higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

25 November 2024 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

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

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N4
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. Start each question on a new page.
5. Subsections of the question must be kept together.
6. Use only black or blue ink, and a pencil for drawings.
7. Sketches must be large, neat and fully labelled.
8. Use $g = 9{,}8\ m/s^2$
9. Round your answer to 3 decimal places.
10. Write neatly and legibly.

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QUESTION 1: KINEMATICS

1.1 A ship that can cruise at 48 km/h in still waters sets course due south-west. It is driven off course by a current flowing West 26° North at a velocity of 8 km/h.

Calculate the following:

1.1.1 The resultant velocity in magnitude and direction (5)

1.1.2 The distance the ship will cruise in 5 hours (1)

1.2 A bullet is fired at an angle of 30° to the horizontal at a velocity of 400 m/s.

Calculate the following:

1.2.1 The maximum height reached by the bullet

1.2.2 The horizontal displacement when the bullet hits the ground (2 × 2) (4)

1.2 Two vehicles start moving simultaneously at a fork in a road. Vehicle B travels at a speed of 120 km/h north-east. Vehicle M travels at 125 km/h directly east.

Calculate the velocity of vehicle M relative to the velocity of vehicle B in magnitude and direction. (5)

[15]

QUESTION 2: ANGULAR MOTION

Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (2.1–2.4) in the ANSWER BOOK.

2.1 A blue racing car of mass of 1,5 tons races around a circular path of diameter 11 000 cm at a speed of 120 km/h and covers a distance of 25 000 mm. The angular displacement of the car is …

A 0,835 rad.
B 0,524 rad.
C 0,355 rad.
D 0,455 rad.

2.2 The angular velocity of the car is …

A 0,535 rad/s.
B 0,606 rad/s.
C 0,582 rad/s.
D 0,833 rad/s.

2.3 A machine has a torque of 230 Nm at its spindle. The diameter of the spindle Is 70 cm and the rotational frequency of the spindle is 13,5 rad/s.

The power exerted is …

A 3,105 kW.
B 2,583 kW.
C 1,582 kW.
D 2,854 kW.

2.4 If the efficiency of the machine is 90%, the input power of the machine is …

A 2,30 kW.
B 3,30 kW.
C 3,45 kW.
D 3,06 kW

(4 × 2) **[8]**

QUESTION 3: DYNAMICS

3.1 A truck with a mass of 1 ton is moving at 80 km/h on a horizontal plane and braked to rest over 40 m.

Calculate the following:

3.1.1 The deceleration

3.1.2 The braking force

(2 × 2) (4)

3.2 A car with a mass of 800 kg accelerates uniformly from rest to 100 km/h for 8 seconds up an incline that makes an angle of 30° with the horizontal. The frictional resistance is 280 N.

Calculate:

3.2.1 The work done against the frictional force when the velocity reaches 100 km/h (3)

3.2.2 The work done against the gravitational component parallel to the plane (2)

3.2.3 The work transformed into kinetic energy (3)

3.2.4 The total force exerted on the car (3)

3.2.5 The total power (2)
[17]

QUESTION 4: STATICS

4.1 A light, uniform beam ABCDE is 8 m long and is supported by two supports, each 1 m from the end. Consider the following loads that the beam carries and then answer the questions that follow.

A concentrated or point load of 30 kN at the left end
A concentrated or point load of 40 kN 2 m from the right end
A concentrated or point load of 40 kN at the right end
A uniformly distributed load of 5 kN/m across the first 6 m from the left end

4.1.1 Draw a neat, detailed sketch of the beam described above. (2)

4.1.2 Calculate the reaction forces at the supports. (4)

4.1.3 Calculate the bending moments at the points where there are supports and 6 m from the left end. (3)

4.1.4 Draw a diagram showing the shearing force and show all the main values. (2)

4.1.5 Draw the bending moment diagram in detail and show ALL the principal values.

NOTE: NO marks will be allocated if the main or principal values are NOT indicated on the diagrams. (3)

4.1.6 Determine the magnitude of the maximum bending moment and its position. (2)

[16]

QUESTION 5: HYDRAULICS

5.1 The data below refer to a single-acting hydraulic press.

Diameter of the ram piston = 450 mm
Diameter of the plunger piston = 100 mm
Stroke length of the plunger = 120 mm
Mechanical advantage of the plunger = 20

Calculate the following:

5.1.1 The effort that must be applied to the handle to lift a load of 4,6 Mg if the efficiency is 90% (5)

5.1.2 The distance the load will be raised after 160 pumping strokes of the plunger if the efficiency is 90% (4)

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5.2 The plunger of a three-cylinder pump has a diameter of 85 mm and a stroke length of 590 mm. The crankshaft speed is 250 r/min.

Calculate the quantity of water delivered in litres per second if the slip is 1,7%. (3)

5.3 The borehole pumps water from a depth of 70 m at a rate of 320 litres/min. The installation efficiency of the borehole pump is 80%.

