higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

21 November 2022 (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.

102Q1E2221

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. Keep subsections of questions together.
5. Rule off across the page on completion of each section.
6. Show all formulae in the answers.
7. Show all calculations.
8. Draw all diagrams in pencil.
9. Round off all answers to THREE decimal places.
10. Take $g = 9{,}8\ m/s^2$.
11. Use only a black or a blue pen.
12. Write neatly and legibly.

QUESTION 1

1.1 A bullet is fired at a velocity of 400 m/s with an angle of projection of 20°.

Calculate:

1.1.1 The maximum height reached by the bullet. (3)

1.1.2 The horizontal range of the bullet. (2)

1.2 Two vehicles start simultaneously at a fork in the road. Vehicle A travels North-east at 90 km/h and vehicle B travels West at 110 km/h.

Calculate the velocity of vehicle A relative to the velocity of vehicle B in magnitude and direction. (6)

1.3 A boat is moving at 35 km/h North across a river that is 49 m wide. The river flows West at 5 m/s.

Calculate the resultant velocity of the boat. (4)

[15]

QUESTION 2

2.1 Define *angular acceleration*. (2)

2.2 A wheel of a truck has a diameter of 100 cm and accelerates from 6 rad/s to 14 rad/s in 13 seconds.

Calculate:

2.2.1 The angular acceleration of the wheel

2.2.2 The angular displacement of the wheel in radians

(2 × 2) (4)

2.3 The effective diameter of a motorcar wheel is 600 mm. The motorcar is travelling at 120 km/h.

2.3.1 Calculate the angular velocity of a point on the tread of the tyre.

2.3.2 Calculate the angular retardation if the motorcar is brought to rest with uniform reduction of speed from 120 km/h in 25 seconds.

(2 × 2) (4)

2.4 A wheel with a diameter of 0,6 m has an angular acceleration of 37,704 rad/s^2.

If the moment of inertia is 4 units, calculate the accelerating torque. (2)

[12]

QUESTION 3

3.1. Define *co-efficient of friction*. (2)

3.2 A motorcar with a mass of 3,6 tonnes is at rest at the top of an incline of 1:30. The length of the incline is 42 m. A frictional force of 200 N is constant (uniform). The brakes are released and the car moves downwards due to the gravitational force, and then onto a horizontal road.

Calculate:

3.2.1 The velocity of the car at the bottom of the incline. (6)

3.2.2 The force applied by the motorcar on the horizontal road. (1)

3.2.3 The distance where the car will come to rest if it continues to travel on the horizontal road. (3)

3.3 Calculate the average power exerted by an engine if it can lift a mass of 300 kg through a distance of 10 m in 2 minutes. (2)

[14]

QUESTION 4

A light, horizontal beam, ABCDE, with A on the left-hand side is 26 m long. It is supported at two points, A and D. A point load of 20 kN is at B, 12 m from A. A point load of 30 is at C, 6 m from B. A uniform distributed load of 8 kN/m is between A and B. D is 4 m from C.

4.1. Make a neat, labelled diagram of the beam as described above. (1)

4.2 Calculate the reactions of the supports at points A and D and test your answers. (5)

4.3 Draw a shear-force diagram and show ALL the main values on the diagram. (4)

4.4 Calculate the bending moments at B and C. (2)

4.5 Draw a neat bending-moment diagram and show ALL the main values on the diagram. (3)

[15]

QUESTION 5

5.1 List any THREE types of the accumulators. (3)

5.2 A mass-loaded accumulator has a ram with a diameter of 350 mm and a mass of 650 kg. A hydraulic pressure of 1 MPa is required by the machine it serves. The ram moves through a distance of 250 mm in 6 s during the working stroke of the machine.

Calculate:

5.2.1 The additional mass required to act as a weight in order to obtain the required hydraulic pressure. (4)

5.2.2 The work done by the ram during the working stroke of the machine it serves. (2)

5.2.3 The power transmitted by the ram during the working stroke of the machine it serves. (2)

5.3 The plungers of a three-cylinder, single-acting pump has a diameter of 10 cm each and stroke lengths of 15 cm each. The pressure during the delivery stroke is 4 MPa.

