higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T610(E)(A9)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N3

(15070413)

9 April 2013 (X-Paper)
09:00–12:00

Steam tables are needed.

Calculators may be used.

This question paper consists of 8 pages, a information sheet and a 2-page formula sheet.

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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. All the calculations should consist of at least the THREE steps:
   - 4.1 The formula used or manipulation thereof
   - 4.2 Substitution of the given data in the formula
   - 4.3 The answer with the correct SI unit
5. Drawing instruments must be used for ALL drawings/diagrams. All drawings/diagram MUST be fully labelled.
6. One mark indicates one percentage point, that is 100 marks = 100%
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.
12. Write neatly and legibly.

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QUESTION 1: MOTION, POWER AND ENERGY

1.1 Distinguish between *speed* and *velocity*. (2)

1.2 Explain the relationship between force, mass and acceleration. (3)

1.3 A train accelerates uniformly in a straight line at 0,3 m/s^2 from rest.

Calculate the following:

1.3.1 The velocity 15 seconds after its departure (1)

1.3.2 The time taken to reach 30 km/h (1)

1.3.3 The distance covered by the train (2)

1.4 A machine must be driven at 100 r/s from a belt pulley of 600 mm diameter revolving at 72 r/s. The maximum tensile force on the belt must not exceed 3 000 N. Assume that the ratio of the tensile forces is 2,5 : 1.

Determine the following:

1.4.1 Diameter of the driven pulley (2)

1.4.2 The power in kW that can be transmitted (4)
[15]

QUESTION 2: MOMENTS

2.1 Define the *moment of force*. (2)

2.2 Determine the magnitude of force P as shown in **FIGURE 1** for the beam to be in equilibrium.

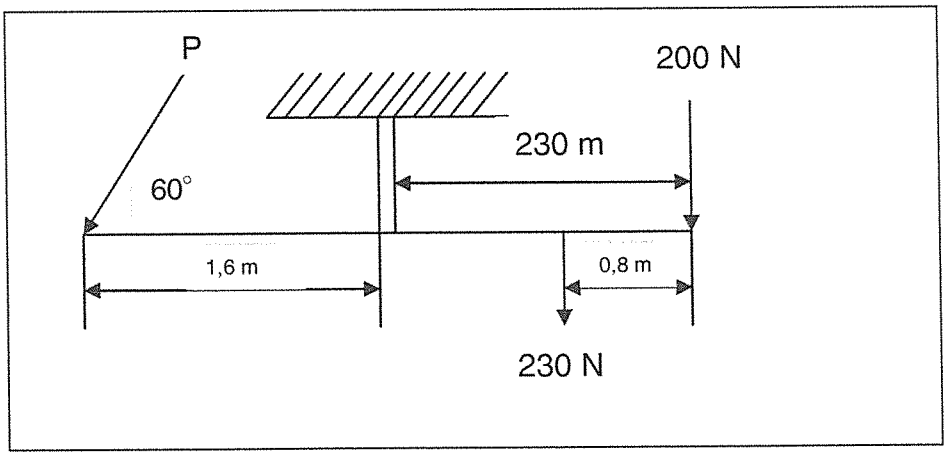


FIGURE 1 (4)

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2.3 A beam is 4 m long and it is being supported at the left end and 1 m from the right end of the beam. There is a uniformly distributed load of 120 N/m placed between the two supports. A point load of 300 N is placed on both ends of the beam and a 200 N load is placed at the middle of the beam.

2.3.1 Calculate the reaction of the two supports. (4)

2.3.2 Draw a shear-force diagram of the beam.
(Use a scale of 1 cm = 0,25 m for the x-axis and 1 cm = 100 N for y-axis.) (3)
[13]

QUESTION 3: FORCES

3.1 Define the *triangle of forces*. (2)

3.2 State TWO conditions which apply if the forces on a framework are in equilibrium. (2)

3.3 **FIGURE 2** below shows a system of forces. Calculate the magnitude and direction of the resultant force that will keep the four forces in equilibrium.

