higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

9 April 2021 (X-paper)
09:00–12:00

This question paper consists of 8 pages, 1 formula sheet and 1 information sheet.

100Q1A2109

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 to calculations must be given correctly to THREE decimal places.

6.. All calculations must contain the following three steps:

   6.1 Formula
   6.2 Replacement of values
   6.3 Answer and correct SI unit

7. Use π = 3,142.

8. Sketches must be done neatly in pencil.

9. Use only a black or blue pen.

10. Write neatly and legibly.

SECTION A

QUESTION 1: GENERAL

Define the following:

1.1 Newton's third law

1.2 Hooke's law

1.3 Stress

1.4 Pascal's law

1.5 Moment of inertia

(5 × 2) **[10]**

TOTAL SECTION A: 10

SECTION B

QUESTION 2: KINEMATICS

2.1 An aircraft can fly at a velocity of 280 km/h with no wind interference. It must fly to an airport 275 km North of its current position. A north-westerly wind with a velocity of 72 km/h is blowing.

2.1.1 Calculate the direction in which the aircraft must fly to get to the airport.

2.1.2 Calculate the time the flight would take.

(3 × 2) (6)

2.2 Bradley kicks a soccer ball at an angle of 32°. The ball has a starting velocity of 23,5 m/s.

Calculate the following:

2.2.1 The height that the ball will reach. (3)

2.2.2 The time it will take for the ball to reach its highest point. (3)

[12]

QUESTION 3: ANGULAR MOTION

3.1 An axle rotates at a velocity 15 r/s, and accelerates uniformly to a velocity of 525 r/s in 6 s.

3.1.1 Calculate the angular acceleration of the axle.

3.1.2 Determine the angular displacement during the 6 s.

(2 × 1) (2)

3.2 An engine block weighs 775 kg. It is hoisted using a lifting device with a drum diameter of 325 mm.

3.2.1 Determine the torque exerted by the engine block on the drum.

3.2.2 Calculate the power if the drum rotates at 18 r/s.

(2 × 1) (2)

[4]

QUESTION 4: DYNAMICS

4.1 A bus with a mass of 5 500 kg travels at a speed of 75 km/h.

4.1.1 Calculate the kinetic energy of the bus. (2)

4.1.2 Calculate the force required when the bus brakes to come to a state of rest over 55 m. (3)

4.2 A bucket of cement with a mass of 35 kg hoisted up to a height of 45 m. It accelerates with an acceleration of 1,6 m/s^2.

4.2.1 Calculate the force needed to accelerate the bucket upwards.

4.2.2 Calculate the work done.

(2 × 2) (4)

4.3 A block of steel with a mass of 17 kg is resting on an incline plane at an angle of 19,5°.

4.3.1 Calculate the frictional force.

4.3.2 Calculate the coefficient of friction.

(2 × 2) (4)

[13]