Determine the power of the driving pump of the electric motor. (3)
[15]

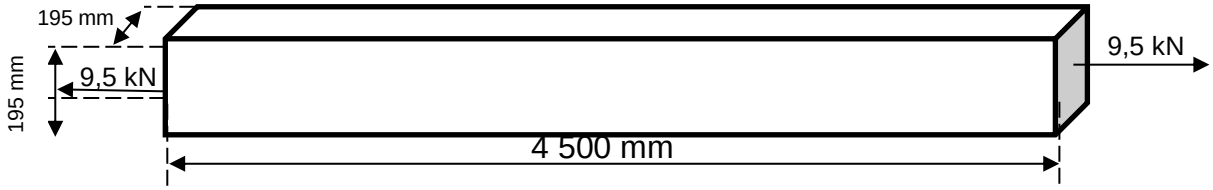
QUESTION 6: STRESS AND STRAIN

6.1 Explain the term *limit of proportionality.* (2)

6.2 The ratio between the outside diameter and the inside diameter of a pipe is 1,8 and the length is 700 mm when the pipe is not subjected to a load (force). When a tensile load or force of 315 kN is applied to the pipe, the length increases by 0,139 mm. Young's modulus of elasticity for the pipe is 200 GPa.

Calculate the outside and the inside diameters of the pipe. (7)

6.3 The diagram below shows a tensile load of 9,5 kN that is applied to a square bar with 195 mm sides and a length of 4500 mm. The change in length is 0,213 mm.



Calculate the following:

6.3.1 The stress (2)

6.3.2 The strain (2)

6.3.3 Young's modulus of elasticity (1)
[14]

QUESTION 7: HEAT

7.1 State any THREE basic gas processes. (3)

7.2 Name a gas process whereby the initial and final temperature are both at constant. (1)

7.3 A copper plate with dimensions 75 cm × 35 cm × 20 cm is placed in an electrical furnace. The copper plate is heated from 38 °C to 400 °C. The coefficient of linear expansion of the copper plate is 17×10^{-6} /°C.

Calculate the following:

7.3.1 The expansion in the length of the plate in cm. (2)

7.3.2 The area in mm^2 of the 75 cm × 35 cm side at the temperature 400 °C (3)

7.3.3 The increase in volume of the plate in m^3 (3)

7.4 The volume of a nitrogen gas is 0,495 m^3 at 75 °C and a pressure of 750 kPa.

Determine the thermodynamic temperature of the gas if the volume is 0,0639 m^3 at a pressure of 1 000 kPa. (3)

[15]

TOTAL: 100

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ENGINEERING SCIENCE N4

FORMULA SHEET

Any other applicable formula may also be used.

$L = \frac{u^2}{g}\sin 2\theta$

$t_L = 2\frac{u}{g}\sin\theta$

$\bar{V} = \frac{s}{t}$

$\theta = 2\pi n$

$S = R\theta$

$\omega = 2\pi N$

$\omega = \frac{\theta}{t}$

$\omega_2 = \omega_1 + \alpha t$

$\omega^2{}_2 = \omega^2{}_1 + 2\alpha\theta$

$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

$v = \omega R$

$v = \pi D n$

$\tau = FR$

$W_{ork} = \tau\theta = WD$

$P = 2\pi n T$

$P = T\omega$

$v = u + at$

$v^2 = u^2 + 2aS$

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

$P = Fv$

$F_a = ma$

$\omega = 2\pi N$

$E_p = mgh$

$E_k = \frac{1}{2}mv^2$

$V_{ave} = \frac{u+v}{2}$

$P = \frac{F}{A}$

$m = \rho \times vol$

$P = \rho gh$

$\frac{W_r}{F_p} = \frac{D^2}{d^2}$

$MA = \frac{F_p}{F_h}.\frac{\eta}{100} = H.V$

$V_s = V_a.\frac{100}{\eta}$

$W_{ork} = P_{ress} \times V_{ol} = A.V$

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

$Q = mc\Delta t$

$\Delta l = l_0\alpha\Delta t$

$\beta = 2\alpha$

$\gamma = 3\alpha$

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

$PV = mRT$

$\in = \frac{x}{l}$

$E = \frac{\sigma}{\in}$

$\sigma = \frac{F}{A}$

$E = \frac{Fl}{Ax}$

$\bar{y} = A\frac{A_1y_1 \pm A_2y_2}{A_1 \pm A_2}$

$\bar{y} = A\frac{vy_1 \pm v_2y_2}{v_1 \pm v_2}$

Centroid of half circle:0.424

Centroid of triangle: $C = \frac{h}{3}$

Centre of gravity of half circle: $G = \frac{3}{8}r$

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INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	CONSTANTS
Atmospheric pressure	101,3 kPa
Density of copper	8 900 kg/m^3
Density of aluminium	2 770 kg/m^3
Density of gold	19 000 kg/m^3
Density of alcohol (ethyl)	790 kg/m^3
Density of mercury	13 600 kg/m^3
Density of platinum	21 500 kg/m^3
Density of water	1 000 kg/m^3
Density of mineral oil	920 kg/m^3
Density of air	1,05 kg/m^3
Electrochemical equivalent of silver	1,118 mg/C
Electrochemical equivalent of copper	0,329 mg/C
Gravitational acceleration	9,8 m/s^2
Heat value of coal	30 MJ/kg
Heat value of anthracite	35 MJ/kg
Heat value of petrol	45 MJ/kg
Heat value of hydrogen	140 MJ/kg
Linear coefficient of expansion of copper	17 × 10^{-6}/°C
Linear coefficient of expansion of aluminium	23 × 10^{-6}/°C
Linear coefficient of expansion of steel	12 × 10^{-6}/°C
Linear coefficient of expansion of lead	54 × 10^{-6}/°C
Specific heat capacity of steam	2 100 J/kg.°C
Specific heat capacity of water	4 187 J/kg.°C
Specific heat capacity of aluminium	900 J/kg.°C
Specific heat capacity of oil	2 000 J/kg.°C
Specific heat capacity of steel	500 J/kg.°C
Specific heat capacity of copper	390 J/kg.°C

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