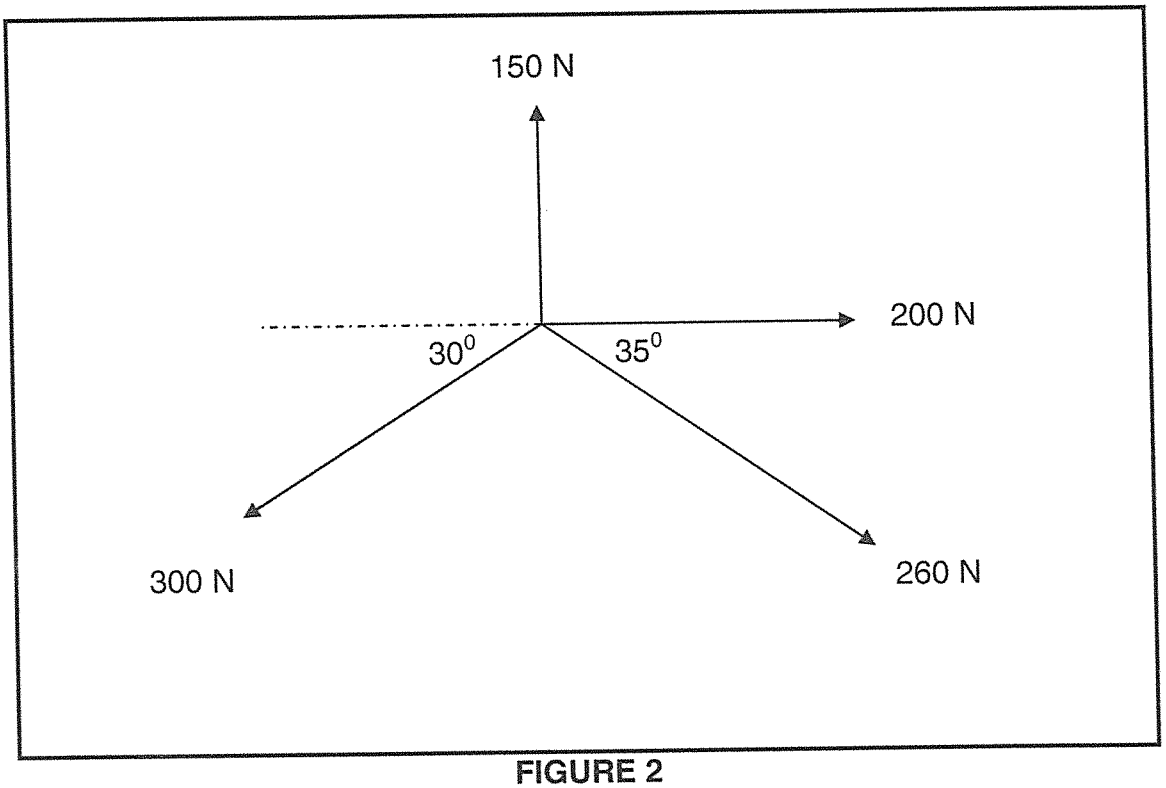


FIGURE 2 (6)

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3.4 **FIGURE 3** below shows a structure of a roof truss. Determine the magnitude and nature of the forces AC and BC in the frame.

