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This question paper consists of 10 pages, 1 information sheet and 1 formula sheet.
INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.

2. All calculations should consist of at least THREE steps:
   2.1 The formula used or manipulation thereof
   2.2 Substitution of the given data in the formula
   2.3 The answer with the correct SI unit

3. The constant values, as they appear on the attachment information sheet, must be used wherever possible.

4. Number the answers according to the numbering system used in this question paper.

5. Keep subsections of questions together.

6. Rule off on completion of each question.

7. Drawing instruments must be used for all drawings/diagrams. All drawings/diagrams must be fully labelled.

8. Use \( g = 9,8 \text{ m/s}^2 \).

9. Answers must be rounded off to THREE decimal places.

10. Write neatly and legibly.
QUESTION 1: MOVEMENT

1.1 A car travelling at 20 m.s\(^{-1}\) applies its brakes and stops after 50 m.

Determine the following:

1.1.1 The average acceleration
1.1.2 The time taken to stop \((2 \times 2)\) \((4)\)

1.2 A Bricklayer throws a brick upwards to a next level to a bricklayer who misses the catch. The brick falls to the ground after 6 seconds.

Calculate the following:

1.2.1 The height that the brick reaches \((3)\)
1.2.2 The total distance covered \((1)\)
1.2.3 The velocity at which the brick hits the ground \((1)\)

1.3 A motor vehicle with a mass of 2.5 tons accelerates uniformly from rest up an incline of 1 in 25 and reaches a speed of 55 km/h after 3 minutes.

Calculate the following:

1.3.1 The acceleration of the motor vehicle \((2)\)
1.3.2 The kinetic energy of the motor vehicle after 3 minutes \((2)\)
1.3.3 The gain in potential energy of the motor vehicle after 3 minutes \([16]\)
QUESTION 2: MOMENTS

2.1 State the definition of a force. (2)

2.2 A uniform beam is 18 m long and rests horizontally on two supports. The one support is at the left end and the other support is 4 m from the right end. The beam carries concentrated loads of 200 N and 100 N 5m and 10 m from the left end respectively. The beam also carries a uniformly distributed load of 15 N/m over the first 6 m from the right end.

2.2.1 Calculate the reactions at the supports and test your answers. (5)

2.2.2 Draw the shear force diagram to scale. (4)

![Figure 1](image1.png)

FIGURE 1

2.3 Calculate the turning moment about the fulcrum in FIGURE 2 below.

![Figure 2](image2.png)

FIGURE 2
QUESTION 3: FORCES

3.1 State the definition of equilibrant of forces. (2)

3.2 Solve analytically the magnitude and direction of the resultant in FIGURE 3 below.

3.3 Three forces shown in FIGURE 4 below are in equilibrium. Calculate the magnitude of the unknown forces analytically.
3.4 Calculate the nature and magnitude of forces with reference to the components AB and BC in the roof truss in FIGURE 5 below.

![FIGURE 5](image)

**QUESTION 4: FRICTION**

4.1 Distinguish between *static friction* and *kinetic friction*.

4.2 Name **TWO** applications of friction.

4.3 The weight of an object in FIGURE 6 below is 2 500 N. The object is placed on an inclined plane that forms an angle of 20° to the horizontal. The coefficient of friction is 0.4 for the surface.

![FIGURE 6](image)
Calculate the following:

4.3.1 The pushing force $P$ required to push the object upwards against the slope

4.3.2 The angle in degrees that the plane must be raised so that the body will slide down by itself

QUESTION 5: HEAT

5.1 Explain the law of conservation of energy.

5.2 45 steel shafts are cooled down in 5 litres of oil. The initial temperature of the shafts is 180 °C and that of the oil 20 °C. Each shaft has a mass of 750 grams.

Calculate the final temperature of the mixture. Use the shc of steel as 500 J/kg °C and that of oil 1,5 kJ/kg °C.

5.3 An overhead crane is used to carry a mould in a foundry workshop. The beam of the overhead crane has a length of 19 m at a temperature of 18 °C. After the moulding process the temperature of the beam of the overhead crane is expected to rise to 100 °C in the foundry.

Use the coefficient of linear expansion of the beam, which is $25 \times 10^{-6}$/°C.

