higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

7 February 2022 (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 section on a new page.

5. Answers must be given to THREE decimal places.

6. All calculations must have the following THREE steps:

   1: The formula
   2: The replacement of the values
   3: The answer and correct SI unit

7. Only use a black or blue pen.

8. Write neatly and legibly.

SECTION A

QUESTION 1: GENERAL

Define the following:

1.1 Newton's second law

1.2 Bending moment

1.3 Strain in Engineering Science N4

1.4 Hooke's' law

1.5 Volumetric coefficient of expansion

(5 × 2) **[10]**

TOTAL SECTION A: 10

SECTION B

QUESTION 2: KINEMATICS

2.1 A river flows in a south-easterly direction while a boat crosses the river in a southerly direction. In ideal circumstances the boat sails at a velocity of 8 m/s and the river flows at a velocity of 5,6 m/s. The boat's destination is 1 200 m away.

Calculate the following:

2.1.1 The resultant of the boat (4)

2.1.2 The time it takes to reach its destination (2)

2.2 TWO friends depart from the college to their respective homes. Thuso rides a bicycle at a velocity of 6 m/s in a direction west 25° south. Bakang walks at 2,5 m/s in a direction north 50° east.

Calculate Thuso's velocity relative to Bakang. (5)
[11]

QUESTION 3: ANGULAR MOTION

3.1 A turbine in an electrical plant has a diameter of 6,5 m and is rotating at 750 r/s. The turbine slows down to 500 r/s in 45 s.

3.1.1 Determine the angular deceleration of the turbine.

3.1.2 Calculate the number of revolutions completed during deceleration.
(2 × 2) (4)

3.2 A car body with a mass of 500 kg is lifted by a winch with a drum diameter of 300 mm. The body is lifted vertically upwards over a distance of 3,5 m. The car body accelerate at a rate of 1,3 m/s^2.

3.2.1 Calculate the work done to lift the car body.

3.2.2 Determine the power required to lift the car body.

(2 × 2) (4)
[8]

QUESTION 4: DYNAMICS

4.1 A car with a mass of 1,1 ton accelerates uniformly from rest to 95 km/h in 85 s up an incline of 1:15.

Calculate the following:

4.1.1 The acceleration of the car

4.1.2 The kinetic energy after 85 s

(2 × 2) (4)

4.2 A hoist lifts a crate of 250 kg from rest to a height of 12 m in 10 s with a uniform acceleration.

Calculate the following:

4.2.1 The gain in potential energy

4.2.2 The power to hoist the crate

(2 × 2) (4)

4.3 An engine with a mass of 85 kg is pulled at a constant velocity of 1,8 m/s along a horizontal surface with a coefficient of friction of 0,5.

Calculate the power required to pull the engine. (3)
[11]

QUESTION 5: STATICS

5.1 FIGURE 1 (below) shows a beam in balance.

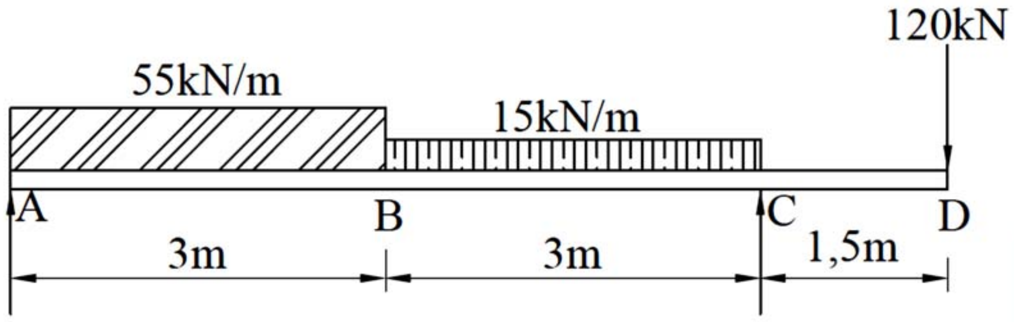

FIGURE 1

Use the information given in FIGURE 1 and calculate the following:

5.1.1 The reaction forces A and C

5.1.2 The bending moments at B and C

(2 × 4) (8)