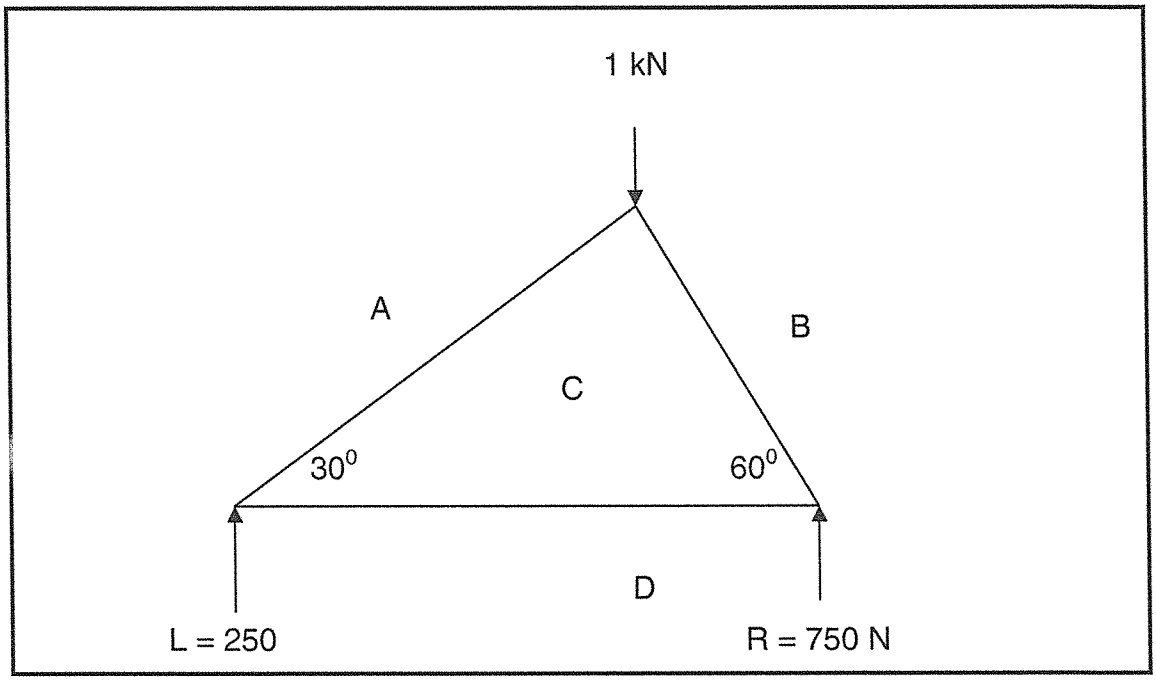


FIGURE 3

(5)
[15]

QUESTION 4: FRICTION

4.1 A casting with a mass of 0,5 tons rests on a sloping surface forming an angle of 15° with the horizontal. The coefficient of friction is 0,4.

Calculate the following:

4.1.1 The component of the weight of the object perpendicular to the surface

4.1.2 The component of the weight of the object parallel to the surface

4.1.3 The friction force between the casting and the incline

4.1.4 The smallest force required to move the casting down the incline

(4 x 2) (8)

4.2 Define the *coefficient of friction*. (3)
[11]

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QUESTION 5: HEAT

5.1 Water is heated from 10 °C to 80 °C in one hour by 15 kg of a fuel with a heat value of 31 MJ/kg. Take the specific heat capacity of water as 4,kJ/kg.°C and assume that no heat is lost.

Calculate the following:

5.1.1 The change in temperature (2)

5.1.2 The heat energy delivered by the fuel in one hour (2)

5.1.3 The volume of water which is heated (2)

5.2 If 10 kg of water at a pressure of 920 kPa and a temperature of 60 °C is heated to boiling point then to dry saturation point and then to superheated steam at a temperature of 210 °C, determine the specific enthalpy (heat energy) of the following:

5.2.1 The liquid enthalpy (2)

5.2.2 The enthalpy of evaporation (2)

5.2.3 The enthalpy of superheated steam added if the specific heat capacity of steam is 2,1 kJ/kg. °C (2)

5.2.4 The saturation temperature of the steam (1)

5.3 Name TWO disadvantages of steam. (2)
[15]

QUESTION 6: HYDRAULICS

6.1 A single-acting piston pump has a piston diameter of 250 mm and a stroke length of 300 mm. The effective pressure is 900 kPa during the delivery stroke.

Calculate the following:

6.1.1 The force exerted by the pump (2)

6.1.2 The work done after 10 strokes (2)

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6.2 The diameter of the ram of a hydraulic press is 90 mm and that of the plunger 15 mm. The press has a plunger stroke length of 25 mm and it has a lever with a mechanical advantage of 15.

Calculate the following:

6.2.1 The effort applied on the lever that can lift a load of 12 kN (2)

6.2.2 The distance that the load can be lifted after 80 strokes (2)

6.3 Define Pascal's law. (2)

6.4 Explain the following concepts:

6.4.1 Static head (1)

6.4.2 Delivery head (1)
[12]

QUESTION 7: ELECTRICITY

7.1 If the battery of a circuit has an EMF of 4 V and an internal resistance (r) of 0,5 Ω, what will the total current flowing in the circuit be when connected as shown in **FIGURE 4**?

