higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T620(E)(M30)T
APRIL 2011

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N3

(15070413)

30 March (X-Paper)
09:00 – 12:00

REQUIREMENTS: Properties of water and steam (BOE 173)

NO graph paper may be issued.

Candidates will require drawing instruments.

Calculators may be used.

This question paper consists of 8 pages, 1 information sheet and a 2-page formula 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 correctly according to the numbering system used in this question paper.
4. ALL the calculations must consist of, at least, the following 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. The constant values, as they appear on the attached information sheet, must be used where ever possible.
6. Keep subsections of questions together.
7. Rule off across the page on completion of each question.
8. Drawing instruments must be used for ALL drawings/diagrams. ALL drawings/diagrams must be fully labelled.
9. Use $g = 9,8\ m/s^2$.
10. Answers must be rounded off to THREE decimal places.
11. Write neatly and legibly.

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QUESTION 1: MOTION, POWER AND ENERGY

1.1 A body with a mass of 20 kg accelerates uniformly in a straight line according to the law, $v = 10 - 2t$, where v is the final velocity after t in seconds.

Calculate the following:

1.1.1 The initial velocity of the body (1)

1.1.2 The acceleration of the body (1)

1.1.3 The initial momentum (2)

1.1.4 The kinetic energy after 4 seconds (3)

1.1.5 The distance travelled after 3 seconds (2)

1.1.6 Rewrite the law $v = 10 - 2t$ in the form $s = ut + \frac{1}{2}at^2$ (2)

1.2 A driving pulley rotates at 3 r/s and has a diameter of 0,3 metres. The pulley exerts a force of 2 000 N at a point on its periphery.

Calculate the following:

1.2.1 The turning moment (torque) (2)

1.2.2 The power in kW (2)
[15]

QUESTION 2: MOMENTS

2.1 State TWO conditions for a beam to be in equilibrium. (2)

2.2 FIGURE 1 shows a light horizontal beam ABCD of uniform cross section loaded as shown. The magnitude of support A is 32,222 kN.

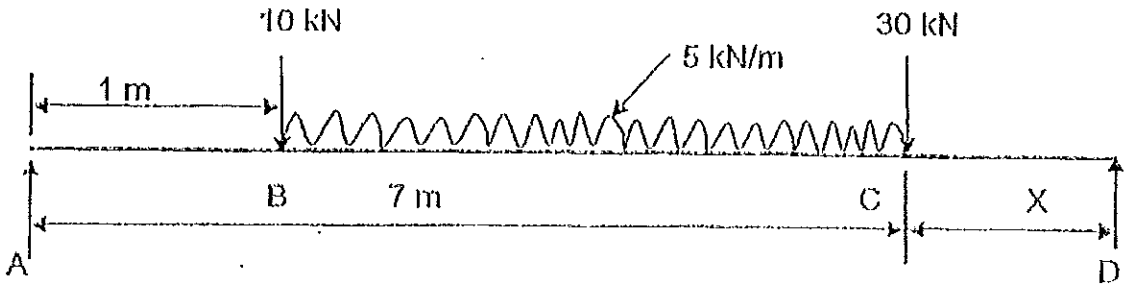

FIGURE 1

2.2.1 Calculate the magnitude of support D by using Newton's third law. (3)

2.2.2 Calculate the distance X by taking moments about support D. (4)

2.2.3 Draw a fully labelled shear-force diagram using a suitable scale. Show ALL the main values on the diagram. (3)
[12]

QUESTION 3: FORCES

3.1 Explain what is understood by the term *resultant* of a number of forces. (1)

3.2 Consider the four forces below acting on the same point:

20 kN directly east
30 kN directly north
50 kN directly west
70 kN directly south

3.2.1 Calculate the sum of the vertical and horizontal components and state their directions. (3)

3.2.2 Calculate the magnitude and direction of the resultant. (4)

3.3 FIGURE 2 shows a structure. Determine graphically or calculate the magnitude and nature of the forces in members PQ and PR.