Calculate the following:

5.3.1 The increase in temperature of the beam

5.3.2 The expected expansion of the beam in mm

5.3.3 The expected final length of the beam in metres
FIGURE 7 above shows a water-to-steam process.

Complete the process in FIGURE 7 by filling in the missing descriptions and symbols. Write only the description and the symbol next to the question number (5.4.1–5.4.4) in the ANSWER BOOK.

QUESTION 6: HYDRAULICS

6.1 Explain the following terminology in hydraulics:

6.1.1 Hydraulics

6.1.2 Hydrostatics

6.1.3 Fluidity

6.2 A single-action water pump with a piston diameter of 120 mm has to deliver $1.4 \times 10^{-3}$ m$^3$ water per stroke. The average force exerted on the piston is 2.4 kN per working stroke.

Calculate the following:

6.2.1 The pressure of the fluid during the working stroke

6.2.2 The length of the stroke

6.2.3 The work done per stroke length
QUESTION 7: ELECTRICITY

7.1 Explain the concept power factor, and distinguish between a high power factor and a low power factor. (2)

7.2 An electrical circuit as shown in FIGURE 8 below consists of 4 cells connecting in series, each having an EMF of 4 volts and a internal resistance of 0.15 ohms per cell, connected in series.

Calculate the following:

7.2.1 The total resistance of the circuit
7.2.2 The voltage across AB (2 × 3) (6)

7.3 A single-phase transformer has a supply voltage of 220 V. The turn ratio of the primary to the secondary is 12 : 1. The secondary current at full load is 20 A and the secondary coil has 50 windings.

Calculate the following:

7.3.1 The secondary voltage
7.3.2 The primary current (2 × 2) (4) [12]
QUESTION 8: CHEMISTRY

8.1 Name TWO precautions to keep moisture and water away from metals which can corrode. (2)

8.2 Name the chemical composition of the following compounds:

8.2.1 Limestone (marble) (2 x 1) (2)
8.2.2 Caustic soda

8.3 Name a non-metal that is a good conductor of electricity. (1)

8.4 Name ONE property of solder. (1)

TOTAL: 100
FORMULA SHEET

ENGINEERING SCIENCE N3

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

\[ W = F_s \]
\[ P = \frac{W}{t} \]
\[ \eta = \frac{U \text{itset} / \text{Output}}{U \text{nset} / \text{Input}} \]
\[ F = m.a \]
\[ \mu = \frac{F}{N_R} \]
\[ \mu = \tan \theta \]
\[ N_R = F_c \pm F_t \sin \alpha \ldots \alpha = 0 \]
\[ F_s = w \sin \theta \]
\[ F_c = w \cos \theta \]
\[ F_t \cos \alpha = F_\mu \pm F_s \ldots \ldots \alpha = 0 \]
\[ F_e = T_1 - T_2 \]
\[ T_1 \quad T_2 = \text{tension ratio} \]
\[ P = F_e \cdot v \]
\[ v = \pi \cdot d \cdot n \ldots \ldots n = \frac{N}{60} \]
\[ W_\mu = F_\mu \cdot s \]
\[ \Delta E_p = m \cdot g \cdot \Delta h \]
\[ \Delta E_k = \frac{1}{2} m v^2 \]
\[ Q = I^2 \cdot R \cdot t \]
\[ m = I \cdot z \cdot t \]
\[ V_P = N_P \quad N_S = I_S \quad I_P \]
\[ V = u + a \cdot t \]
\[ M = F \cdot \perp \quad s \]
\[ P_{\text{ABS}} = P_{\text{ATM}} + P_{\text{MET}} \]
\[ \frac{1}{R_{\text{PAR}}} = \frac{1}{R_2} + \ldots + \frac{1}{R_n} \]
\[ V_1 - V_2 = e(U_1 - U_2) \]
\[ m_1 u_1 \pm m_2 u_2 = m_1 v_1 \pm m_2 v_2 \]
\[ D_e = (D + t) \]
\[ h_{\text{nat/wet}} = h_f + x h_{fr} \]
\[ P = 2 \cdot \pi \cdot T \cdot n \ldots \ldots T = F \cdot r \]
\[ P = \frac{F_{\text{RAM}}}{A_{\text{RAM}}} = \frac{F_{\text{PL}}}{A_{\text{PL}}} \ldots A = \frac{\pi D^2}{4} \]
\[ V_{\text{RAM}} = V_{PL} \times n \]
\[ A_{\text{RAM}} \cdot H_{\text{RAM}} = A_{PL} \cdot L_{PL} \]
\[ F_x = F \cos \theta \]
\[ F_y = F \sin \theta \]
\[ \sum F_x = F_1 \cos \theta_1 + \ldots + F_n \cos \theta_n \]
\[ \sum F_y = F_1 \sin \theta_1 + \ldots + F_n \sin \theta_n \]
\[ R = \sqrt{\sum F_x^2 + \sum F_y^2} \]
\[ \tan \Phi = \frac{\sum F_y}{\sum F_x} \]
\[ Q = m \cdot c \cdot \Delta t \ldots \ldots \tau_f = to \pm \Delta t \]
\[ m \cdot w \cdot w = Q = m \cdot hv \]
\[ P = \frac{Q}{t} \]
\[ \Delta L = L_0 \cdot \alpha \cdot \Delta t \ldots \ldots L_f = L_0 \pm \Delta L \]
\[ \Delta A = A_0 \cdot \beta \cdot \Delta t \ldots \ldots A_f = A_0 \pm \Delta A \]
\[ 2 \cdot a \cdot s = v^2 - u^2 \]
\[ s = u \cdot t + \frac{1}{2} \cdot a \cdot t^2 \]
\[ \sum \uparrow F = \sum \downarrow F \]
\[ \sum \text{CWM} = \sum \text{ACWM} \]
\[ P = \delta \times g \times h \]
\[ R_{\text{SER}} = R_1 + \ldots + R_n \]
\[ V = I \times R \]
<table>
<thead>
<tr>
<th>QUANTITY</th>
<th>CONSTANTS HOEVEELHEID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric pressure</td>
<td>101,3 kPa</td>
</tr>
<tr>
<td>Density of copper</td>
<td>8 900 kg/m$^3$</td>
</tr>
<tr>
<td>Density of aluminium</td>
<td>2 770 kg/m$^3$</td>
</tr>
<tr>
<td>Density of gold</td>
<td>19 000 kg/m$^3$</td>
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<tr>
<td>Density of alcohol (ethyl)</td>
<td>790 kg/m$^3$</td>
</tr>
<tr>
<td>Density of mercury</td>
<td>13 600 kg/m$^3$</td>
</tr>
<tr>
<td>Density of platinum</td>
<td>21 500 kg/m$^3$</td>
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<td>Density of water</td>
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<td>Density of mineral oil</td>
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<td>Density of air</td>
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<td>Electrochemical equivalent of</td>
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<td>silver</td>
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<tr>
<td>Electrochemical equivalent of</td>
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<tr>
<td>copper</td>
<td></td>
</tr>
<tr>
<td>Gravitational acceleration</td>
<td>9,8 m/s$^2$</td>
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<td>Heat value of coal</td>
<td>30 MJ/kg</td>
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<td>Heat value of anthracite</td>
<td>35 MJ/kg</td>
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<td>45 MJ/kg</td>
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<td>Heat value of hydrogen</td>
<td>140 MJ/kg</td>
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<td>Linear coefficient of expansion of copper</td>
<td>17 x 10$^{-5}$/C</td>
</tr>
<tr>
<td>Linear coefficient of expansion of aluminium</td>
<td>23 x 10$^{-5}$/C</td>
</tr>
<tr>
<td>Linear coefficient of expansion of steel</td>
<td>12 x 10$^{-5}$/C</td>
</tr>
<tr>
<td>Linear coefficient of expansion of lead</td>
<td>54 x 10$^{-5}$/C</td>
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<td>Specific heat capacity of steam</td>
<td>2 100 J/kg.$^\circ$C</td>
</tr>
<tr>
<td>Specific heat capacity of water</td>
<td>4 187 J/kg.$^\circ$C</td>
</tr>
<tr>
<td>Specific heat capacity of aluminium</td>
<td>900 J/kg.$^\circ$C</td>
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<tr>
<td>Specific heat capacity of oil</td>
<td>2 000 J/kg.$^\circ$C</td>
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<tr>
<td>Specific heat capacity of steel</td>
<td>500 J/kg.$^\circ$C</td>
</tr>
<tr>
<td>Specific heat capacity of copper</td>
<td>390 J/kg.$^\circ$C</td>
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</table>
MARKING GUIDELINE

NATIONAL CERTIFICATE
APRIL EXAMINATION
ENGINEERING SCIENCE N3

30 MARCH 2016

This marking guideline consists of 11 pages.
NOTE: ALTERNATE CORRECT ANSWERS MUST BE CONSIDERED.