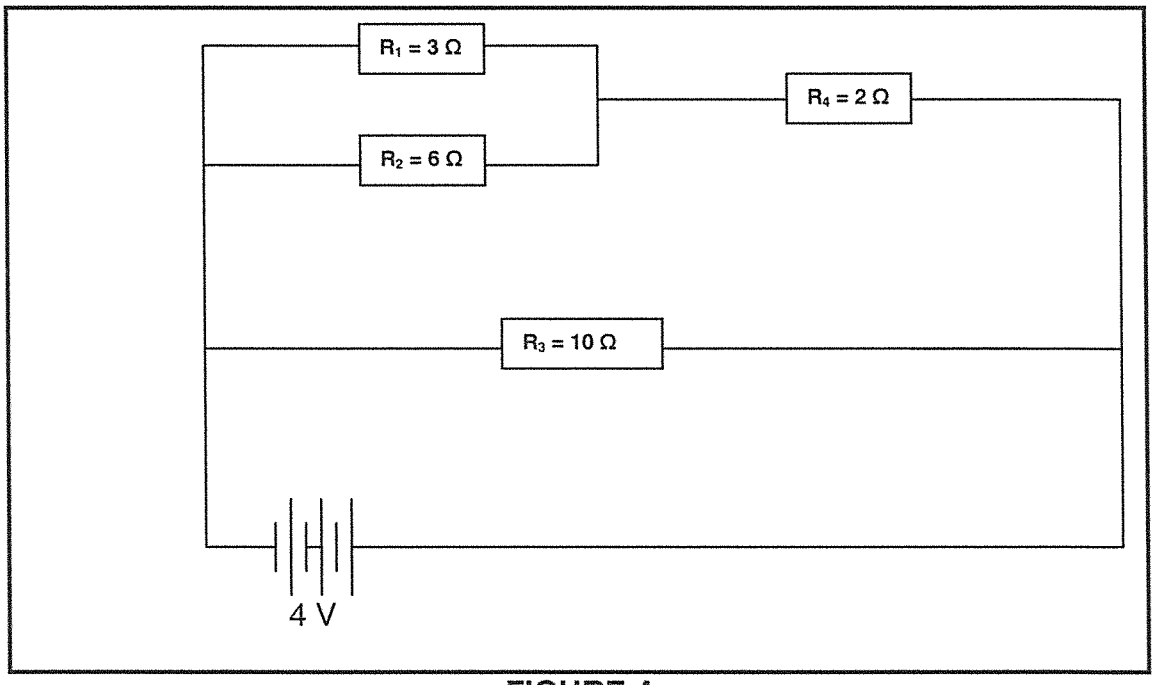


FIGURE 4

(8)

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7.2 An electric appliance connected to a supply of 220 V, draws a current of 35 A.

Determine:

7.2.1 The electrical energy consumption for one hour (2)

7.2.2 The cost per hour if the rate is 65 cents per kWh (2)
[12]

QUESTION 8: CHEMISTRY

8.1 Distinguish between *metals* and *nonmetals* and give an example of each. (4)

8.2 Name the THREE different groups of matter and give an example of each. (3)
[7]

TOTAL: 100

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INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	CONSTANTS	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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ENGINEERING SCIENCE N3

FORMULA SHEET

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

$W = F.s$

$W = \rho.V$

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

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

$F = m.a$

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

$\mu = \tan\Phi$

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

$F_S = wsin\theta$

$F_C = wcos\theta$

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

$F_e = T_1 - T_2$

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

$P = F_e . v$

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

$W_\mu = F_\mu . s$

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

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

$Q = I^2 . R . t$

$m = I . z . t$

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

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

$D_e = (D + t)$

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

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

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

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

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

$F_X = Fcos\theta$

$F_Y = Fsin\theta$

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

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

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

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

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

$m.ww = Q = m.hv$

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

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

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

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

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

$v = u + a.t$

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

$M = F . \perp s$

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

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

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

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

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

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

$$V = I \times R$$

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MARKING GUIDELINE

NATIONAL CERTIFICATE

APRIL EXAMINATION

ENGINEERING SCIENCE N3

9 APRIL 2013

This marking guideline consists of 11 pages.

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QUESTION 1

1.1 Speed is the rate of distance covered by a moving body in relation to time ✓

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

1.2 Force is that influence which change or tends to change the state of rest or uniform motion in a straight line of a object. ✓
The mass of an object is the quantity of matter it contains.✓
Acceleration is the rate of change of velocity. ✓ (3)

1.3 $u = 0$ m/s
$a = 0,3$ m/s^2 and $t = 15$ sec

1.3.1 $v = u + at$
$= 0 + (0,3)(15)$
$= 4,5$ m/s ✓ (1)

1.3.2 $v = u + at$

$t = \frac{v-u}{a}$
$= \frac{8,333 - 0}{0,3}$
$= 27,778$ sec. ✓ (1)