5.2 FIGURE 2 (below) shows a lamina.

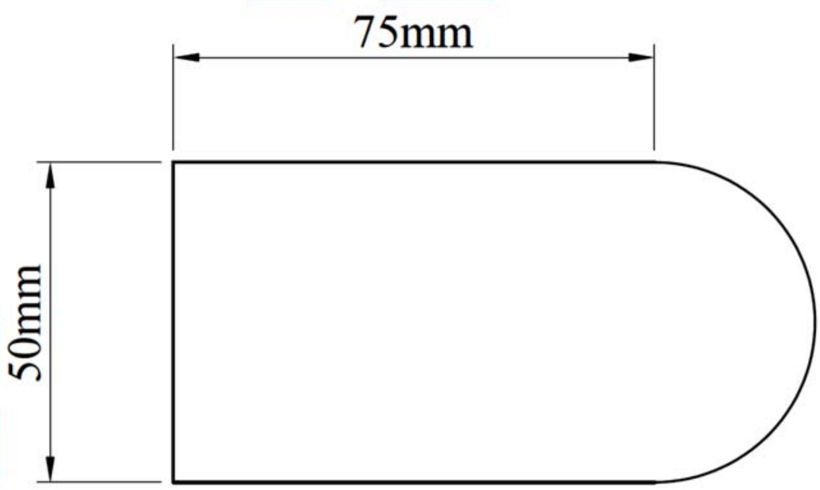

FIGURE 2

Use the information given in FIGURE 2 and calculate the centroid of the lamina. (5)

[13]

QUESTION 6: HYDRAULICS

6.1 The pressure during the delivery of a two-cylinder pump is 575 kPa. The diameter of the plungers is 225 mm and the stroke length is 250 mm.

Calculate the following:

6.1.1 The power to drive the pump at 175 r/min if the efficiency of the motor is 75% (4)

6.1.2 The volume of water delivered per minute in litres if there is a slip of 6% (2)

6.2 The diameter of the ram of a hydraulic jack is 90 mm and the diameter of the plunger is 20 mm. The mechanical advantage is 14 and the stroke of the plunger is 28 mm.

Calculate the following:

6.2.1 The effort applied on the handle required to lift a mass of 1 500 kg if the efficiency is 85% (4)

6.2.2 The number of strokes required to lift the load 42,25 mm (3)

6.3 An accumulator with a ram diameter of 220 mm is used in conjunction with a press and a single-acting hydraulic pump. The press must operate 1,5 strokes per minute while it uses 250 ℓ of water. The stroke of this operation takes 5 s. The plunger of the pump has a diameter of 72 mm and a stroke length of 250 mm.

Calculate the following:

6.3.1 The smallest permissible rise of the ram

6.3.2 The rotational frequency of the pump if there is a slip of 4%

(2 × 3) (6)

[19]

QUESTION 7: STRESS, STRAIN AND YOUNG'S MODULES

7.1 A tensile force of 120 kN is applied to a bronze rod, causing a stress of 28 MPa. The original length of the rod is 4,5 m and Young's modulus for bronze is 96 GPa.

Calculate: the following:

7.1.1 The diameter of the rod

7.1.2 The strain

(2 × 3) (6)

7.2 The compressive stress on a steel pillar with a rectangular profile of 220 mm × 300 mm and a height of 6 m is 200 GPa.

Calculate the working load on the pillar. (3)

7.3 A steel bar is 6 mm × 12 mm and 1,8 m long. It is compressed by a force of 32 kN and has a deformation of 0,37 mm.

Calculate the following:

7.3.1 The stress

7.3.2 The strain

(2 × 3) (6)
[15]

QUESTION 8: HEAT

8.1 A square lead plate has an area of 50 625 mm^2 at 115 °C. The temperature decreases to 25 °C.

Calculate the side lengths of the plate at 25 °C. (4)

8.2 A racing car's tyres are filled with nitrogen gas. At the start of the race the tyre pressure of a single tyre reads 1,95 bar at a temperature of 5 °C. The temperature rises to 32 °C at midday.

Calculate the following:

8.2.1 The tyre pressure at midday if the volume stays the same

8.2.2 The mass of the nitrogen at 5 °C if the gas constant for nitrogen is 297 J/kg.K and the volume of one tyre is 0,57 m^3

(2 × 3) (6)

8.3 A tanker at a diesel depot has a capacity of 35 kℓ at 25 °C. It is filled to capacity with diesel fuel with a coefficient of volume expansion of 950 ×10^{-6}/K.

If the temperature rises to 38 °C, calculate the volume of the diesel in litres. (3)
[13]

TOTAL SECTION B: 90
GRAND TOTAL: 100

FORMULA SHEET

Any other applicable formula may also be used.

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

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

$$v = u + at$$

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

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

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

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

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

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

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

$$v = \omega.R$$

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

$$S = R.\theta$$

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

$$a = \alpha.R$$

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

$$T = FR$$

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

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

$$P = T.\omega$$

$$P = F.v$$

$$F_a = m.a$$

$$E_p = m.g.h$$

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

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

$$m = p \times vol$$

$$P = p.g.h$$

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

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

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

$$Q = mc\Delta t$$

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

$$\beta = 2.\alpha$$

$$\gamma = 3.\alpha$$

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

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

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

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

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

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

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

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

INFORMATION SHEET

PHYSICAL CONSTANTS

QUANTITY	**CONSTANTS**
Atmospheric pressure	101,3 kPa
Density of copper	8 900 kg/m^3
Density of aluminum	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 aluminum	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