higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

**NATIONAL CERTIFICATE**

# ENGINEERING SCIENCE N4

(15070434)

**30 July 2021 (X-paper)**
**09:00–12:00**

**Drawing instruments and nonprogrammable calculators may be used.**

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

106Q1G2130

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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. Subsections of questions must be kept together.
5. Rule off across the page on completion of each section.
6. All formulae should be shown in the answers.
7. Show all the calculations.
8. Only use a black or blue pen.
9. All diagrams should be drawn in pencil.
10. All the answers must be rounded off to THREE decimal places.
11. Take g = 9,8 $m/s^2$
12. Write neatly and legibly.

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## QUESTION 1

1.1 An express train travels from north to south at 130 km/h. A helicopter flies over the train at 178 km/h from the front.

Calculate the velocity of the helicopter relative to the velocity of the train in magnitude and direction. (3)

1.2 A stone is thrown at a velocity of 39 m/s at an angle of 35° to the horizontal.

Calculate the following:

1.2.1 The maximum height reached by the stone (3)

1.2.2 The horizontal displacement or range (3)

1.3 A boy throws a cricket ball at an angle of 15° to the horizontal with an initial velocity of 50 m/s. The path of the ball is that of a projectile.

Calculate the following:

1.3.1 The time to reach maximum height

1.3.2 The maximum height reached by the ball

1.3.3 The horizontal displacement of the ball

(3 × 2) (6)

**[15]**

## QUESTION 2

2.1 Define the term *angular displacement.* (2)

2.2 The torque on a gear driven directly by a machine is 120 N·m. The power transmitted by the gear is 4,5 kW.

Calculate the rotational frequency of the machine in r/s. (3)

2.3 A force of 500 N is applied to the end of a spanner. The perpendicular distance between the nut and the working line of the force is 200 cm.

Calculate the following:

2.3.1 The torque on the spanner (2)

2.3.2 The work done when the nut is turned through an angle of 60° (2)

**[9]**

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## QUESTION 3

3.1. What is the conservation of energy? (2)

3.2 A ball with a mass of 10 kg rolls from rest down a frictionless incline of 1:30 over a distance of 30 m.

Calculate the following:

3.2.1 The loss in potential energy (4)

3.2.2 The velocity of the ball after 30 m by making use of the law of the conservation of energy (4)

3.2 A motorcar is travelling on a horizontal road at a velocity of 54 km/h. The mass of the motorcar is 750 kg and the resistance to motion is 300 N. The motorcar stops over a distance of 35 m when the brakes are applied.

Calculate the deceleration. (2)

**[12]**

## QUESTION 4

4.1 Define the following terms:

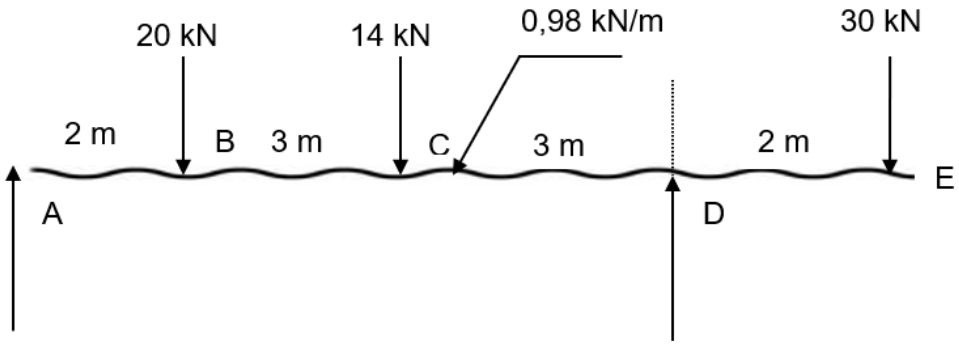
4.1.1 Cantilever

4.1.2 Bending moment

(2 × 2) (4)

4.2 A beam, ABCDE, with A on the left-hand side, is 10 m long and simply supported at A and D. At B, 2 m from A, is a point load of 20 kN. At C, 3 m from B, is a point load of 14 kN. At the right end, E, is a point load of 30 kN. D is 2 m from E. The beam has a mass of 1 000 kg.

Study the image below and calculate the reactions at the supports A and D.




(9)

**[13]**

## QUESTION 5

5.1 Define the following terms:

5.1.1 Density

5.1.2 Pressure (2 × 2) (4)

5.2 Full explain *Pascal's principle*. (2)

5.3 The diameter of the ram cylinder of a hydraulic press is 100 mm and the stroke length of the plunger is 40 mm. The mechanical advantage is 30 on the plunger.

Calculate the following:

5.3.1 The volume of liquid needed per stroke if the load has to be lifted 80 mm is 50 strokes. There is a slip of 5%. (4)

5.3.2 The diameter of the plunger. (3)

5.3.3 The effort required on the bundle to lift a load with a mass of 1,2 Mg. (6)

5.4 The plunger of a three-cylinder pump has a diameter of 90 mm and a stroke length of 590 mm. The crankshaft speed is 240 r/min.

Calculate the quantity of water delivered in litre per second if the slip is 1,8%. (3)

**[22]**

## QUESTION 6

6.1 Name THREE types of stress found in materials. (3)

6.2 Define *Hooke's Law.* (3)

6.3 A tensile force of 27 kN is applied to a steel bar with a rectangular cross-sectional area of 29 mm wide and 15 mm thick. The length of the bar is 2,8 m.