QUESTION 1: MOVEMENT

1.1 1.1.1 \( V^2 = u^2 + 2as \)
\[
a = \frac{v^2 - u^2}{2s}
\]
\[
a = \frac{(0)^2 - (20)^2}{2(50)}
\]
\[
= -4 \text{ m/s}^2
\]
✓ Correct substitution
✓ Negative answer only (2)

1.1.2 \( v = u + at \)
\[
t = \frac{v - u}{a}
\]
\[
t = \frac{(0) - (20)}{-4}
\]
\[
= 5 \text{ s}
\]
✓ Correct answer (2)

1.2 1.2.1 \( g = -9.8 \text{ m/s}^2 \)
\[
v = u + gt
\]
\[
u = v - gt
\]
\[
= (0) - (-9.8)(3)
\]
\[
= 29.4 \text{ m/s}
\]
✓ u value
\[
s = \frac{v^2 - u^2}{2gt}
\]
\[
= \frac{(0)^2 - (29.4)^2}{-9.8(2)}
\]
\[
= 44.1 \text{ m}
\]
✓ Substitution
✓ Correct answer (3)

1.2.2 \( s = 44.1 \times 2 \)
\[
= 88.2 \text{ m}
\]
✓ Correct answer (1)

1.2.3 \( u = v = 29.4 \text{ m/s} \)
✓ Correct answer (1)
1.3

\[ v = 55 \text{ km/h} \quad \frac{55 \times 1000}{3600} = 12.278 \text{ m/s} \]

\[ t = 3 \text{ min} \times 60 = 180 \text{ s} \]

\[ u = 0 \text{ m/s} \]

\[ m = 2.5 \times 1000 = 2500 \text{ kg} \]

1.3.1

\[ a = \frac{v - u}{t} \]

\[ a = \frac{15.277 - 0}{180} \]

\[ a = 0.085 \text{ m/s} \]

(✓) substitution

(✓) Correct answer \( (2) \)

1.3.2

\[ E_K = \frac{1}{2} mv^2 \]

\[ E_K = \frac{1}{2} (2500)(15.277)^2 \]

\[ E_K = 291733411 \text{ J} \]

(✓) substitution

(✓) Correct answer \( (2) \)

1.3.3

\[ S377m \]

\[ S = ut + \frac{1}{2} at^2 \]

\[ = (0)(180) + \frac{1}{2}(0.085)(180)^2 \]

\[ = 1377 \text{ m} \]

\[ E_p = mgh \]

\[ = 2500(9.8)(1377/25) \]

\[ = 1349460 \text{ J} \]

(✓) Substitution

(✓) Correct answer \( (3) \)

\[
\begin{align*}
\text{h} & \\
1 \text{ to 25} & \\
2.5 \text{ tons} & \\
\end{align*}
\]
QUESTION 2: MOMENTS

2.1 A force is that influence which changes or tends to change the state of rest of a body. (✓) If the body is already moving, a force is that influence which brings the body to rest or changes the direction of the body. (✓) (2)

2.2 2.21 Taking moments about L:

\[ \Sigma \text{Anti-clockwise Moments} = \Sigma \text{Clockwise Moments} \]

\[ (R \times 14) = (200 \times 5) + (90 \times 15) + (100 \times 10) \]

\[ E = 239,286 \text{ N} (✓) \] (2)

Taking moment about R:

\[ \Sigma \text{Anti-clockwise moments} = \Sigma \text{Clockwise Moments} \]

\[ (100 \times 4) + (200 \times 9) = (L \times 14) + (90 \times 1) \]

\[ L = 150,714 \text{ N} (✓) \] (2)