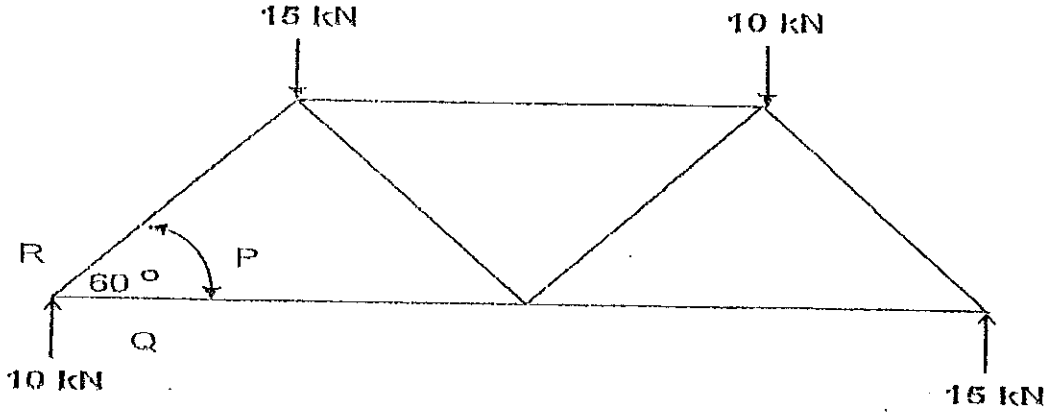

FIGURE 2

(6)
[14]

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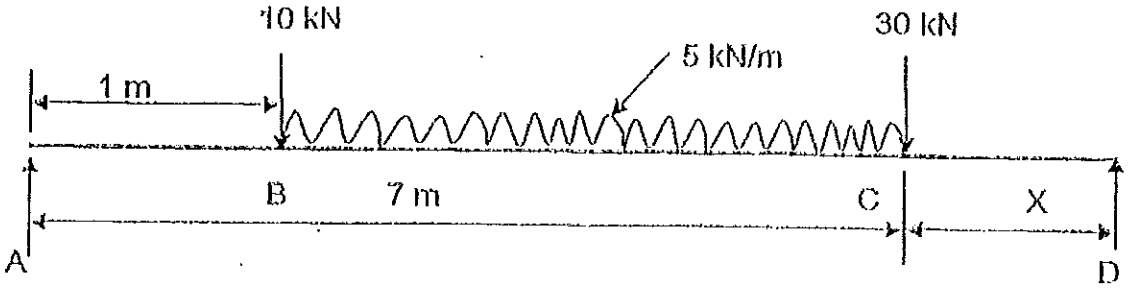

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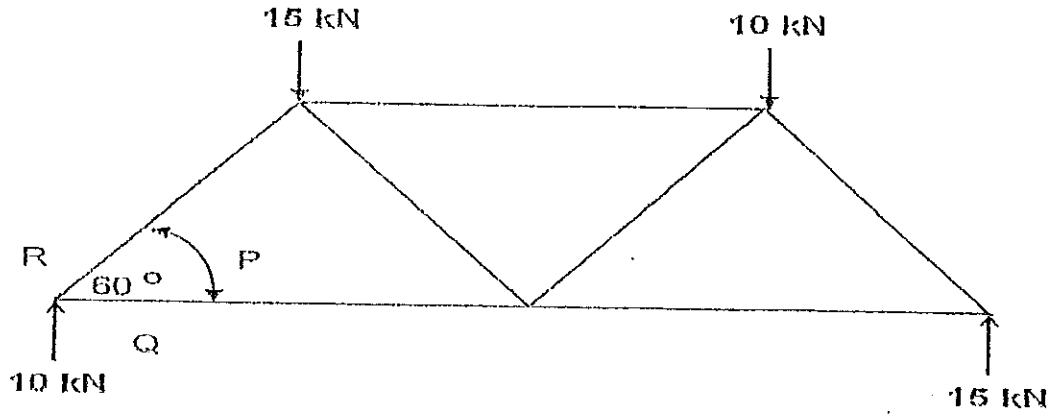

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QUESTION 4: FRICTION

4.1 Explain the term *angle of friction.* (2)

4.2 A horizontal force of 500 N is required to move an object with a mass of 100 kg across a horizontal surface at a constant speed.