Young's modulus of elasticity for a steel bar is 208 GPa.

Calculate the following:

6.3.1 The stress in the steel bar (3)

6.3.2 The strain in the steel bar (2)

6.3.3 The change in length of the steel bar (3)

**[14]**

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## QUESTION 7

7.1 Define *coefficient of linear expansion* of a substance. (2)

7.2 A square metal plate of 37 cm × 37 cm is at a temperature of 31 °C. The coefficient of linear expansion of the metal is 17 × $10^{-6}$/°C.

Calculate the increase in area of the metal plate in $cm^2$ if its temperature rises to 98 °C. (2)

7.3 The density of 1 $m^3$ mercury at 0 °C is 1,07 × $10^4$ kg/$m^3$ and the volumetric coefficient of expansion is 200 × $10^{-6}$/°C.

Calculate the density of mercury at 70 °C. (5)

7.4 A container has a capacity of 0,184 $m^3$ and is filled with nitrogen gas at a pressure of 410 kPa and a temperature of 61 °C. Later it is found that the pressure has dropped to 300 kPa and the temperature has decreased to 32 °C resulting from a leak.

Calculate the following:

7.4.1 The mass of nitrogen gas that was initially in the container if the gas constant is 273 J/kg K

7.4.2 The mass of nitrogen gas that leaked out

(3 × 2) (6)

**[15]**

**TOTAL: 100**

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**ENGINEERING SCIENCE N4**

**FORMULA SHEET**

Any applicable formula may also be used.

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

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

$v = u + at$

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

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

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

$\omega = 2\Pi N$

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

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

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

$v = \omega R$

$\Theta = 2\Pi n$

$S = R\Theta$

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

$a = \alpha R$

$v = \Pi DN$

$T = FR$

$AV = T\Theta = WD$

$P = 2\Pi NT$

$P = T\omega$

$P = Fv$

$F_a = ma$

$E_p = mgh$

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

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

$m = p \times vol$

$P = pgh$

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

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

$AV = mgh = WD$

$Q = mc\Delta t$

$\Delta I = I_o \alpha \Delta t$

$\beta = 2\alpha$

$\gamma = 3\alpha$

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

$PV = mRT$

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

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

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

$E = \frac{F l}{Ax}$

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

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

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## INFORMATION SHEET

## PHYSICAL CONSTANTS

| QUANTITY | CONSTANTS<br>KONSTANTE | HOEVEELHEID |
|---|---|---|
| Atmospheric pressure | 101,3 kPa | Atmosferiese druk |
| Density of copper | 8 900 kg/m$^3$ | Digtheid van koper |
| Density of aluminium | 2 770 kg/m$^3$ | Digtheid van aluminium |
| Density of gold | 19 000 kg/m$^3$ | Digtheid van goud |
| Density of alcohol (ethyl) | 790 kg/m$^3$ | Digtheid van alkohol (etiel) |
| Density of mercury | 13 600 kg/m$^3$ | Digtheid van kwik |
| Density of platinum | 21 500 kg/m$^3$ | Digtheid van platina |
| Density of water | 1 000 kg/m$^3$ | Digtheid van water |
| Density of mineral oil | 920 kg/m$^3$ | Digtheid van minerale olie |
| Density of air | 1,05 kg/m$^3$ | Digtheid van lug |
| Electrochemical equivalent of silver | 1,118 mg/C | Elektrochemiese ekwivalent van silwer |
| Electrochemical equivalent of copper | 0,329 mg/C | Elektrochemiese ekwivalent van koper |
| Gravitational acceleration | 9,8 m/s$^2$ | Swaartekragversnelling |
| Heat value of coal | 30 MJ/kg | Warmtewaarde van steenkool |
| Heat value of anthracite | 35 MJ/kg | Warmtewaarde van antrasiet |
| Heat value of petrol | 45 MJ/kg | Warmtewaarde van petrol |
| Heat value of hydrogen | 140 MJ/kg | Warmtewaarde van waterstof |
| Linear coefficient of expansion of copper | 17 × 10$^{-6}$/°C | Lineêre uitsettingskoëffisiënt van koper |
| Linear coefficient of expansion of aluminium | 23 × 10$^{-6}$/°C | Lineêre uitsettingskoëffisiënt van aluminium |
| Linear coefficient of expansion of steel | 12 × 10$^{-6}$/°C | Lineêre uitsettingskoëffisiënt van staal |
| Linear coefficient of expansion of lead | 54 × 10$^{-6}$/°C | Lineêre uitsettingskoëffisiënt van lood |
| Specific heat capacity of steam | 2 100 J/kg.°C | Spesifieke warmtekapasiteit van stoom |
| Specific heat capacity of water | 4 187 J/kg.°C | Spesifieke warmtekapasiteit van water |
| Specific heat capacity of aluminium | 900 J/kg.°C | Spesifieke warmtekapasiteit van aluminium |
| Specific heat capacity of oil | 2 000 J/kg.°C | Spesifieke warmtekapasiteit van olie |
| Specific heat capacity of steel | 500 J/kg.°C | Spesifieke warmtekapasiteit van staal |
| Specific heat capacity of copper | 390 J/kg.°C | Spesifieke warmtekapasiteit van koper |

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