1.3.3 $s = u\,t + \frac{1}{2}\,at^2$
$= 0x\,(27,778) + \frac{1}{2}(0,3)27.778^2$ ✓
$= 115,742$m ✓
Or
or
$s = \frac{v^2 - u^2}{2a}$
$= \frac{(8,333)^2 - 0^2}{2(0,3)}$

$= 115,732$m (2)

1.4 $N_2 = 100$ r/s
$D_1 = 600$ mm
$N_1 = 72$ r/s
$F = 3000$ N
Ratio 2,5:1

1.4.1 $N_1 \times D_1 = D \times N_2$

$72 \times 600 = 100 \times D_2$

$D_2 = \frac{600 \times 72}{100}$ ✓

$= 432mm$ ✓ (2)

1.4.2 $P = FX\ v$

$= 3000 \times 135,717$ ✓

$= 407151\ W$ ✓

$V = \pi dn$

$= \pi x 0,6 \times 72$

$v = 135,717\ m/s$ ✓✓

= (4)

[15]

QUESTION 2

2.1 The moment of a force can be defined as the force multiplied by the vertical distance from the turning point to the line of action of the force. ✓✓ (2)

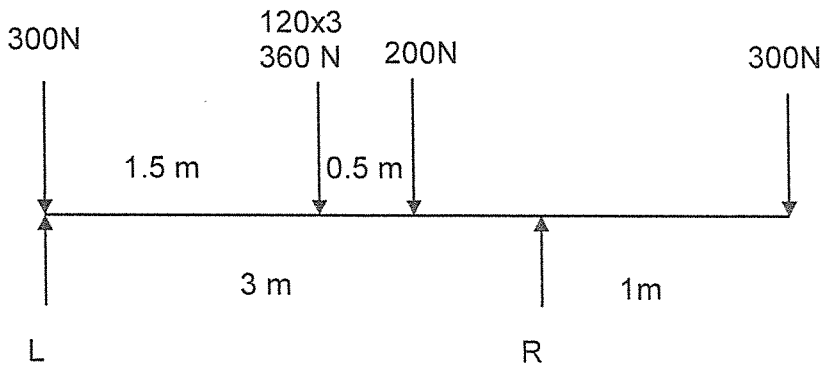
2.2 Sum of the left hand forces = sum of the right hand forces

$P \cos 30° \times 1,6 = 230 \times 1,2 + 2 \times 200$ ✓✓

$P = \frac{676}{\cos 30° \times 1,6}$ ✓

$= 487,861\ N$ ✓ (4)

2.3



2.3.1 Taking moments about L

Sum of the right hand forces = sum of the left hand forces.

$360 \times 1,5 + 200 \times 2 + 300 \times 4 = R \times 3$

$540 + 400 + 1200 = R \times 3$

$2140 = R \times 3$ ✓

$R = 713,333$ N ✓ (2)