Test:

Upward forces = Downward forces

\[ 239,286 + 150,714 \text{ kN} = 390 \text{ kN} \] (✓) (1)

2.2.2

2.3 \[ \cos \theta \times F \times 5 \text{ m} = 1.2 \times 120 + 200 \times 3.1 \text{ m} \]

\[ \cos 30 \times F \times 5 = 144 + 620 \] (✓)

\[ F = \frac{764}{\cos 30 \times 5} \]

\[ F = 176,443 \text{ N} (✓) \] (2) [13]
**QUESTION 3: FORCES**

3.1 The equilibrant of a system of forces in the same plane( ✓) is that single force which will balance the system of forces. (✓)

3.2 HC = -150 + 216.506 + 141.421 = 207.927 N ✓
VC = 300 + 125 – 141.42 = 283.579 N ✓

\[ R = \sqrt{(207.927)^2 + (283.579)^2} \]
\[ = \sqrt{123650.686} \]
\[ = 351.64 \text{ N ✓} \]

Tan \( \theta \) = \frac{283.579}{207.927}
\[ = 1.36 \]

\( \Theta \) = Tan \(^{-1}\) 1.36
\[ = 53.67^0 \]
\[ = E \ 53.67^0 \text{ N ✓} \]

3.3

\[ \begin{align*}
\text{P} & \quad \text{Psin}35^0 \\
\text{PCos}35^u & \\
\text{QCos}40 & \\
\text{Q} & \quad \text{QSin}40^u \\
\end{align*} \]

560 N
\[ V_c = \sum \downarrow F = \sum \uparrow F \]
\[ P \sin 35 = Q \sin 40 \]
\[ P = \frac{Q \sin 40}{\sin 35} \]
\[ P = 1,1207 Q \] \hspace{1cm} (1) \hspace{1cm} (✓) Equation (1)

\[ \sum H \quad P \cos 35 + Q \sin 40 = 560 \]
\[ (1,1207Q) \cos 35 + Q \sin 40 = 560 \]
\[ 0,918Q + 0,766Q = 560 \]
\[ Q = \frac{560}{1,684} \]
\[ Q = 332,537 N \] \hspace{1cm} (✓) Value of Q

\[ P = \frac{295,82 \sin 40}{\sin 35} \]
\[ = 372,663 N \] \hspace{1cm} (✓) Value of P \hspace{1cm} (5)

3.4

\[ A \]
\[ \downarrow 60^\circ \]
\[ 350 N \]
\[ B \]
\[ \uparrow 60^\circ \]
\[ \text{ABCos}60^\circ \]
\[ \text{ABSin}60^\circ \]
\[ \sum \downarrow F = \sum \uparrow F \]

\[ AB \sin 60^0 = 350 \] \hspace{1cm} (✓) Equation

\[ AB = \frac{350}{\sin 60^0} \]
\[ = 404.145 \text{kN} \] \hspace{1cm} (✓) AB Value

\[ \sum \leftarrow F = \sum \rightarrow F \]

\[ AB \cos 60^0 = BC \]
\[ 404.145 \cos 60^0 = BC \]
\[ BC = 202.225 \text{kN} \] \hspace{1cm} (✓) BC Value

<table>
<thead>
<tr>
<th>Member</th>
<th>Magnitude</th>
<th>Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>404,145</td>
<td>Strut</td>
</tr>
<tr>
<td>BC</td>
<td>202,07</td>
<td>Tie</td>
</tr>
</tbody>
</table>

(✓) Nature

\[ \text{Strut} \hspace{1cm} \]

\[ \text{Tie} \hspace{1cm} \]

(4)

(15)

QUESTION 4: FRICTION

4.1 Static friction opposes the initial movement. The force required to just move a body is called the static friction force. (✓)

Kinetic friction opposes the force causing the movement after the body is in motion. (✓) (2)

4.2
- Braking pads of vehicles, trains, lifts and aircraft
- Clutch engagement to transmit torque or power
- Drilling, cutting, turning made possible by friction between cutting surface and material. (✓) (Any 2 × 1) (2)

4.3

\[ \begin{array}{c}
\text{P} \\
30^0 \\
20^0
\end{array} \]

