higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N2

(15070402)

8 April 2021 (X-paper)
09:00–12:00

Candidates must use drawing instruments.

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

084Q1A2108

Copyright reserved

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N2
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. Each calculation must consist of at least the following THREE steps:
   (a) The formula used or the manipulation thereof
   (b) The substitution of the given data in the formula
   (c) The answer together with the correct SI-unit
5. Use the following values whenever applicable:

Gravitational acceleration	$= 9{,}8\ m/s^2$
Atmospheric pressure	$= 101{,}3\ kPa$
Heat value of petrol	$= 25\ MJ/kg$
Heat value of coal	$= 30\ MJ/kg$
Density of water	$= 1\,000\ kg/m^3$
Specific heat capacity of water	$= 4\,187\ J/kg$ ℃
Specific heat capacity of steam	$= 2\,100\ J/kg$ ℃
Specific heat capacity of steel	$= 500\ J/kg$ ℃
Specific heat capacity of copper	$= 390\ J/kg$ ℃
Specific heat capacity of aluminium	$= 900\ J/kg$ ℃
Linear coefficient of expansion of steel	$= 0,000\,012$ / ℃
Linear coefficient of expansion of copper	$= 0,000\,017$ / ℃
Linear coefficient of expansion of aluminium	$= 0,000\,023$ / ℃
Resistivity of steel at 20 ℃	$= 0,000\,000\,155\ \Omega\, m$
Resistivity of copper at 20 ℃	$= 0,000\,000\,018\ \Omega\, m$
Resistivity of aluminium at 20 ℃	$= 0,000\,000\,028\ \Omega\, m$

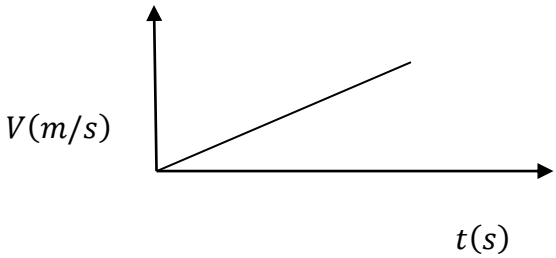
6. Rule off on completion of each question.
7. Keep subsections of questions together.
8. Write neatly and legibly.

Copyright reserved

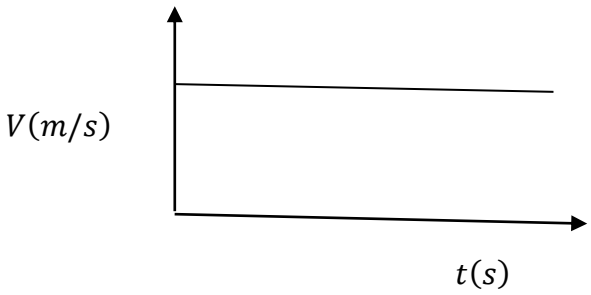
QUESTION 1: DYNAMICS

1.1 Describe the motion of a body depicted by the graphs below in terms of velocity and acceleration.

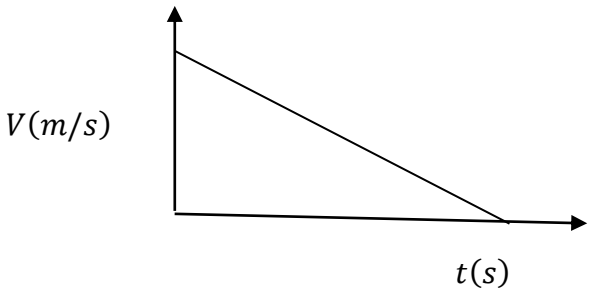
1.1.1



1.1.2



1.1.3



(3 × 2) (6)

1.2 A tennis player throws a tennis ball up as he is about to serve. The ball took $5\ s$ to come back to the same position from which it was thrown:

1.2.1 Calculate the velocity with which the ball leaves the player's hand. (3)

1.2.2 Calculate the maximum height reached by the tennis ball from the player's hand. (2)

1.3 An athlete preparing for her race was jogging at a velocity of 5 m/s. She noticed a barking dog in front of her and she decided to stop. It took her $\mathbf{10}\ \boldsymbol{s}$ to come to a standstill.

1.3.1 Calculate the athlete's acceleration as she noticed the dog.

1.3.2 Calculate the accompanying displacement covered by the athlete.

(2 × 2) (4)

[15]

Copyright reserved

QUESTION 2: STATICS

2.1 The resultant vector is represented by two aspects in a parallelogram. One aspect is the magnitude of the diagonal.

Name the other aspect. (1)

2.2 State the law of moments. (2)

2.3 A force of 30 N is placed 200 mm from the fulcrum to the left.
A second force of 10 N is placed at the right end from the fulcrum.
A third force of 15 N is placed 0,1 m from the right end.

Calculate the distance between the fulcrum and the force of 15 N. (4)

2.4 A couple is formed by two 12 N forces applied at 30° from the vertical. The distance between the forces from the point of application is 800 mm.

Calculate the moment of the couple. (3)
[10]

QUESTION 3: ENERGY AND MOMENTUM

3.1 Name the TWO factors that the kinetic energy of the body or an object depends on. (2)

3.2 A ball with a mass of 10 kg is rolling down a frictionless incline of 20°. The distance from the top to the bottom of the incline is 5 m.

