higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N2

(15070402)

23 August 2021 (X-paper)
09:00–12:00

Candidates may use drawing instruments and nonprogrammable calculators.

This question paper consists of 6 pages and 1 formula sheet.

090Q1G2129

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. All calculations should consist of at least the following THREE steps:

   - Formula used or manipulation thereof
   - Substitution of given data in formula
   - Answer with correct SI unit

5. Use the following values where 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 expansion of steel	=	$0,000\,012$ / ℃
Linear coefficient 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. Drawing instruments must be used for all drawings.

8. Subsections of questions must be kept together.

9. Work neatly.

QUESTION 1: DYNAMICS

1.1 Define each of the following terms:

1.1.1 Displacement

1.1.2 Acceleration

(2 × 1) (2)

1.2 A motorbike is travelling at a constant velocity of 30 m/s for 15 s and accelerates for 10 s reaching a velocity of 50 m/s.

1.2.1 Draw the velocity/time graph of the motorbike speed over the total time taken. (5)

1.2.2 Calculate the acceleration of the motorbike. (2)

1.2.3 Calculate the displacement of the motorbike for the duration of the observation. (4)

1.2.4 Calculate the average velocity of the motorbike. (2)

[15]

QUESTION 2: STATICS

A horizontal beam resting on two supports L and R which are 7 m apart has the following specifications:

- Support L is 3 m from the left end.
- Support R is at the right end.
- 50 N is at the left end.
- 40 N is 2 m from support L.
- 30 N is 4 m from support R.

2.1 Draw the beam and clearly label all important information. (4)

2.2 Calculate the magnitude of the reactions by taking moments about both supports. (6)

[10]

QUESTION 3: ENERGY AND MOMENTUM

3.1 Define the *potential energy* of an object or body. (2)

3.2 An object with a mass of 5 kg is falling from point A at the top of a building which is 8 m from the ground at point C. The object passes point B which is the first floor of the building and is 2 m below point A.

3.2.1 Calculate the potential energy of the object before falling. (2)

3.2.2 Calculate the kinetic energy of the object at point B. (3)

[7]

QUESTION 4: WORK, POWER AND EFFICIENCY

4.1 Define *energy*. (1)

4.2 A crane hoists a load of 5 000 N to the top of a building 30 m high. The chain used to hoist the load has a weight of 20 N/m.

4.2.1 Calculate the total work done in hoisting the load and the chain. (4)

4.2.2 Calculate the total power required in hoisting the load and chain if it takes 5 minutes to hoist the total load. (3)

4.3 A 40 kg object is placed on an inclined plane forming an angle of 20° with the horizontal.

Calculate the required force to pull the object up the incline. (2)
[10]

QUESTION 5: MECHANICAL DRIVES AND LIFTING MACHINES

5.1 A clock watch has two gear drives with gear A driving gear B. The following is known:

$N_A = 750\, r/min$
$T_A = 25\, T$
$T_B = 50\, T$

Calculate each of the following:

5.1.1 Rotational frequency of gear B

5.1.2 Velocity ratio for the system

(2 × 2) (4)

5.2 Name TWO types of hoisting devices. (2)

5.3 A differential wheel and axle device has a velocity ratio of 20 with $d_1 = 300\, mm$ and $d_2 = 240\, mm$, with a mass on effort of 60 kg. The mass of the load is 800 kg.

Calculate each of the following:

5.3.1 Mechanical advantage of machine (2)

5.3.2 Effort distance for 1rev of the drum. (3)

5.3.3 Efficiency of machine (2)

5.4 The tension ratio of the tight side force to the slack side of a belt is 5:1 and the force in the slack side is 500 N. The driving pulley has a diameter of 300 mm and its rotational frequency is 50 r/s.

Calculate each of the following:

5.4.1 Speed of the belt

5.4.2 Power transmitted

(2 × 2) (4)
[17]

QUESTION 6: FRICTION

6.1 A trailer with a mass of 75 kg is pulled up an incline which forms an angle of 40° with the horizontal. The coefficient of friction is 0,4.

Calculate each of the following:

6.1.1 Weight component parallel to plane (2)

6.1.2 Minimum force required to pull trailer up the incline (6)

6.2 Calculate absolute pressure at the bottom of a 5m deep dam full of water. (2)
[10]

QUESTION 7: HEAT

7.1 Give ONE example where linear expansion of metals is useful in practice. (1)

7.2 The length of a metal bar at 26 °C was found to be 5 m. After being heated to 89° the bar had expanded by 7,245 mm.

Identify the metal of the bar. An answer without calculation will not be accepted. (3)

7.3 Explain what is meant by each of the following terms with regard to the heat content of water:

7.3.1 Specific heat capacity

7.3.2 Latent heat of evaporation

7.3.3 Sensible heat

(3 × 2) (6)
[10]

QUESTION 8: PARTICLE STRUCTURE OF MATTER

8.1 Define *element*. (2)

8.2 Give TWO examples of an element. (2)

8.3 Give TWO examples of compounds used in households. (2)

8.4 Name TWO types of ions. (2)

. **[8]**

QUESTION 9: ELECTRICITY

9.1 What is the relationship between *current* and *resistance*? (2)

9.2 Name three disadvantages of induction (3)

9.3 A simple DC circuit has a supply voltage of 12 V and resistor $R_1 = 3\,\Omega$ is connected in series with the supply. This resistor is connected in series with two resistors, $R_2 = 6\,\Omega$ and $R_3 = 4\,\Omega$, connected in parallel to each other.

Calculate each of the following:

9.3.1 Effective resistance of circuit (3)

9.3.2 Total current flowing through circuit (2)

9.3.3 Current flowing through 6-ohm resistor (3)

[13]

TOTAL: 100

ENGINEERING SCIENCE N2

FORMULA SHEET

All formula needed are not necessarily included. Any other applicable formula may be used.

$W = m.g$

$W = F.s$

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

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

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

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

$\mu = \tan \phi$

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

$F_S = w \sin \theta$

$F_C = w \cos \theta$

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

$F_e = T_1 - T_2$

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

$P = F_e . v$

$v = \pi . d . n$

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

$N_A . T_A = N_B . T_B$

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

$E_P = m . g . h$

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

$E_T = E_p + E_k$

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

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

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

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

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

$Q = m . c . \Delta t$

$m . ww = Q = m . h_v$

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

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

$l_f = l_o \pm \Delta l$

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

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

$v = u + at$

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

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

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

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

$P = pgh$

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

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

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