30$ Volts ✓

$R_3 = \frac{V_P}{I}$

$R_3 = \frac{30}{0,02}$

$R_3 = 1500\ \Omega$ ✓

$\frac{1}{R_P} = \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_P} = \frac{1}{1000} + \frac{1}{1500}$ ✓

$R_P = 598,8\ \Omega$ ✓

$R_T = R_1 + R_P$

$R_T = 1,2 \times 10^3 + 598,8$

$R_T = 1,8\ k\Omega$ ✓ (5)

7.1.3

Power = V x I x t
Power = 30 x 0,02 ✓
Power = 0,6 Watt ✓ (2)

7.2 7.2.1

$\frac{V_p}{N_p} = \frac{V_s}{N_s}$

$V_s = \frac{V_p \times N_s}{N_p}$

$V_s = \frac{300 \times 240}{50}$ ✓

$V_s = 1440$ Volts ✓ (2)

7.2.2 $\frac{I_p}{I_s} = \frac{N_s}{N_p}$

$I_s = \frac{I_p \times N_p}{N_s}$

$V_s = \frac{50 \times 20}{30}$ ✓

$V_s =$ 3,333 Amps ✓ (2)
[15]

QUESTION 8: CHEMISTRY

8.1 8.1.1 Electric current ✓

8.1.2 Ions ✓

8.1.3 Solder ✓

8.1.4 Lead ✓

8.1.5 Strength ✓

8.1.6 High melting point ✓ (6)
[06]

TOTAL 100