higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

# NATIONAL CERTIFICATE

# ENGINEERING SCIENCE N4

(15070434)

**04 April 2023 (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

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**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. Answers to calculations must be given correctly to THREE decimals after the comma.
5. All calculations must have the following three steps:
   - 5.1 The formula
   - 5.2 The replacement of values
   - 5.3 The answer and correct SI-unit
6. Use only a black or blue pen for written answers.
7. Sketches must be drawn in pencil.
8. Write neatly and legibly.

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## QUESTION 1: GENERAL

Define the following:

1.1 Newton's First Law (2)

1.2 Angular displacement (2)

1.3 Gay Lussac's Law (2)

1.4 Pascal's Law (2)

**[8]**

## QUESTION 2: KINEMATICS

2.1 Two ships leave Cape Town harbour simultaneously. Ship A sails at a velocity of 125 km/h in a direction Northwest and ship B sails at a velocity of 92 km/h in a direction South 25°West.

Calculate the magnitude and direction of the velocity of boat A relative to boat B. (5)

2.2 A cannon is aiming at a distant target. When the projectile is fired it has a muzzle velocity of 850 m/s. The cannon is aimed at an angle of 38°.

2.2.1 Calculate the maximum height the projectile will reach.

2.2.2 Calculate the time to reach the maximum height.

2.2.3 Calculate the displacement of the projectile.

(3 × 2) (6)

2.3 An aircraft has to fly 120 km directly East. It can travel in still air a 300 km/h. A South-westerly wind of 55 km/h is blowing.

2.3.1 Calculate direction to be taken to reach its destination.

2.3.2 Calculate the magnitude of the resulting velocity.

(3 × 2) (4)

**[15]**

## QUESTION 3: ANGULAR MOTION

3.1 A lawnmower's starter pulley has a diameter of 175 mm. The starting rope is wound 5 times around the pulley. The rope is pulled with a force of 68N for 1 second.

3.1.1 Calculate the torque applied on the pulley.

3.1.2 Calculate the work done.

(2 × 2) (4)

3.2 The flywheel of a motorcar rotates at 210 r/min. It is uniformly retarded to 25 r/min for the next 25 s.

3.2.1 Calculate the retardation of the flywheel.

3.2.2 Calculate the revolutions made by the flywheel during retardation.

(2 × 2) (4)

3.3 A wheel rotates at an angular velocity of 95 rad/s. It rotates for 0,5 seconds.

Calculate the angular displacement of the wheel. (2)

**[10]**

## QUESTION 4: DYNAMICS

4.1 A casting with a mass of 45 kg, is placed on an incline with an angle of 25°. The casting is at rest. The coefficient of friction is 0,4.

4.1.1 Calculate the frictional force needed to keep the casting at rest.

4.1.2 Calculate the force needed to move the casting up the plane.

4.1.3 Calculate the tractive resistance if the casting is moving up the incline.

(3 × 2) (6)

4.2 A steel ball with a mass of 12 kg is at rest on the top of an incline. The ball starts to roll down the incline of 30 m with a slope of 1 in 25.

Ignoring friction, calculate the following:

4.2.1 The loss in potential energy if it rolled 15 m.

4.2.2 The speed of the ball if it rolled 30 m.

(2 × 3) (6)

**[12]**

## QUESTION 5: STATICS

5.1 FIGURE 1 shows a cantilever in balance.

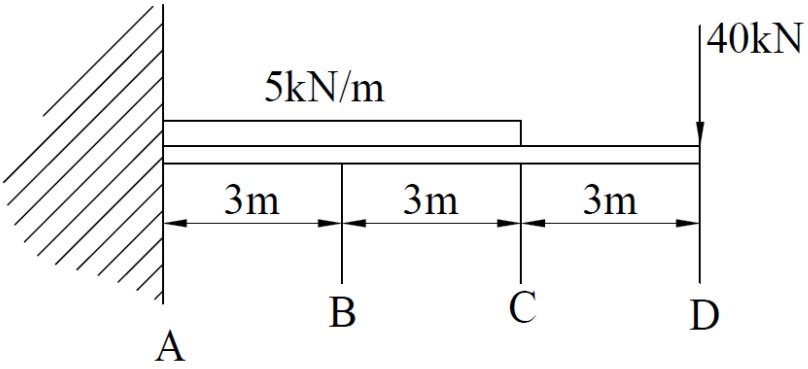



**FIGURE 1**

5.1.1 Calculate the reaction at A. (2)

5.1.2 Calculate the bending moments. (4)

5.1.3 Draw the bending moment diagram. (4)

5.2 Calculate the centroid of the lamina in FIGURE 2.

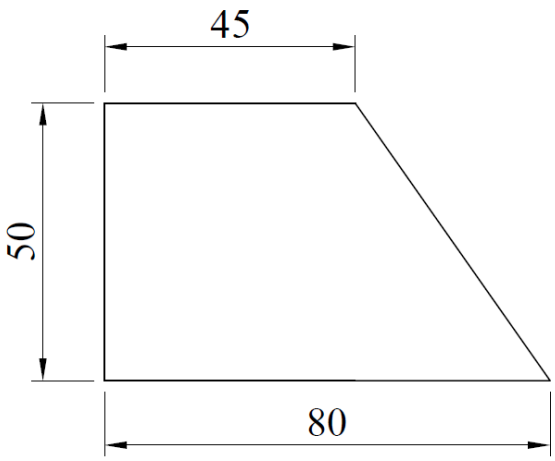



**FIGURE 2**

(5)
**[15]**

## QUESTION 6: HYDRAULICS

6.1 A single-acting hydraulic press has a plunger diameter of 55 mm, a stroke length of 106 mm and a ram diameter of 144 mm.