QUESTION 5: STATICS

5.1 A light beam is loaded as shown in FIGURE 1.

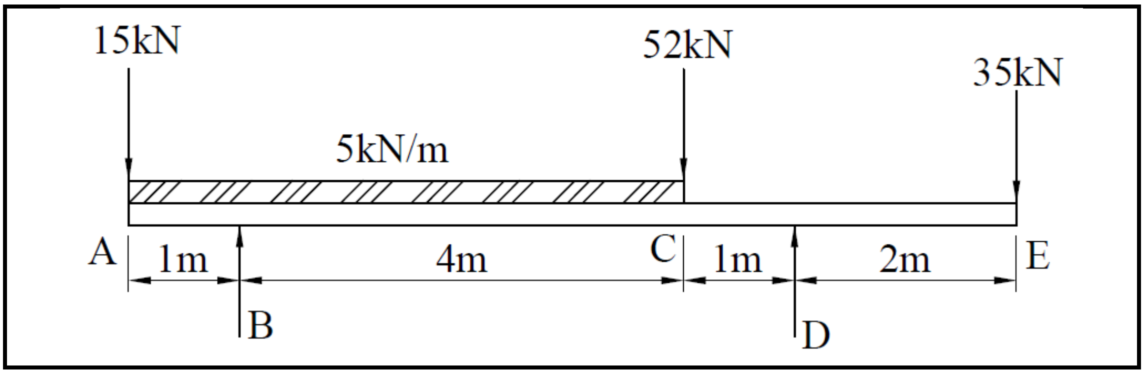


FIGURE 1

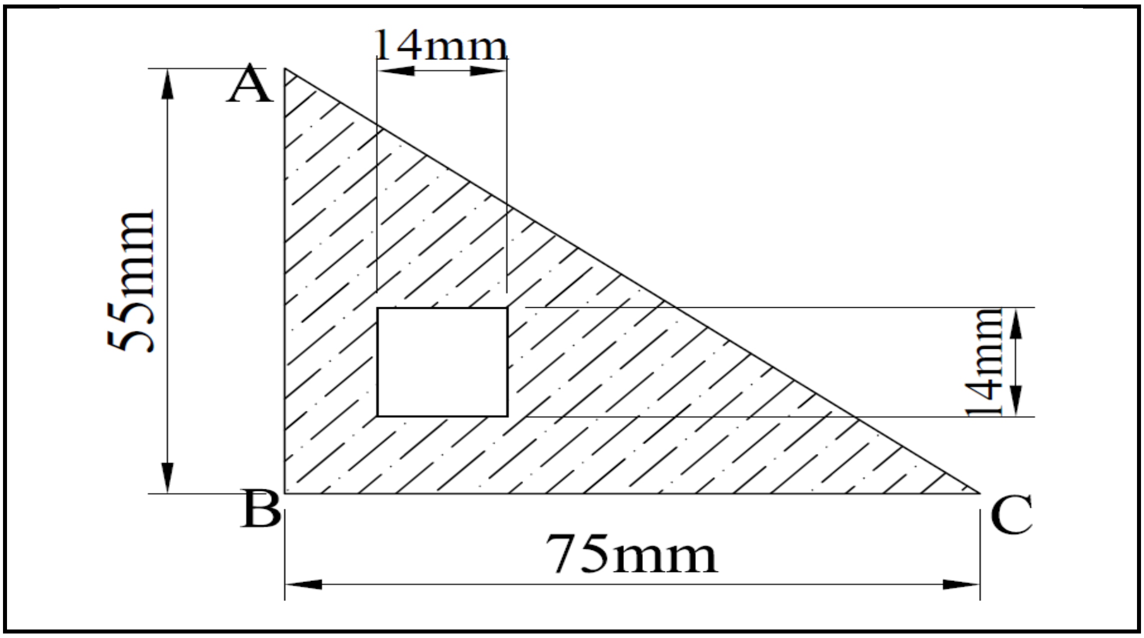
By referring to FIGURE 1 determine the following:

5.1.1 The reaction forces B and D.

5.1.2 Draw the shear force diagram.

(2 × 3) (6)

5.2 Calculate the coordinates of the centroid for the lamina shown in FIGURE 2.



(7)

FIGURE 2

[13]

QUESTION 6: HYDRAULICS

6.1 A mass loaded accumulator has a ram diameter of 450 mm and a mass of 650 kg. A hydraulic pressure of 1,2 MPa is required as constant pressure in the hydraulic system. The ram moves through a distance of 300 mm in 5 s during a working stroke of the machine.

Calculate the following:

6.1.1 The additional mass required to maintain the working hydraulic pressure. (3)

6.1.2 The work done by the ram in the working stroke. (2)

6.1.3 The power transmitted by the ram during the working stroke. (2)

6.2 The plunger of a three cylinder water pump has a diameter of 75 mm and a stroke length of 225 mm. The pressure during the stroke is 775 kPa.

Calculate:

6.2.1 The power required to drive the pump at 175 r/m if the efficiency is 85%. (4)

6.2.2 The volume of water delivered per minute in litres, if there is a slip of 4%. (3)

6.3 A hydraulic press has a ram diameter of 85 mm. The plunger diameter is 15 mm with a stroke of 30 mm. The mechanical advantage on the lever is 11. Calculate the following:

6.3.1 The force needed to lift a mass of 3,5 ton if the efficiency is 75%.

6.3.2 The number of strokes needed to lift the load 150 mm if there is a slip of 6%.

(2 × 3) (6)

[20]

QUESTION 7: STRESS, STRAIN AND YOUNG'S MODULUS

7.1 A steel rod with a length of 4,7 m increases in length by 0,8 mm when a load of 650 kg is added.

7.1.1 Calculate the tensile stress on the rod.

7.1.2 Calculate the strain on the rod.

(2 × 2) (4)

7.2 The following readings were obtained during a tensile test:

Load in kN	0	10	20	30	40	50
Extension in mm	0	0,0151	0,0221	0.0325	0,0465	0,0575

The original diameter at the gauge length-section = 18 mm.
Gauge length = 75 mm.
The gauge length was 86,84 mm and the neck diameter was 12,16 mm at fracture.

Answer the following questions.

7.2.1 Draw a stress strain graph for these values.
(Tip: 10 mm = 10 MPa and 10 mm = 50 × 10^{-6}) (6)

7.2.2 Determine Young's modulus of elasticity with the aid of the graph. (2)

7.2.3 Determine the percentage reduction in area. (2)

[14]

QUESTION 8: HEAT

8.1 A copper ball has a volume of 0,685 m^3 at a temperature of 289 K. If the temperature rises to 347 K calculate the increase in volume of the copper ball. (2)

8.2 The volume of an unknown mass of a given gas at 115 °C and a pressure of 645 kPa is 0,65 m^3. The gas constant is 518J/kg.K.

Calculate the mass of the gas. (3)

8.3 A cylinder is filled with 12 kg of oxygen gas at a pressure of 185 kPa and 21 °C. More oxygen is added to the cylinder until the pressure is 245 kPa at a temperature of 33 °C.

Calculate the amount of oxygen added. (3)

8.4 A glass flask with a capacity of 500 mℓ is filled completely with benzene at a temperature of 12 °C. The linear expansion coefficient of glass is 9×10^{-6}/K and the volumetric expansion coefficient of benzene is $1{,}28 \times 10^{-3}$/K.

Calculate the volume that will overflow if the temperature rises to 42 °C. (6)

[14]

TOTAL SECTION B: 90

GRAND TOTAL: 100

ENGINEERING SCIENCE N4

FORMULA SHEET

Any other applicable formula may also be used.

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

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

$$v = u + at$$

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

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

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

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

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

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

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

$$v = \omega.R$$

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

$$S = R.\theta$$

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

$$a = \alpha.R$$

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

$$T = FR$$

$$AV = T.\theta = W.D$$

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

$$P = T.\omega$$

$$P = F.v$$

$$F_a = m.a$$

$$E_p = m.g.h$$

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

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

$$m = p \times vol$$

$$P = p.g.h$$

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

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

$$AV = m.g.h = W.D$$

$$Q = mc\Delta t$$

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

$$\beta = 2.\alpha$$

$$\gamma = 3.\alpha$$

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

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

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

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

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

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

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

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

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 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