Calculate the power required to drive the pump at 130 r/min if the efficiency of the motor is only 85%. (4)

[15]

QUESTION 6

6.1 State Hook's law and Young's modulus of elasticity. (3)

6.2 The following readings were obtained from a tensile test on a mild steel bar at Modise Engineers Pty Ltd.

Load KN	0	2,5	9,87	17,27	24,7	32,1
Extension	0	0,0056	0,0246	0,0456	0,0666	0,0896

Gauge length = 56 mm
Original diameter of the bar = 11,27 mm

Copy and complete the stress-strain table of the above information in exactly the following format:

$\sigma = MPa$ Load						
ε ($\times 10^{-4}$)						

(3)

6.3 A steel bar which is axially loaded by a tensile load F, shown in FIGURE 1 below, causes a maximum stress of 120 MPa in the bar. Young's modulus is 200 GPa.

Calculate the total change in length.

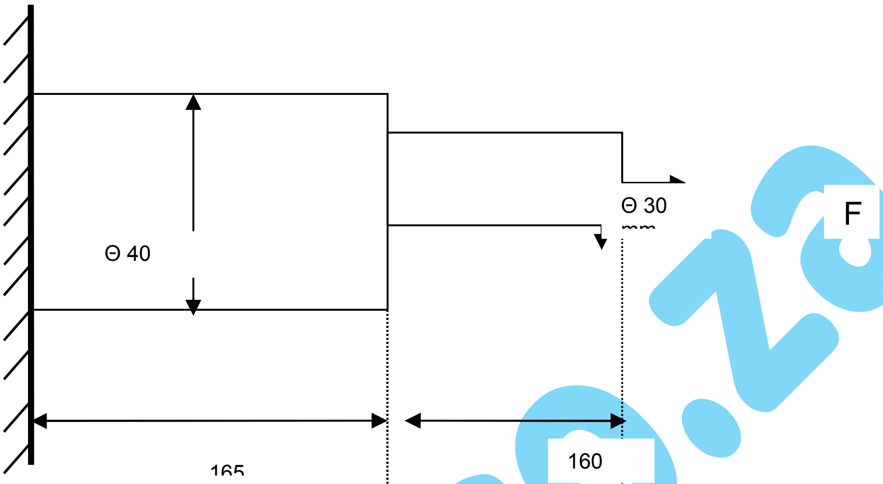

FIGURE 1 (8)

[14]

QUESTION 7

7.1 List two basic gas processes. (2)

7.2 A rectangular metal plate of 73 cm × 60 cm is at a temperature of 71 °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 121 °C. (2)

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

Calculate the density of mercury at 70 °C. (6)

7.4 A circular copper disc has a radius of 0,44 m at 22 °C. The linear expansion coefficient of the copper material is 17×10^{-6}/ °C.

Calculate the increase in the diameter of the disc if the final temperature is increased to 84 °C. (5)

[15]

TOTAL: 100

FORMULA SHEET

Any applicable formula may also be used.

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

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

$v = u + at$

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

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

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

$\omega = 2\pi N$

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

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

$\omega_2 = \omega_1 + \alpha t$

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

$v = \omega R$

$\theta = 2\pi n$

$S = R\theta$

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

$a = \alpha R$

$v = \pi DN$

$T = FR$

$AV = T\theta = WD$

$P = 2\pi NT$

$P = Fv$

$P = T\omega$

$F_a = ma$

$E_p = mgh$

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

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

$m = \rho \times vol$

$P = \rho gh$

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

$W.D. = P \times V = A.V.$

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

$AV = mgh = WD$

$Q = mc\Delta t$

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

$\beta = 2\alpha$

$\gamma = 3\alpha$

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

$PV = mRT$

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

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

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

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

$\overline{y} = \frac{A_1y_1 \pm A_2y_2 \ldots}{A_1 \pm A_2 \ldots}$

$\overline{y} = \frac{v_1y_1 \pm v_2y_2 \ldots}{v_1 \pm v_2 \ldots}$

INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	CONSTANTS 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