higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N2

(15070402)

20 November 2019 (X-Paper)
09:00–12:00

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

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. ALL the calculations should 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

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

4. The following values MUST be used in this question paper, 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 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 °C	$= 0,000\,000\,155 \ \Omega m$
Resistivity of copper at 20 °C	$= 0,000\,000\,018 \ \Omega \ m$
Resistivity of aluminium at 20 °C	$= 0,000\,000\,028 \ \Omega \ m$

5. Rule off on completion of each question.

6. Drawing instruments MUST be used for ALL the drawings.

7. Subsections of questions MUST be kept together.

8. Write neatly and legibly.

QUESTION 1: DYNAMICS

1.1 Indicate whether the following statements are TRUE or FALSE. Choose the answer and write only 'True' or 'False' next to the question number (1.1.1–1.1.3) in the ANSWER BOOK.

    1.1.1 Scalar is a physical quantity that has both magnitude and direction.

    1.1.2 Velocity is the rate of change of distance. ⌘

    1.1.3 The initial velocity of a dropped object or a body is 9.8 m/s^2.

                  (3 × 1)   (3)

1.2 FIGURE 1 below contains a graph representing the velocity of a vehicle with respect to time as the vehicle moves past A, B and C. Movement takes place in a straight line.
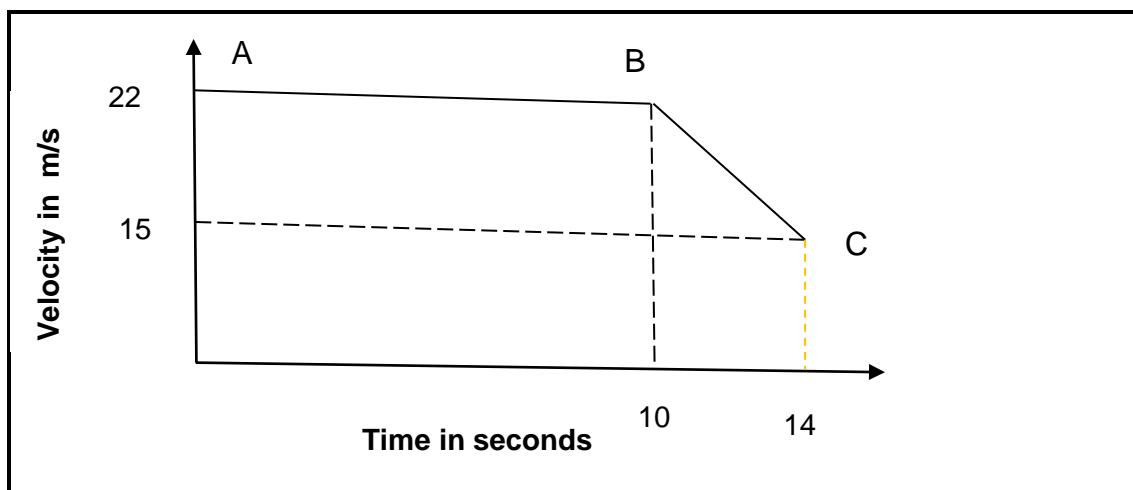

FIGURE 1

Determine the following:

    1.2.1 The deceleration of the vehicle between B and C   (3)

    1.2.2 Total distance between A and C   (4)

    1.2.3 Average velocity of the vehicle between A and C   (2)

1.3 A motor car is travelling at 144 km/h in a 90 km/h speed zone. The driver suddenly sees a speed camera 80 m ahead before the camera can read the car's speed. ⌘

Calculate the deceleration required to comply with the speed limit before being caught by the camera.   (3)

                                            [15]

QUESTION 2: STATICS

2.1 Define *turning moment*. (2)

2.2 A uniform beam of 15 m has two supports, A and B respectively. Support A is 3 m from the left end and support B at the right end. The beam carries a point load of 100 N on the left end, another point load of 250 N is 7 m from the left end and also carries a point load of 150 N that is 3 m away from the 250 N point load towards support B. Ignore the weight of the beam.

    2.2.1 Make a neat labelled drawing of the beam and clearly show ALL its dimensions and loads. (4)

    2.2.2 Calculate the reactions on both supports by taking moments about each support in turn. (4)

[10]

QUESTION 3: ENERGY AND MOMENTUM

3.1 Write down the formula for Newton's second law of motion and what does it mean? (2)

3.2 A spherical object with a mass of 5 kg is allowed to roll down an incline from point A which is 10m above the ground.

    3.2.1 Calculate the potential energy of the ball at point A. (2)

    3.2.2 Calculate the velocity of the object when it is at point B which is 4m above the ground. (4)

[8]

QUESTION 4: WORK, POWER AND EFFICIENCY

4.1 Define *efficiency*. (1)

4.2 A crane is hoisting a load of 3 000 N to a height of 30 m. The weight of the chain the crane uses to hoist the load is 20 N/m.