3.2.1 Calculate the potential energy of the ball at the top of the incline. (3)

3.2.2 Calculate the velocity of the ball at the bottom of the incline. (3)
[8]

QUESTION 4: WORK, POWER AND EFFICIENCY

4.1 Define *power*. (1)

4.2 A man is pushing a trolley with an applied force of 500 N and the trolley is moving with a velocity of 10 m/s.

Calculate the power required to maintain the movement of the trolley. (2)

4.3 A crane is hoisting a load of 50 kg onto a platform which is 15 m high. It requires an input energy of 8 050 J

Calculate the efficiency of the crane. (4)

4.4 The wheel of a car has a diameter of 800 mm. A force of 1 600 N is applied at the circumference whilst the wheel is turning at 40 r/pm.

Calculate the work rate in turning the wheel. (3)
[10]

Copyright reserved

QUESTION 5: MECHANICAL DRIVES AND LIFTING MACHINES

5.1 Indicate whether the following statements are TRUE or FALSE by writing only 'True' or 'False' and your motivation next to the question number (5.1.1–5.1.2) in the ANSWER BOOK.

5.1.1 Gears are used to transfer a turning movement with a slip.

5.1.2 The velocity ratio of a gear system is the ratio between the rotational frequency and the mechanical advantage.

(2 × 1) (2)

5.2 Driver gear A on the shaft of an electric motor drives gear B.
Gear B is coupled with gear C on the same shaft, which drives gear D.

Gear A: 45 T
Rotational frequency of A: 75 r/min
Gear B: 144 T
Gear C: 72 T
Gear D: 60 T

Calculate the following:

5.2.1 The unknown rotational frequency of gear B

5.2.2 The rotational frequency of gear D

5.2.3 The velocity ratio of the system

(3 × 2) (6)

5.3 State THREE methods in which belt drives are applied. (3)

5.4 A differential winch lifting device has an effort distance of 600 mm.
An effort of 25 N and a load of 60 N are applied.
d_1 = 200 mm and d_2 = 80 mm

Calculate the following:

5.4.1 The velocity ratio of the device

5.4.2 The mechanical advantage of the device

5.4.3 The efficiency of the device

(3 × 2) (6)
[17]

Copyright reserved

QUESTION 6: FRICTION

A body with a mass of 40 kg is placed on an inclined plane at an angle of 25° with the horizontal. The coefficient of friction between the body and the plane is 0,2.

Calculate the following:

6.1 The weight component perpendicular to the incline

6.2 The weight component parallel to the incline

6.3 The frictional force

6.4 The minimum force required to pull the body up the incline

(4 × 2) **[8]**

QUESTION 7: HEAT

7.1 Define *heat value*. (2)

7.2 A mass of 5 kg of coal is used to heat a container with 80 kg water from 30 °C to 70 °C.

Calculate the following:

7.2.1 The energy released by the coal (2)

7.2.2 The heat gained by the water (3)

7.2.3 The efficiency of the heating system (2)

7.3 The gauge pressure at the bottom of a water tank is 60,4 kPa.

Determine the height of the water in the tank. (2)
[11]

QUESTION 8: PARTICLE STRUCTURE OF MATTER

8.1 Name the TWO kinds of particles found in the nucleus and their charges. (4)

8.2 Define *valence electron*. (1)

8.3 Give THREE examples of electrolytes. (3)
[8]

Copyright reserved

QUESTION 9: ELECTRICITY

9.1 State Ohm's law. (2)

9.2 An electric conductor with a length of 2 km has a diameter of 4 mm and a resistivity of 3.1x 10^{-8}Ωm.

Calculate the resistance of the conductor. (4)

9.3 A simple DC circuit with a supply voltage of 24 V is connected to two parallel resistors R_1 and R_2 with a resistance of 3 Ω and 4 Ω respectively. The two resistors are connected in series with a third resistor R_3 with a resistance of 5Ω.

Calculate the following:

9.3.1 The total current flowing through the circuit (4)

9.3.2 The current flowing through the 4 Ω resistor (3)

[13]

TOTAL: 100

Copyright reserved

FORMULA SHEET

Any applicable formula may be used.

W =m . g

W = F . s

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

$\eta = \frac{Output}{input} . 100\%$

$\eta = \frac{Uitset}{Inset} . 100\%$

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

$\mu = \tan \phi$

$F_T = F_\mu \ldots \begin{matrix} horizontal \\ horisontaal \end{matrix} \ldots a = o$

$F_S = w \sin \theta$

$F_C = w \cos \theta$

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

$F_e = T_1 - T_2$

$\frac{T_1}{T_2} = \begin{matrix} tension\ ratio \\ spanningsverhouding \end{matrix}$

$P = F_e . v$

$v = \pi . d . n$

$n = \frac{N}{60}$

$N_A . T_A = N_B . T_B$

$SV = \frac{N_A}{N_Z} = VR$

$E_P = m . g . h$

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

$E_T = E_p + E_k$

$HV = \frac{L}{E} = MA$

$VV \frac{S_E}{S_L} = DR$

$\frac{HV}{VV} . 100\% = \eta = \frac{MA}{DR} . 100\%$

$VV = \frac{2D}{(d_1 - d_2)} = DR$

$VV = \frac{2D}{(D - d)} = DR$

$Q = m . c . \Delta t$

$m . ww = Q = m . h_v$

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

$\Delta l = l_o . \alpha . \Delta t$

$l_f = l_o \pm \Delta l$

$1\ m/s = 3{,}6\ km/h$

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

$v = u + at$

$v^2 = u^2 + 2as$

$\sum \uparrow F = \sum \downarrow F$

$\sum \curvearrowleft M = \sum \curvearrowright M$

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

$P = pgh$

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$

$R_s = R_1 + R_2 + \cdots + R_n$

$R = \frac{p . l}{a}$

Copyright reserved