higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

27 November 2023 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 pages, a formula sheet and an 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 a blue or black pen and a pencil for drawings.
7. Use g = 9.8 m/s^2.
8. Round all answers of to THREE decimal places.
9. Write neatly and legibly.

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QUESTION 1: KINEMATICS

1.1 A steam train is travelling due north at a velocity of 19 m/s. A woman walks from the back of the train to the front at a velocity of 1,9 m/s.

Calculate the woman's velocity relative to the ground. (2)

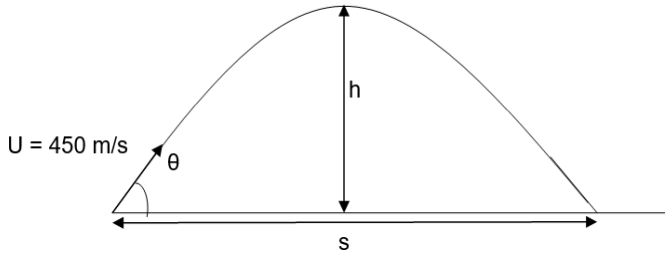
1.2 A scooter is moving at 120 km/h in the direction S 40^{o} E. A car is moving at a velocity of 100 km/h to the east.

What is the relative velocity of the car with respect to that of the scooter? (5)

1.3 A helicopter is flying at 220 km/h in the direction N 65^{o} E while a southeasterly wind is blowing at 45 km/h.

Calculate the resultant velocity in magnitude and direction. (5)

1.4 The diagram below shows the path of a projectile. It takes the projectile 35s to reach the target.



Calculate the angle of projection of the projectile. (3)
[15]

QUESTION 2: ANGULAR MOTION

2.1 In a belt drive system, the tensions on the tight side and the slack side are 800 N and 450 N, respectively.

If the driver pully with diameter 70 mm rotates at 350 rpm, calculate the following:

2.1.1 The effective torque (3)

2.1.2 The power transmitted by the belt (2)

2.2 A flywheel rotates at 3 500 rpm. If the diameter of the wheel is 80 mm, calculate the following:

2.2.1 The angular velocity (3)

2.2.2 The angular displacement after 15 seconds (2)

2.2.3 The circumferential velocity in m/s (2)
[12]

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QUESTION 3: DYNAMICS

3.1 In your own words, write down Newton's first law, also known as the law of inertia. (1)

3.2 A truck with a mass of 4 tons accelerates uniformly from 2 m/s to 10 m/s up an incline of 8º for 45 seconds. The resistance against motion is 500 N.

Calculate the following:

3.2.1 The acceleration (2)

3.2.2 The distance covered when the truck reaches a velocity of 15 m/s (2)

3.2.3 The force needed to cause the acceleration (3)

3.2.4 The total power (2)

3.3 A rock with a mass of 15 kg falls freely from rest and reaches a velocity of 16,4 m/s. Calculate the following:

3.3.1 The initial potential energy

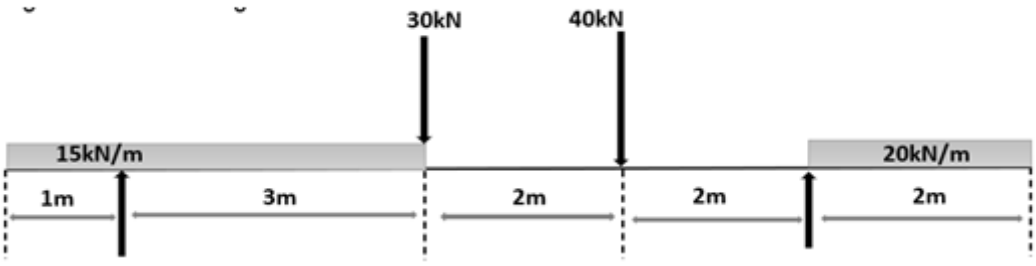
3.3.2 The height through which it falls

(2 × 2) (4)

[14]