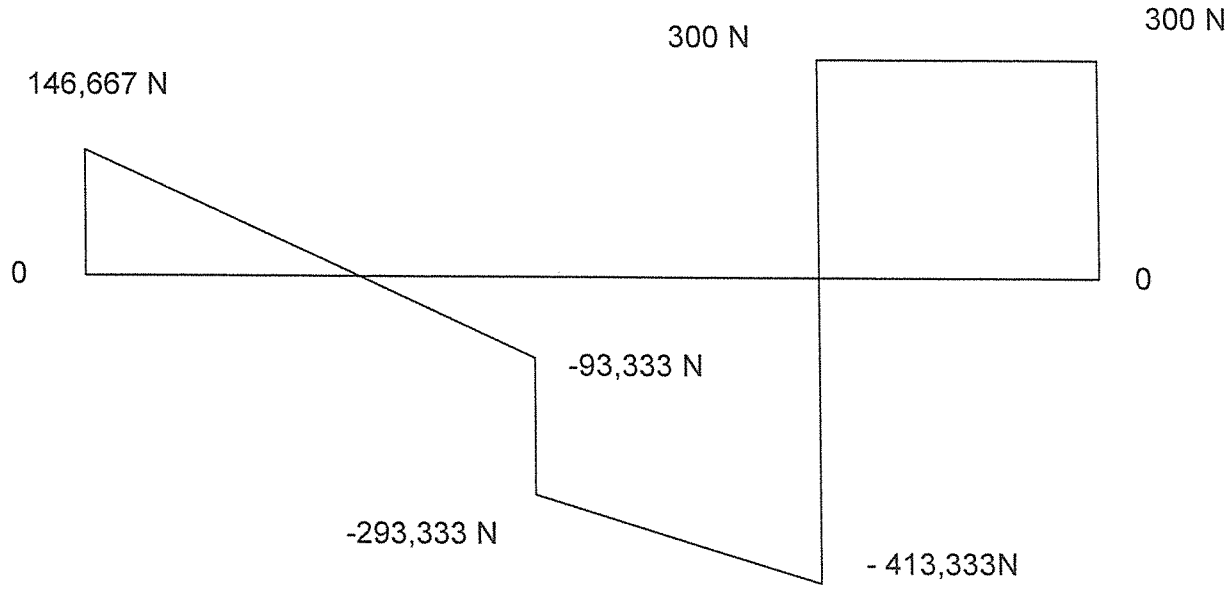
Upwards forces = downwards forces

$713,333 + L = 300 + 360 + 200 + 300$

$L = 1160 - 713,333$ ✓

$L = 446,667$ N ✓ (2)

2.3.2



(3)
[13]

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QUESTION 3

3.1 If three forces acting at a point are in equilibrium, they can be represented in magnitude and direction by the sides of a triangle taken in order. The converse is also true. ✓✓ (2)

3.2 Sum of all the forces in any direction must be zero
The sum of all the moments of the forces about the fulcrum must be zero ✓✓ (2)

3.3 $\sum VC = 150 - (300 \times \sin 30° + 260 \times \sin 35°)$
$= 150 - 299.1298$
$= -149,129$ N ✓✓ (2)

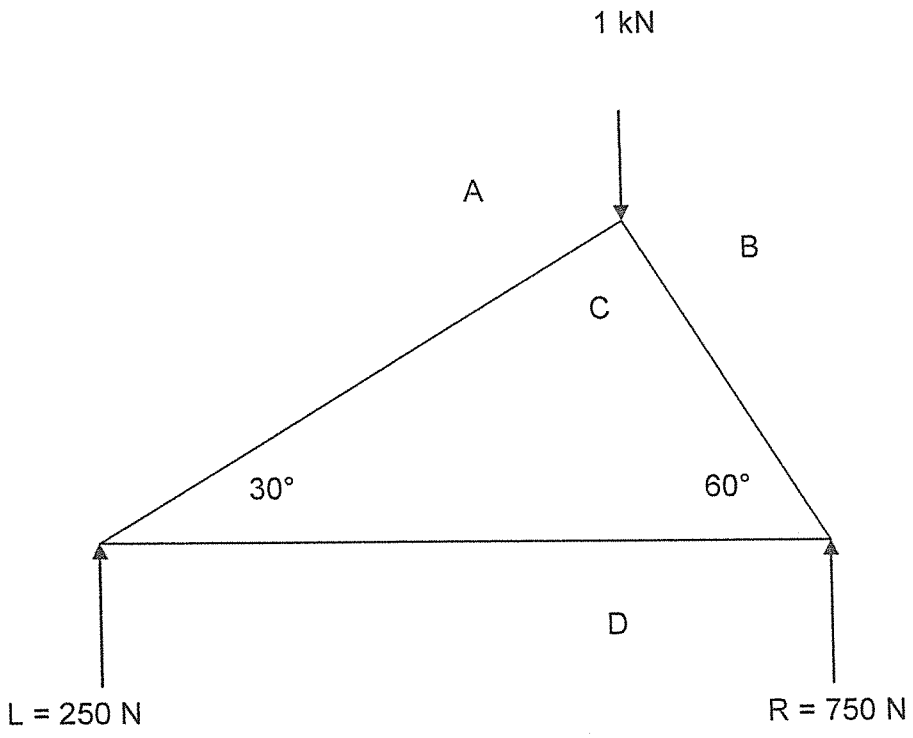
$\sum HC = 200 + 260 \times \cos 35° - 300 \cos 30°$
$= 200 + 212,98 - 259,808$
$= 153,172$ N ✓✓ (2)

$\tan \emptyset = \frac{VC}{HC}$
$\emptyset = \tan^{-1} \frac{149,129}{153,172}$
$\emptyset = \tan^{-1} 0,974$
$\emptyset = W\ 44,245°\ N$ or $44,245^0$ north of west.✓ (1)