Calculate the coefficient of friction. (3)

4.3 FIGURE 3 shows a body with a mass of 50 kg on an inclined plane making an angle of 20° with the horizontal.

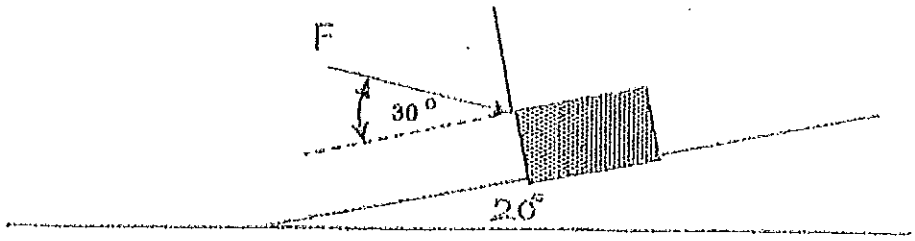

FIGURE 3

Calculate the magnitude of force F required to push the object up the incline at a constant velocity if the coefficient of friction is 0,4. (5)
[10]

QUESTION 5: HEAT

5.1 Briefly explain the term *area expansion.* (1)

5.2 Calculate the efficiency with which 2 kg of hydrogen is completely burnt under normal conditions to produce 210 MJ of heat energy. (2)

5.3 A copper plate has an area of 75,2 cm^2 at -5 °C.
Calculate the area when heated to 100 °C. (2)

5.4 5.4.1 State ONE advantage of steam. (1)

5.4.2 State ONE disadvantage of steam. (1)

5.5 Calculate the total enthalpy in MJ required to produce 3 kg of wet steam with a dryness fraction of 0,82 and at a pressure of 1 000 kPa. (3)

5.6 Calculate the change in temperature of 5 kg oil at 10 °C when 5 000 kJ of heat energy is transferred to the oil. (2)
[12]

QUESTION 6: HIDRAULICS

6.1 Explain, with reference to hydraulics, what is meant by the term *pressure*. (1)

6.2 The following data refer to a single-acting pump which delivers water from a bore hole:

Area of pump piston	= $28,274 \times 10^{-4}$ m^2
Stroke length of pump piston	= 88,42 mm
Volume of water delivered	= 120 ℓ/min
Depth of bore hole	= 50 m

Calculate the following:

6.2.1 The pressure at which the pump must work in kPa (2)

6.2.2 The volume of water delivered per stroke of the piston in litres

6.2.3 The power delivered by the pump

6.3 The following data refer to a single-acting hydraulic press. The ratio between the diameters of the plunger piston to the diameter of the ram piston is 1:4.

Volume of liquid displaced by the plunger per stroke	= 35 342,917 mm^3
Stroke length of plunger piston	= 50 mm
Force applied to plunger piston	= 250 N

Calculate the following:

6.3.1 The force exerted by the ram (2)

6.3.2 The diameter of the plunger piston (4)
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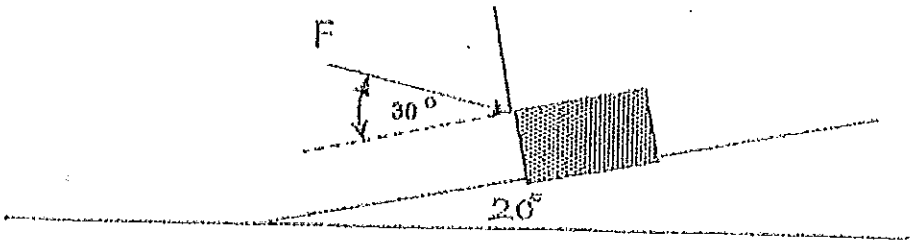