QUESTION 4: STATICS

4.1 Study the beam below and answer the questions that follow:

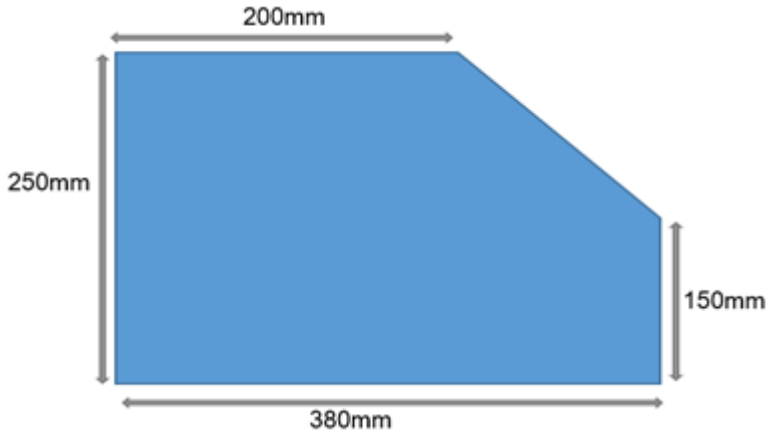


4.1.1 Calculate the magnitude of the reactions. (3)

4.1.2 Draw the shear force diagram. (3)

4.1.3 Calculate the bending moments at the principal points. (4)

4.2 Calculate the distance from the 250-mm side of the shape below to its centroid. (5)



[15]

QUESTION 5: HYDRAULICS

5.1 An effort of 185 N is applied at the end of a lever operating a plunger. The efficiency of the hydraulic press is 82%, while the mechanical advantage is 12. The ratio of the diameters of the ram and the plunger is 8:1.

Calculate the weight of the load that can be exerted by the ram of the hydraulic press. (5)

5.2 A three-cylinder pump with plunger diameters of 125 mm each and stroke lengths of 400 mm has a delivery pressure of 500 kPa.

Calculate the power required to drive the pump at 500 rpm if the efficiency of the motor is 80%. (4)

5.3 A pressure pump has an accumulator to keep a constant pressure in a closed system. The diameter of the accumulator is 200 mm and the mass of the ballast is 900 kg.

5.3.1 Calculate the pressure in the liquid.

5.3.2 Calculate the water stored in litres if the ram is lifted by 2 200 mm.

(3 × 2) (6)

[15]

QUESTION 6: STRESS, STRAIN AND YOUNG'S MODULUS

6.1 Four 1,9-m pipes, having outside diameters of 60 mm and inside diameters of 52 mm each, are used as the legs of a stand.

The maximum compressive stress in the pipe material must not exceed 65 MPa. Young's modulus for the pipe material is 210 GPa.

6.1.1 Calculate the maximum mass that can be placed on the stand. (3)

6.1.2 Calculate by how much the pipes will shorten under the maximum load. (3)

6.2 The following data were obtained by means of a tensile test on a steel rod with a diameter of 20 mm. The distance between the gauge points was 200 mm and the maximum load applied was 121 kN.

Load in kN	0	10	30	50	70	90	110
Extension (x 10^{-3} mm)	0	15	67,5	125	183	237	292

6.2.1 Calculate the stress and strain values at each interval. (6)

6.2.2 Draw the stress-strain graph. (2)

[14]

QUESTION 7: HEAT

7.1 A round bar is heated by 300 K, and its length increases to 2 032,5 mm from an original length of 2 m.

7.1.1 Calculate the linear coefficient of the expansion of the material of the round bar. (2)

7.1.2 State which material was used. (1)

7.2 A glass flask is filled with 45 m^3 paraffin at a temperature of 21 °C. The linear expansion of glass is 8,6 × 10^{-6}/°C and the volumetric expansion of paraffin is 76,4 × 10^{-5}/°C.

If the temperature increases to 45 °C, calculate the volume that will overflow in cm^3. (6)

7.3 80 cm^3 of gas is compressed isothermally from 250 kPa to 400 kPa.

Calculate its final volume in m^3. (3)

7.4 An air bubble at the bottom of a lake has a volume of 0,5 m^3 at a temperature of 5 °C and a pressure of 490 kPa.

Calculate the volume of the bubble when it reaches the surface, where the pressure is 101,3 kPa and the temperature is 29 °C. (3)

[15]

TOTAL: 100

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ENGINEERING SCIENCE N4

FORMULA SHEET

Any applicable formula may also be used.

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

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

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

$$\theta = 2\pi n$$

$$S = R\theta$$

$$\omega = 2\pi N$$

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

$$\omega_2 = \omega_1 + \alpha t$$

$$\omega_2^2 = \omega_1^2 + 2\alpha\theta$$

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

$$v = \omega R$$

$$v = \pi D n$$

$$a = \alpha R$$

$$\tau = FR$$

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

$$P = 2\pi nT$$

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

$$P = T\omega$$

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

$$v = u + at$$

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

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

$$P = Fv$$

$$F_a = ma$$

$$E_p = mgh$$

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

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

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

$$m = \rho \times vol$$

$$P = \rho gh$$

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

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

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

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

$$Q = mc\Delta t$$

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

$$\beta = 2\alpha$$

$$\gamma = 3\alpha$$

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

$$PV = mRT$$

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

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

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

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

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

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

Centroid of half circle 0.424r

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

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

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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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