6.1.1 Calculate the volume of liquid per stroke.

6.1.2 Calculate the force exerted by the ram if a force of 75 N is applied on the plunger.

(2 × 2) (4)

6.2 A hydraulic accumulator has to work under a pressure of 2 MPa.

Calculate the mass needed for it to act under the pressure of 2 MPa if the ram has a mass of 750 kg and a diameter of 450 mm. (4)

6.3 A water pump delivers 12,5 litres of water per stroke if the effective force on the piston is 27 kN. The diameter of the piston is 250 mm.

6.3.1 Calculate the stroke length of the piston. (3)

6.3.2 Calculate the work done per stroke. (2)

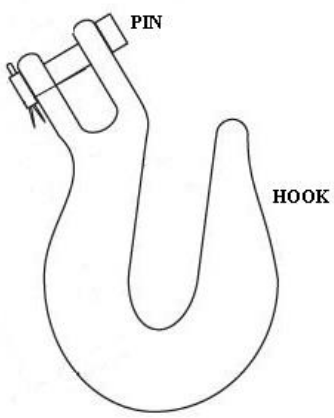
**[13]**

## QUESTION 7: STRESS, STRAIN & YOUNG'S MODULES

7.1 A pillar has a cross-sectional profile of 450 mm × 450 mm. The maximum compressive stress cannot exceed 5,5 MPa.

Calculate the maximum allowable load on the pillar. (4)

7.2 FIGURE 3 shows a clevis-type hook. The clevis will be attached to a rope, that needs to lift up a load of 15 ton. The maximum shear stress in the pin of 45 MPa should not be exceeded.




Calculate the diameter of the pin suitable for the task. (5)

7.3 A tensile force of 85 kN is applied to a copper rod, causing a stress of 30 MPa. The original length of the rod is 4 m. Young's modules for copper is 117 GPa.

7.3.1 Calculate the diameter of the rod. (3)

7.3.2 Calculate the strain. (2)

**[14]**

## QUESTION 8: HEAT

8.1 A man buys 10 litres of paraffin at a shop with a room temperature of 21 °C. He places the can in the boot of his car. While driving back to his house the temperature in the boot rises to 38 °C. If coefficient of volume expansion of paraffin is $764 \times 10^{-6}$/K, calculate the increase in volume at 38 °C. (2)

8.2 The volume of a certain gas at a temperature of 32 °C and a pressure of 0,15MPa is 39 $m^3$.

If the temperature stays at 32 °C and the pressure decreases to 5 kPa, calculate the volume of the gas. (2)

8.3 The volume of helium gas at 10 °C and at a pressure of 750 kPa is 0,42$m^3$. The gas constant is 2,08 kJ/kg·K.

Calculate the mass of the gas. (3)

8.4 A rectangular prism of aluminium has dimensions of 45 mm x 36 mm x 28 mm at a temperature of 18 °C. It is heated to 45 °C.

Calculate the volume at 45 °C. (3)

8.5 A copper plate with dimensions 105 mm × 642 mm at 15 °C is heated to a temperature of 325 °C.

Calculate the area of the copper plate at 325 °C. (3)

**[13]**

**TOTAL: 100**

(15070434)

## FORMULA SHEET

Any other applicable formula may also be used.

$$S = \frac{u+v}{2} \times t$$

$$v = \frac{s}{t}$$

$$v = u + at$$

$$s = u.t + \tfrac{1}{2}a.t^2$$

$$v^2 = u^2 + 2.a.s$$

$$v_a = \frac{u+v}{2}$$

$$\omega = 2.\pi.N$$

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

$$\theta = \frac{\omega_2 + \omega_1}{2} \times t$$

$$\omega_2 = \omega_1 + \tfrac{1}{2}\alpha.t$$

$$v = \omega.R$$

$$\theta = 2.\pi.n$$

$$S = R.\theta$$

$$\alpha = \frac{(\omega_2)^2 - (\omega_1)^2}{2\theta}$$

$$a = \alpha.R$$

$$v = \pi.D.N$$

$$T = FR$$

$$A.V = T.\theta = W.D$$

$$P = 2\pi.N.T$$

$$P = T.\omega$$

$$P = F.v$$

$$F_a = m.a$$

$$E_p = m.g.h$$

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

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

$$m = p \times vol$$

$$P = p.g.h$$

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

$$H.V = \frac{F_p}{F_h} = M.A$$

$$A.V = m.g.h = W.D$$

$$Q = mc\Delta t$$

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

$$\beta = 2.\alpha$$

$$\gamma = 3.\alpha$$

$$\frac{P_1.V_1}{T_1} = \frac{P_2.V_2}{T_2}$$

$$P.V = m.R.T$$

$$\in = \frac{x}{1}$$

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

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

$$E = \frac{F.l}{A_x}$$

$$\bar{y} = \frac{A_1.y_1 + A_2.y_2 + .....}{A_T}$$

$$\bar{y} = \frac{V_1.y_1 + V_2.y_2 + .....}{V_T}$$

**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 |
| 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 |