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QUESTION 7: ELECTRICITY

7.1 FIGURE 4 shows an electrical circuit consisting of the following components:

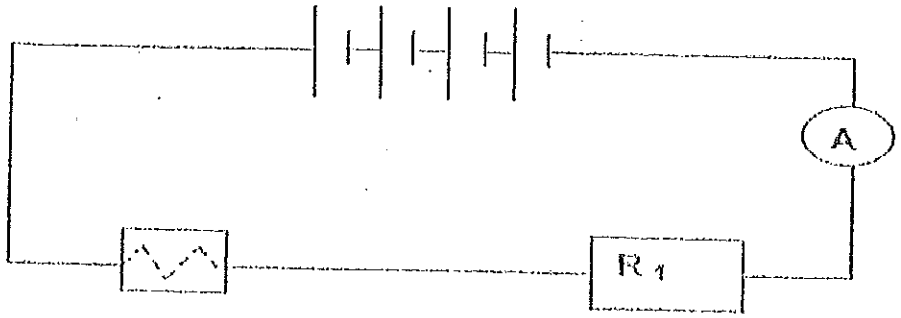

FIGURE 4

A battery having four cells, EMF per cell	= 2 volts
Internal resistance per cell	= 0,3 ohm
ONE external resistor: R1	= 0,5 ohm
ONE ammeter with resistance	= 0,1 ohm
Ammeter reading	= 2 amperes
A lamp with unknown resistance	

Calculate the following:

7.1.1 The total internal resistance (2)

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7.1.4 The potential difference across the lamp (2)

7.1.5 The energy consumed by the lamp in 4 minutes (2)

7.2 The following data refer to a single-phase transformer:

Primary voltage	= 220 volts
Secondary voltage	= 110 volts
Primary current	= 2 amperes
Primary turns	= 100

Calculate the following:

7.2.1 The secondary current (2)

7.2.2 The secondary turns (2)

[15]

QUESTION 8: CHEMISTRY

8.1 Name ONE method to combat corrosion. (1)

8.2 Neatly copy and complete the following table in the ANSWER BOOK.

COMPOUND	TWO COMPOUND ELEMENTS
Hydrochloric acid	
Table salt	
Sulphuric acid	
Limestone (Marble)	

(4)

8.3 Calculate the mass of silver deposited on a teaspoon when a current of 2 amperes flows through a silver nitrate solution for 1 hour during an electroplating process. (3)
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TOTAL: 100

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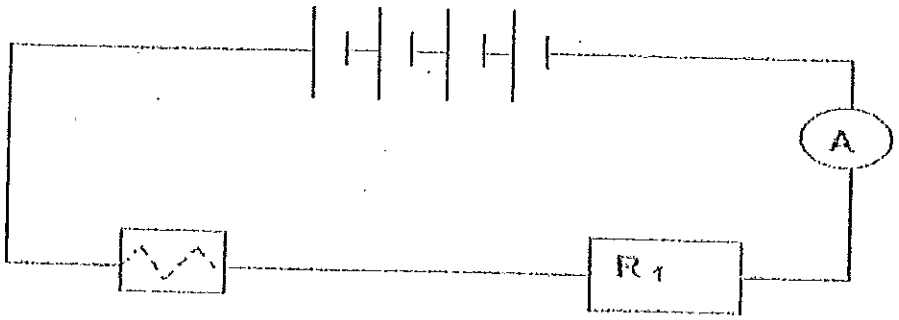

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NATURAL SCIENCE
MARKING GUIDELINES

April 2011

ENGINEERING SCIENCE N3
15070413

April 2011

INGENIEURSWETENSKAP N3

QUESTION 1

From $v = u + at$

1.1.1 $v = 10 - 2t$

$u = 10m/s$ √ (1)

1.1.2 From $v = u + at$

$v = 10 - 2t$

$a = -2\ m/s^2$ √ (1)

1.1.3 Initial Momentum $p = m \times u$ √

$p = 20 \times 10$

$p = 200\ kg.m/s$ √ (2)

1.1.4 Where $v = u + at$

$v = 10 - 2t$

$v = 2\ m/s$ √

$Ek = \frac{1}{2}mV^2$

$Ek = \frac{1}{2}(20)x(2)^2$

$Ek = 40\ J$ √√ (3)