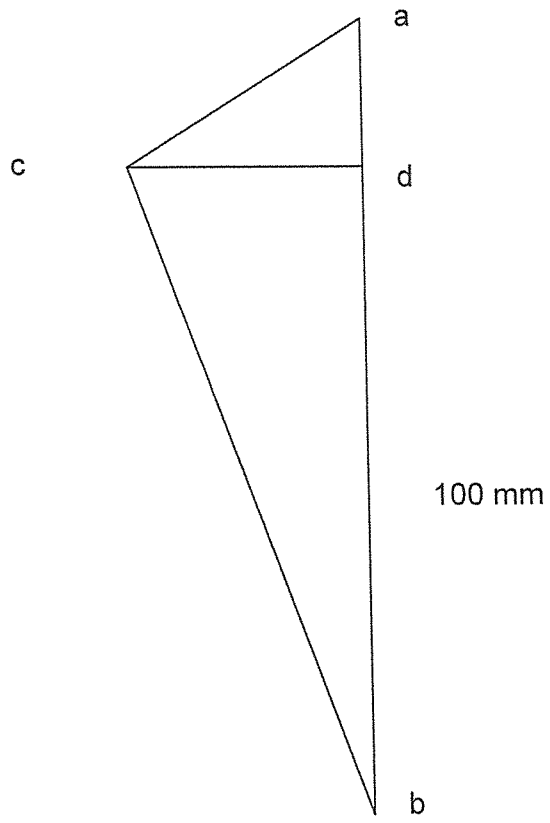
$R = \sqrt{HC^2 + VC^2}$
$= \sqrt{(153,172)^2 + (149,129)^2}$
$R = 213,779$ N (1)

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3.4



Scale 1 000 N = 100 mm



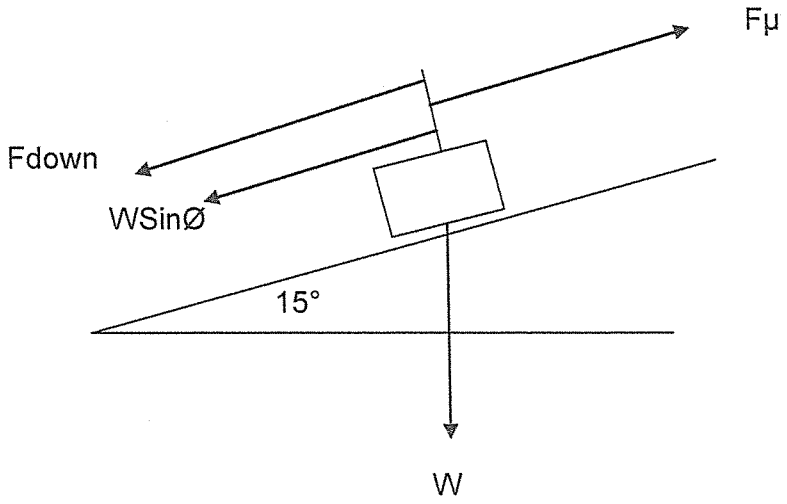
BC = Strut = 865 N
AC = Strut = 500 N

Cos 30^0 = 750/BC
BC = 866,025 N

SIN 30^0 = 250/AC
AC = 500 N (5)
[15]

QUESTION 4

4.1



4.1.1 Fc = W x Cos Ø
= 4900 x Cos15° ✓
= 4733,037 N ✓ (2)

4.1.2 Fs = W Sin Ø
= 4900 x sin 15° ✓
= 1268,213 N ✓ (2)

4.1.3 Fμ = μ x w cos Ø
= fμ x w cos Ø
= 0.4 x 4733,037 ✓
= 1893,215 N ✓ (2)

4.1.4 F_{down} + Fs = Fμ
F_d = Fμ - Fs
= 1893,215 – 1268,213 ✓
= 625 N ✓ (2)

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4.2 The coefficient of friction between two surfaces is the ratio✓ of the friction force between the surfaces✓ to the force which presses together. ✓ (3)
[11]

QUESTION 5

5.1 5.1.1 $\Delta t = t_2 - t_1$
$= 80 - 10$ ✓
$= 70°C$ ✓ (2)