    4.2.1 Draw a neat, labelled force/distance graph representing the process and indicate ALL the important values. (4)

    4.2.2 Use the graph and calculate the total work done. (3)

4.3 Calculate the power required by a tow truck during the towing process of a car if the force applied by the truck is 3 300 N and it has a velocity of 10 m/s. (2)

[10]

QUESTION 5: MECHANICAL DRIVES AND LIFTING MACHINES

5.1 Define the *velocity ratio* of a gear system. (2)

5.2 A driver gear with 75 teeth is driving a driven gear with an unknown number of teeth and the rotational frequencies of the driver and the driven gear respectively are 25 r/s and 5 r/s.

    5.2.1 Calculate the unknown number of teeth on the driven gear.

    5.2.2 Calculate the velocity ratio of the gears.

                                                        (2 × 2) (4)

5.3 State THREE disadvantages of friction. (3)

5.4 State the TWO factors on which the tension ratio T_1/T_2 of a belt drive depends on. (2)

5.5 A differential wheel and axle lifting device has a load 150 kg and an effort of 15 kg that is supposed to lift the load. The diameters of the lifting machine are as follows:

Wheel   550 mm
Big axle   270 mm
Small axle   200 mm

    5.5.1 Calculate the mechanical advantage of the lifting device.

    5.5.2 Calculate the velocity ratio of the lifting device.

    5.5.3 Calculate the efficiency of the lifting device.

                                                        (3 × 2) (6)
                                                           [17]

QUESTION 6: HYDRAULICS AND FRICTION

6.1 A vertical cylindrical shape container of water has a diameter of 250mm and a perpendicular height of 10 m.

Calculate the absolute pressure at the bottom of the container. (4)

6.2 A body weighing 15 kg is placed on the incline plane with an angle of 30° with the horizontal surface. The coefficient of friction between the body and the sliding surface is 0.25.

    6.2.1 Calculate the weight component perpendicular to the incline.

    6.2.2 Calculate the frictional force.

                                                        (2 × 2) (4)
                                                           [8]

QUESTION 7: HEAT

7.1   Tabulate TWO differences each between heat and temperature. (4)

7.2   A steam boiler uses 50 kg of diesel to heat water of 1 000 kg from 20 °C to 60 °C. Assume the heat value of diesel is equal to that of petrol.

    7.2.1   Calculate the energy released if 20% of heat energy is lost due to incomplete combustion. (3)

    7.2.2   Calculate the heat gained by the water. (2)

    7.2.3   Calculate the efficiency of the heating system. (2)

[11]

QUESTION 8: PARTICLE STRUCTURE OF MATTER

8.1   Define *element*. (2)

8.2   Differentiate between *atomic number* and *atomic mass*. (2)

8.3   Name TWO examples of compounds used in a household. (2)

8.4   Explain clearly when an atom has a positive ion and when a negative ion. (2)

[8]

QUESTION 9: ELECTRICITY

9.1   A simple DC-circuit consists of two resistors of $R_1 = 6\Omega$ and $R_2 = 2\Omega$ connected in parallel. Both are connected in series with R_3 that has an unknown resistance and a voltage drop of 9 V is read across R_3. The ammeter reading before the parallel part of the circuit is 2 A.

    9.1.1   What is the relationship between the current and resistance? (1)

    9.1.2   Calculate the supply voltage of the circuit. (5)

    9.1.3   Calculate the unknown resistance for R_3. (3)

9.2   State TWO factors that affect the resistance of a conductor and their relationship with the resistance of a conductor (4)

[13]

TOTAL: 100

FORMULA SHEET

All formula needed are not necessarily included.

Any applicable formula may be used.

$W = m \cdot g$

$W = F \cdot s$

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

$\eta = \dfrac{Output}{input} \cdot 100\%$

$\eta = \dfrac{Uitset}{Inset} \cdot 100\%$

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

$\mu = \tan \phi$

$F_T = F_\mu \dots \dfrac{horizontal}{horisontaal} \dots a = o$

$F_S = w \sin \theta$

$F_C = w \cos \theta$

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

$F_e = T_1 - T_2$

$\dfrac{T_1}{T_2} = \dfrac{tension\ ratio}{spanningsverhouding}$

$P = F_e \cdot v$

$v = \pi \cdot d \cdot n$

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

$N_A \cdot T_A = N_B \cdot T_B$

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

$E_P = m \cdot g \cdot h$

$E_k = \dfrac{1}{2} \cdot m \cdot v^2$

$E_T = E_p + E_k$

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

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

$\dfrac{HV}{VV} \cdot 100\% = \eta = \dfrac{MA}{DR} \cdot 100\%$

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

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

$Q = m \cdot c \cdot \Delta t$

$m \cdot ww = Q = m \cdot h_v$

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

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

$l_f = l_o \pm \Delta l$

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

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

$v = u + at$

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

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

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

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

$P = \rho g h$

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

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

$R = \dfrac{p \cdot l}{a}$