1.1.5 $S = ut + \frac{1}{2}at^2$

$S = 10x3 + \frac{1}{2}(-2)x(3)^2$

$S = 21\ m$ √√ (2)

1.1.6 $S = ut + \frac{1}{2}at^2$ and

$v = u + at$

$v = 10 - 2t$ √

$S = 10t + \frac{1}{2}(-2)t^2$

$S = 10t - t^2$ √ (2)

1.2.1 $F = 2000$ N and diameter = 0,3 therefore the radius = 0,15

Torque $= F \times r$

$T = 2000 \times 0,15$

$T = 300\ N.m$ √√ (2)

1.2.2 $P = 2 \times \pi \times n \times T$

$P = 2 \times 3,142 \times 3 \times 300$

$P = 5\,655$ W or 5.655 kW √√ (2)

[15]

QUESTION 2

2.1 $\sum \uparrow\uparrow$ Forces = $\sum \downarrow\downarrow$ Forces √

Or

$\sum$ CW moments = $\sum$ ACW moments

The algebraic sum of moments about a turning point is equal to zero √ (2)

2.2.1 $\sum \uparrow\uparrow$ Forces = $\sum \downarrow\downarrow$ Forces √

$\underline{A} + \underline{D} = \underline{10} + \underline{30} + \underline{(5X6)}$ √√√

D = 70 – 32,222... (A = 32,222 kN given) √

D = 37,778 kN √ (3)

2.2.2 Take moments about 'D'

$\sum$ CW moments = $\sum$ ∫ACW moments √

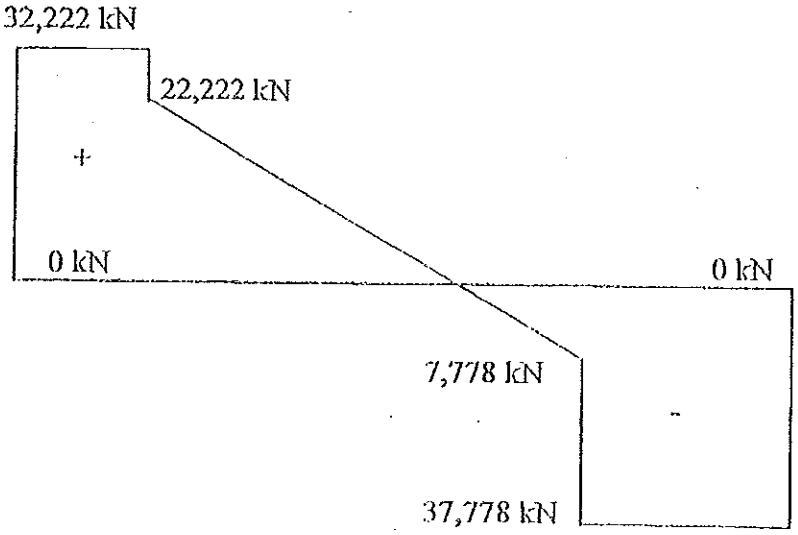
[32,222 x (X + 7)] = (30 x X) + [(30X(3+X) 1 + [10 x (6 + X)] √√√√

225,554 + 32,222X = 30X + (90+30X) + 60 + 10X √

75,554 = 37,778 X √

X = 2m √ (4)

2.2.3



(3)

[12]

QUESTION 3

3.1. The resultant of 2 or more forces (vectors) is that single force that can replace 2 or more forces in magnitude and direction and has the same effect. (1)

3.2.1 $\Sigma F_y = 30 - 70$ √
$= -40$ kN √
$\Sigma F_y = 40$ kN South/Suid √ (1½)

$\Sigma F_x = 20 - 50$ √
$= -30$ kN √
$\Sigma F_x = 30$ kN West/Wes √ (1½)

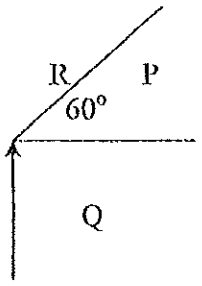
3.2.2 $R = \sqrt{(\Sigma F_y)^2 + (\Sigma F_x)^2}$
$R = \sqrt{(30)^2 + (40)^2}$
$R = 50$ kN √√ (2)

