higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

22 November 2017 (X-Paper)
09:00–12:00

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

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. Subsections of questions should be kept together.
5. Rule off across the page on completion of each question.
6. ALL formulae should be shown in the answer. Show ALL the steps in between your answers.
7. Use only BLUE or BLACK ink.
8. ALL sketches and diagrams must be done in pencil.
9. Take g = 9,8 m/s^2.
10. Write neatly and legibly.

QUESTION 1: GENERAL

1.1 Define the following:

1.1.1 The angular displacement

1.1.2 Strain

(2 × 1) (2)

1.2 State the following laws:

1.2.1 Pascal law (1)

1.2.2 Newton's first law of motion (2)

1.2.3 Hook's law (2)

1.3 Discuss Boyle's law in detail (show the statement, equation and the sketch). (4)

1.4 The velocity of a Jet-C fighter plane is 650 km/h. The flight sergeant wants to fly directly west but the southerly wind of 110 km/h blows the plane off course.

Draw a velocity vector diagram of the above in detail. (2)

1.5 1.5.1 State TWO characteristics of liquid. (2)

1.5.2 Name TWO types of hydraulic accumulators. (2)

1.6 What is the direction of the north-easterly wind that is blown at 55 m/s? (1)

1.7 In your own words explain the following:

1.7.1 Pressure is directly proportional to the density of liquid.

1.7.2 The braking force of the moving vehicle is 350 N.

(2 × 1) (2)

[20]

QUESTION 2: KINEMATICS

2.1 A Cheetah-C jet plane flies and covers a displacement of 280 km while a south-westerly wind of 90 km/h blows it off course. The pilot wants to go N35°W within 1 hour 35 minutes.

Calculate the following:

2.1.1 The resultant velocity (2)

2.1.2 The direction of flight in order for the pilot to go N35°W (4)

2.2 Two vehicles start moving simultaneously. Vehicle P moves at 270 km/h W64°N while vehicle Q moves at 200 km/h directly east.

Calculate the velocity of P relative to Q. (4)

2.3 In the commonwealth games that were played last summer, Rosina Madihlaba was the hopeful gold medalist for South Africa. She won a gold medal from one of the fields (high jump) that she participated in at her maximum speed ever of 12,4 m/s at 40° to the ground.

Calculate the following:

2.3.1 The maximum height she jumped

2.3.2 The velocity she needs to jump a maximum height of 4,21 m at 40°

(2 × 2) (4)

[14]

QUESTION 3: ANGULAR MOTION

3.1 Various options are given as possible answers to the following questions. Choose the answer and write only the letter (A–D) next to the question number (3.1.1–3.1.2) in the ANSWER BOOK.

3.1.1 A blue racing car of mass of 1,8 tons races around a circular path of diameter 120 m at a speed of 180 km/h and covers a distance of 35 m.

The angular displacement of the car is …

A 0,835 rad.
B 0,524 rad.
C 0,355 rad.
D 0,583 rad.

3.1.2 The angular velocity of the car is …

A 0,535 rad/s.
B 0,825 rad/s.
C 0,582 rad/s.
D 0,833 rad/s.

(2 × 2) (4)

3.2 A machine has a torque of 228 Nm at its spindle. The diameter of the spindle is 68 cm and the rotational frequency of the spindle is 12,5 rad/s.

3.2.1 The power exerted is …

A 1,85 kW.
B 2,55 kW.
C 1,58 kW.
D 2,85 kW.

3.2.2 If the efficiency of the machine is 94%, the input power of the machine is …

A 2,30 kW.
B 3,30 kW.
C 3,032 kW.
D 2,30 kW.

(2 × 2) (4)
[8]

QUESTION 4: DYNAMICS

4.1 A soccer star is travelling with a car of a mass of 880 kg on a horizontal road at a velocity of 30 m/s. He immediately applies the brakes so as to stop 50 m away (he was successful). The resistance to motion on the horizontal road is 295 N.