FIGURE 6
4.3.1 \[ F_{\text{applied}} = F\mu + W \times \sin\alpha \]

\[ P \times \cos\theta = \mu(W \times \cos\alpha + P \times \sin\alpha) + W \times \sin\alpha \quad (\checkmark) \]

\[ P \times \cos(30^\circ) = 0,4(2500 \times \cos20^\circ + P \times \sin30^\circ) + 2500 \times \sin20^\circ \]

\[ P \times 0,866 = 0,4(2500 \times 0,9397 - P \times 0,5) + 855,05 \quad (\checkmark) \]

\[ P \times 0,866 = 939,7 - 0,2 \times P + 855,05 \quad (\checkmark) \]

\[ P \times 0,866 \times 2 \times P = 939,7 + 8379,494 \quad (\checkmark) \]

\[ 0,666 \times P = 939,7 + 8379,494 \quad (\checkmark) \]

\[ P = 2694,82 \text{ N} \quad (\checkmark) \]  

4.3.2 \[ \tan \theta = \mu \]

\[ \mu = \tan^{-1} 0,4 \]

\[ = 21,8^\circ \quad \checkmark \]  

\[ \text{QUESTION 5: HEAT} \]

5.1 Energy cannot be created or destroyed(\checkmark) therefore heat gained is equal to heat lost by an object.\( (\checkmark) \]

5.2 \[ m = 45 \times 0,75 = 33,75 \]

\[ t_1 = 180^\circ C \]

\[ \text{shc}_{\text{steel}} = 500 \text{ J/kg} \cdot ^\circ C \]

\[ m_{\text{oil}} = 1500 \text{ J/kg} \cdot ^\circ C \]

\[ t_2 = 20^\circ C \]

Heat lost by steel = Heat gained by oil

\[ m \times \text{shc} \times (T_2 - T_1) = m \times \text{shc} \times (T_3 - T_2) \quad (\checkmark) \]

\[ 45 \times 0,75 \text{ kg} \times 500 \text{ J/kg} \cdot ^\circ C \times (180 - T_2) = 5 \text{ kg} \times 1500 \text{ J/kg} \cdot ^\circ C \times (T_2 - 20) \]

\[ 16875 \times (180 - T_2) = 7500 \times (T_2 - 20) \quad (\checkmark) \]

\[ 3037500 - 16875 \times T_2 = 7500 \times T_2 - 1500000 \]

\[ 7500 \times T_2 + 16875 \times T_2 = 3037500 + 1500000 \quad (\checkmark) \]

\[ 24375T_2 = 3187500 \]

\[ T_2 = 130,769^\circ C \quad (\checkmark) \]

5.3 \[ l = 19 \text{ m} \]

\[ t_1 = 18^\circ C \]

\[ t_2 = 100^\circ C \]

\[ \alpha = 25 \times 10^{-6} /^\circ C \]
5.3.1 \[ \Delta t = 100 - 18 \quad (\checkmark) \]
\[ = 82 \, ^\circ C \quad (1) \]

5.3.2 \[ \Delta l = t_0 \times \alpha \times \Delta t \]
\[ \Delta l = 19 \times 25 \times 10^6 \times 82 \quad (\checkmark) \]
\[ \Delta l = 0,03895 \, m \, \text{or} \, 38,95 \, mm \quad (\checkmark) \quad (2) \]

5.3.3 \[ L_F = \Delta l + t_0 \]
\[ L_F = 0,03895 + 19 \quad (\checkmark) \]
\[ L_F = 19,03895 \, m \quad (\checkmark) \quad (2) \]

5.4
5.4.1 \( h_l \) = liquid enthalpy
5.4.2 \( h_{fg} \) = enthalpy of evaporation
5.4.3 \( h_g \) = enthalpy of dry steam
5.4.4 \( h_{su} \) = enthalpy of superheated steam

\[ (4 \times 1) \quad (4) \quad [15] \]

**QUESTION 6: HYDRAULICS**

6.1
6.1.1 Hydraulics refers to the pressure(\( \checkmark \)) and work done of fluids.(\( \checkmark \)) \( (2) \)