5.1.2 $Q = m \times hv$
$= 31 \times 10^6 \times 15$ ✓
$= 465$ MJ ✓ (2)

5.1.3 $Q = Q$
$Q = m \times c \times \Delta t$
$465 \times 10^6 = m \times 4200 \times 70$ ✓
$m = 1581{,}633$ kg
1 litre = 1 kg
$= 1581{,}633$ litre ✓ (2)

5.2 10kg
920Lpa
60°C
210°
Ts =

hf = 747 kJ/kg
hfg = 2006 kJ/kg
hg = 2773 kJ/kg
ts = 176,3°C

5.2.1 hf = 10 kg x 747 kJ/kg ✓
= 7470 kJ ✓ (2)

5.2.2 hfg = 10 kg x 2026 kJ/kg ✓
= 20260 kJ
= 20,26 MJ ✓ (2)

5.2.3 Dry steam = hf + hfg
= 7,47 + 20,26 ✓
= 27,73 kJ ✓ (2)

5.2.4 ts = 176,3°C ✓ (1)

5.3 Steam takes a long time to generate
Causes corrosion
Lost in heat due to heat radiation
Large and expensive equipment

Any two ✓✓ (2)
[15]

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QUESTION 6

6.1 6.1.1

$Pr = \frac{F}{A}$ where $A = \frac{\pi d^2}{4}$

$F = Pr \times A$

$= 900 \times 10^3 \times 0,049$ ✓

$A = 44178,646$ N

$= 44,2$ kN ✓

$A = \frac{\pi \times (0,25)^2}{4}$

$= 0.049\ mm^2$

(2)

6.1.2 Work done $= \frac{F \times S}{Stroke}$

$Wd = 44100 \times 0,3$

$= 13230$ /stroke

$= 13,23$ kJ ✓

10 strokes = wd x 10 strokes

$= 13,23 \times 10$

$= 132,3$kJ ✓

(2)

6.2

6.2.1 $MA = \frac{Load}{EFFORT}$

$EFFORT = \frac{Load}{MA}$

$= \frac{12000}{15}$ ✓

$= 800$ N ✓

(2)

6.2.2 Volume = Volume

Area x h = Area x h

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

$D^2 \times H = d^2 \times h$

$H = \frac{d^2 \times h}{D^2}$

$H = \frac{15^2 \times 25}{90^2}$

$H = 0,694$ mm ✓

For 80 strokes = 0,694 x 80

$H = 55,556$ mm ✓

(2)

6.3 When the piston moves/punched down an equal quantity of water will spout out of each hole. ✓ The pressure in a liquid is transmitted evenly in all directions. ✓

(2)

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6.4 Static head is the suction head plus delivery head ✓
Delivery head is the distance from the centre of the pump to the height of the substance delivered ✓ (2)
[12]

QUESTION 7

7.1 E = 4 V E = I (R + r)
R = 0,5 Ω

$$R_p = \frac{1}{R_{p1}} = \frac{1}{6} + \frac{1}{3}$$ ✓
$R_T = 2\Omega$ ✓

Rs = Rp1 + R4
= 2 + 2 ✓
= 4Ω ✓ (4)

$$I = \frac{E}{R + r}$$
$$= \frac{4}{2,857 + 0,5}$$ ✓
= 1,192 A ✓

$$\frac{1}{R_T} = \frac{1}{R5} + \frac{1}{R3}$$
$$\frac{1}{RT} = \frac{1}{4} + \frac{1}{10}$$ ✓
RT = 2,857 Ω ✓ (4)

7.2 7.2.1 Electrical energy = V x I x t
= 220 x 35 x (3600) ✓
= 27,72 MJ ✓ (2)

7.2.2 Cost = tariff per kWh x number of kWh consumed
= 65 x (27,72 x $\frac{1}{3,6}$) ✓
Cost = 500,5 cents or R 5 ✓ (2)
[12]

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QUESTION 8

8.1 **Metals** are elements on the left side of the periodic table. ✓
Non metals will be on the right side of the periodic table. ✓

Example of Metals	Example of Non Metals
Aluminium (Al)	Carbon (C)
Copper (Cu) ✓	Chlorine (Cl) ✓

(4)

8.2 **Solids** - Objects such as steel bar and copper bushes ✓
Liquids - Water and oil ✓
Gases – Water vapour and exhaust fumes of a car ✓ (3)
[7]

TOTAL : 100

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