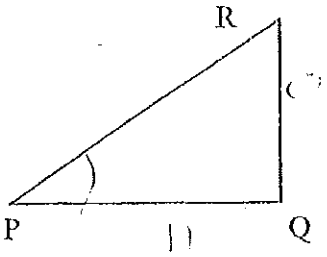
$\text{Tan } \emptyset = \frac{\Sigma F_y}{\Sigma F_x}$

$\text{Tan } \emptyset = \frac{40}{30}$
$\Theta = \tan^{-1}(1.333)$
$\Theta = 36{,}869^0$

Θ = West $36{,}869^\circ$ South √√ (2)

3.3





Vertical Components:

$\text{Sin } 60^\circ = 10\text{kN}/PR$
$PR = 11{,}547$ kN strut √√√ (3)

Horizontal components:

$PQ = PR \times \cos 60^\circ$
$= 11{,}547 \times \cos 60^\circ$
$PQ = 5{,}774$ kN tie √√√ (3)
[14]

QUESTION 4

4.1 Angle of friction is that angle between the resultant forces (which can replace the normal reaction force & the minimum friction force), and the normal reaction force (on a horizontal plane) (2)

4.2 $\mu \times (m \times g) = F\mu$ $(F\mu = F)$ √

$$\mu = \frac{F\mu}{W}$$

$$= \frac{500\ N}{(m \times g)} \quad √$$

$$= \frac{500\ N}{(100 \times 9,8)} \quad √$$

$\mu = 0,53$ √ (3)

4.3 $F \cos Ø = \mu [W \cos Ø + F \sin Ø] + W \sin Ø$ √

$F \cos 30^{o} = \mu [50 \times 9,8 \times \cos 20^{o} + F \sin 30^{o}] + 50 \times 9,8 \times \sin 20^{o}$

$0,866\ F = 0,4[460,449 + 0,5\ F] + 167,59$ √

$0,866\ F = 184,18 + 0,2\ F + 167,59$ √

$0,666\ F = 351,77$

$$F = \frac{351,77}{0,666} \quad √$$

$F = 528,183\ N$ √ (5)

[10]

QUESTION 5

5.1 When a metal is heated, its area will increase uniformly (1)

5.2 Efficiency (η) = Energy out/ Energy in x 100

Efficiency (η) = 210/(2 x 140) x 100

Efficiency (η) = 75% √√ (2)

5.3 $\Delta A = Ao \times \beta \times \Delta t$ .....($\beta = 2\alpha$)

$\Delta A = 75{,}2 \times (2 \times 17 \times 10^{-6}) \times (100 - (-5))$

$\Delta A = 0{,}268\ cm^2$ √√ (2)

5.4 5.4.1 Advantages:
Steam can be used repeatedly
Coal & water is reasonably cheap & readily available
A steam installation has a long life span
Water can be used repeatedly (1)

5.4.2 Disadvantages
Steam layout must be erected where water & coal is available
Water is lost due to evaporation
Initial installation cost is very high
Due to combustion ..... a lot of atmospheric polution (1)

5.5 $H = m \times (hf + x\ hfg)$

$= 3 \times (763 + (0{,}82 \times 2014)$ √

$= 3 \times (763 + 1651{,}48)$

$= 3 \times 2\,414{,}48$ √

$H = 7{,}243$ MJ √ (3)

5.6 $Q = m \times c \times \Delta t$

$\Delta t = \frac{Q}{m \times c}$ √

$\Delta t = \frac{5\,000 \times 10^3}{5 \times 2\,000}$ √

$\Delta t = 500\ ^\circ C$ √ (2)

[12]

QUESTION 6

6.1 Force exerted per unit area (1)

6.2.1 $P = \rho \times g \times h$

$P = 1000 \times 9,8 \times 50$

$P = 490\ 000$ Pa or 490 kPa √√ (2)