6.1.2 Hydrostatics refers to fluids that are at rest. \( (1) \)

6.1.3 Fluidity is a fluid or a gas which has no form(\( \checkmark \)) but takes up the form of a vessel in which it is captured.(\( \checkmark \)) \( (2) \)

6.2
6.2.1 \[ \text{Volume} = 1,4 \times 10^{-3} \, m^3 \]
\[ F = 2,4 \, kN \]
\[ A = \pi (0,06)^2 \quad \text{or} \quad A = \pi d^2 \quad \frac{4}{4} \quad (\checkmark) \quad \text{Area} \]
\[ P_r = \frac{F}{A} \quad (\checkmark) \quad \text{Substitution} \]
\[ = \frac{2 \, 400}{0,0113} \]
\[ = 212,2 \, kPa \quad (\checkmark) \quad \text{Answer} \quad (3) \]
6.2.2

\[ \text{Stroke length} = \frac{\text{Volume}}{\text{Area}} \]
\[ = \frac{1.4 \times 10^{-3} m^3}{0.0113 m^2} \quad (\checkmark) \text{Substitution} \]
\[ = 0.1238 \text{ m or } 123.8 \text{ mm} \quad (\checkmark) \text{Answer} \quad (2) \]

6.2.3

\[ WD = P \times v \]
\[ = 212 \cdot 200 \times 1.4 \times 10^{-3} \]
\[ = 297 \text{ J/stroke} \quad (2) \]

**QUESTION 7: ELECTRICITY**

7.1

Power factor \((\cos \alpha)\) is the ratio of actual power or watts to volt amps. \((\checkmark)\)
The smaller the phase angle the higher the efficiency and vice versa. \((\checkmark)\) \quad (2)

7.2

7.2.1

\[ R_P = \frac{R_1 + R_2 + R_3}{R_1R_2 + R_1R_3 + R_2R_3} \]
\[ = \frac{8 \times 5 \times 5}{8 \times 5 + 8 \times 5 + 5 \times 5} \quad (\checkmark) \text{Substitution} \]
\[ = \frac{200}{105} \quad (\checkmark) \quad R_P = 1.905 \Omega \]
\[ = 1.905 \Omega \quad (\checkmark) \quad R_T = 9.505 \Omega \]
\[ R_t = 1.905 + 0.6 + 0.5 + 4.5 + 2 \]
\[ = 9.505 \Omega \quad (3) \]

7.2.2

\[ \text{Emf} = 4 \times 4 = 16 \text{ V} \]
\[ \text{Rt} = 4 \times 0.5 = 0.6 \text{ \Omega} \]

\[ I = \frac{E}{R + r} \]
\[ = \frac{16}{9.505 + 0.6} \quad (\checkmark) \text{Substitution} \]
\[ = 1.583 \text{ A} \quad (\checkmark) \text{Current} \]

\[ V = IR \]
\[ = 1.583 \times 2 \]
\[ = 3.166 \text{ V} \quad (3) \]
7.3  7.3.1
\[
\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_S}{I_p}
\]
\[
V_s = \frac{N_s V_p}{N_p} = \frac{50 \times 220}{600} \times \frac{1 \times 220}{12} = 18.33 \text{ V}
\]
(\checkmark) Substitution  
(\checkmark) Solution  
\[(2)\]

7.3.2
\[
I_p = \frac{N_s \times I_S}{N_p} = \frac{V_s \times I_S}{V_p} = \frac{50 \times 20}{600} \times \frac{18.33 \times 20}{220} = 1.667 \text{ A}
\]
(\checkmark) Substitution  
(\checkmark) Solution  
\[(2)\]

QUESTION 8: CHEMISTRY

8.1  
- By painting the metal  
- By applying oil or grease  
- By electroplating with zinc or tin  
- By galvanising  
- By using plastic film  
(Any 2 × 1)  
\[(2)\]

8.2  8.2.1  Limestone (Marble) = \(\text{CaCO}_3\)

8.2.2  Caustic soda = \(\text{NaOH}\)  
\[(2 \times 1)\]  
\[(2)\]

8.3  Carbon  
\[(1)\]

8.4  
- Low melting point  
- Soft  
- Good adhesion to other metals  
(Any 1 × 1)  
\[(1)\]

TOTAL: 100
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