6.2.2 Volume = area x height

$V = a \times l$

$V = 28,27 \times 10^{-4} \times 88,42 \times 10^{-3}$

$V = 2,5 \times 10^{-4}$

But 1 m3 = 1000 liters therefore

Volume $= 2,5 \times 10^{-4} \times 1000$

Volume = 0,25 liter √√√ (3)

6.2.3 $P = \rho \times V/s$ or $P = F \times s$

$P = 490 \times 10^3 \times \frac{120}{60} \times 10^{-3}$ or $P = \frac{120}{60} \times 9,8 \times 50$

$P = 980$ W or $P = 980$ W √√ (2)

6.3.1 $\frac{f}{d^2} = \frac{F}{D^2}$

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

$$F = \frac{250 \times 9,8 \times (4)^2}{(1)^2}$$

$F = 4000$ N √√ (2)

6.3.2 Volume = area x length

$$\text{Area} = \frac{\text{Volume}}{\text{Length}} = \frac{35\,342{,}917}{50}$$

$A = 706{,}858\ mm^2$ √√ (2)

But the Area $= \frac{\pi d^2}{4}$

$$D = \sqrt{\frac{\text{area} \times 4}{\pi}}$$

$$D = \sqrt{\frac{706{,}858 \times 4}{\pi}}$$

$D = 30\ mm$ √√ (2)
[14]

QUESTION 7

7.1.1 $R_T = R_1 + R_2 + R_3 + R_4$ or $R_1 \times 4$

$R_T = 0,3 + 0,3 + 0,3 + 0,3$ or $0,3 \times 4$

$R_T = 1,2\ \Omega$ or $1,2\ \Omega$ √√ (2)

7.1.2 $EMF_T = EMF_1 + EMF_2 + EMF_3 + EMF_4$ or $EMF_1 \times 4$

$EMF_T = 2 + 2 + 2 + 2$ or 2×4

$EMF_T = 8\ V$ √

$R_{ext} = (EMF_T/I) - R_T$ √

$R_{ext} = (8/2) - 1,2$

$R_{ext} = 4 - 1,2$

$R_{ext} = 2,8\ \Omega$ √ (3)

7.1.3 $R_{ext} = R_{lamp} + R_1 + R_{amp}$

$R_{lamp} = R_{ext} - R_1 - R_{amp}$ √

$R_{lamp} = 2,8 - 0,5 - 0,1$

$R_{lamp} = 2,2\ \Omega$ √ (2)

7.1.4 $V = I \times R_{lamp}$ or $Q = I^2 \times R \times t$

$V = 2 \times 2,2$ √

$V = 4,4$ Volts √ (2)

7.1.5 $Q = V \times I \times t$ or $Q = I^2 \times R \times t$

$Q = 4,4 \times 2 \times (4 \times 60)$ or $Q = 2^2 \times 2,2 \times (4 \times 60)$

$Q = 2\ 112$ J or $Q = 2\ 112$ J

$Q = 2,112$ kJ √√ (2)

7.2.1 $\frac{V_1}{V_2} = \frac{I_s}{I_p}$

$I_s = \frac{220}{110} \times 2$ √

$I_s = 4$ A √ (2)

7.2.2 $\frac{V_1}{V_2} = \frac{N_1}{N_2}$

$I_s = \frac{220}{110} \times 100$ √

$I_s = 50$ turns √ (2)

[15]

QUESTION 8

8.1 Galvanizing
Electroplating
Painting
Oil or grease √ (1)

8.2

COMPOUND	COMPOSITION (2 OFF)
Hydrochloric acid	Hydrogen ; Chlorine (HCl) .
Table salt	Sodium; Chlorine (NaCl)
Sulphuric acid	Hydrogen; Sulphur; Oxygen (H_2SO_4)
Limestone (Marble)	Calcium; carbon; oxygen ($CaCO_3$)

2 X ½ MARKS FOR EACH (4)

8.3 $m = I \times z \times t$

$= 2 \times 1,118 \times (1 \times 60 \times 60)$

$= 8049,6$ mg

$= 8,0496$ gram (3)

[8]

TOTAL = 100