Calculate the following:

4.1.1 The deceleration of the car (2)

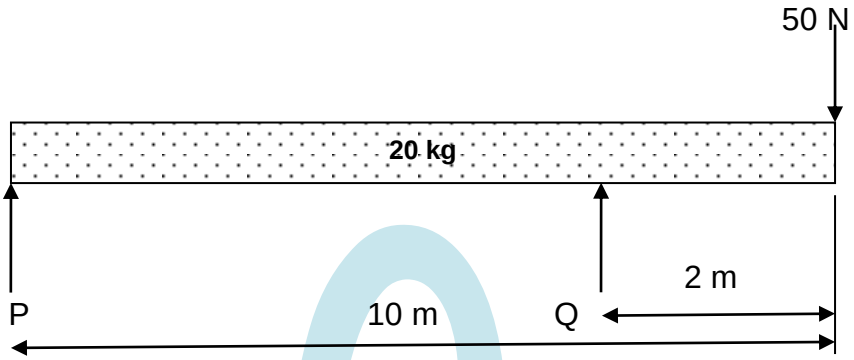
4.1.2 The braking force (4)

4.2 An engine exerts a force of 40 000 N on a vehicle and draws it up an incline of 550 00 N and draws it up an incline plane of 1 : 150 against a resistance of 80 N/ton. The total mass of the engine and the vehicle is 280 ton.

Calculate the acceleration of the vehicle. (3)
[9]

QUESTION 5: STATICS

5.1



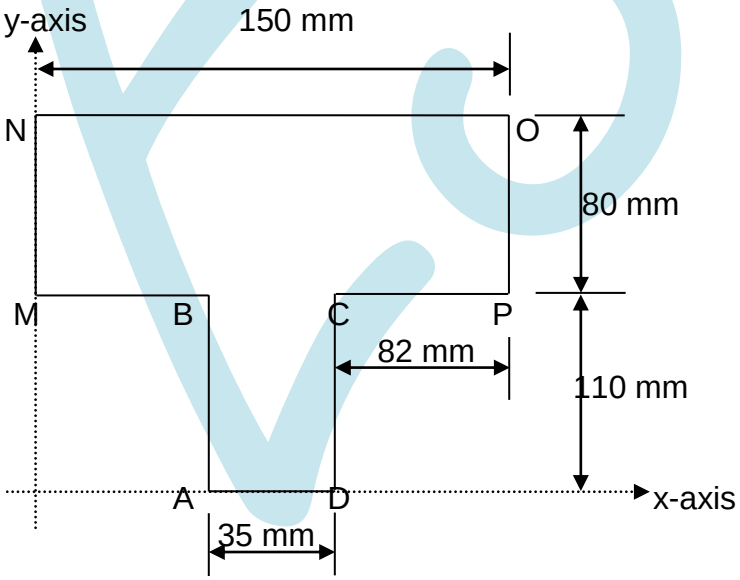
5.1.1 Calculate the magnitude of the supports. (2)

5.1.2 Draw a shear-force diagram in detail. (2)

5.1.3 Determine the bending moments at main principal points. (3)

5.1.4 Draw the bending moment diagram in detail. (3)

5.2 Calculate the position of the centroids of laminae from the x-axis (from AD).



(5)
[15]

QUESTION 6: HYDRAULICS

6.1 The data below refer to a single-acting hydraulic press.

Diameter of the ram piston = 440 mm
Diameter of the plunger piston = 100 mm
Stroke length of the plunger = 130 mm
Mechanical advantage of the plunger = 22

Calculate the following:

6.1.1 The effort force that must be applied to the handle to lift a load of 4,8 Mg if the efficiency is 92% (5)

6.1.2 The distance the load will be raised after 150 pumping strokes of the plunger if the efficiency is 92% (4)

6.2 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 litres per second if the slip is 1,8%. (3)

6.3 The borehole pumps water from a depth of 65 m at a rate of 320 litres/minute. The installation efficiency of the borehole pump is 75%.

Determine the power of the driving pump of the electric motor. (3)
[15]

QUESTION 7: STRESS, STRAIN AND YOUNG'S MODULUS OF ELASTICITY

7.1 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)

7.2 The following is the calculated stress-strain results of the data obtained from a tensile test carried out on metal test by ISCOR.

STRESS-STRAIN TABLE

Stress ($\times 10^6$)	0	14	28	42	56	84	112
Strain ($\times 10^{-4}$)	0	2	4	6	8	13	18,4

7.2.1 Use the table above to draw a neat stress-strain graph in detail (use reasonable scales). (3)

7.2.2 Use the graph in QUESTION 7.2.1 to determine the value of the Young's modulus of elasticity of the material. (3)
[9]

QUESTION 8: HEAT

8.1 A 90 litre cylinder is filled with nitrogen to capacity at a pressure of 20,11 kPa. If the cylinder enlarges, the pressure drops to 11 kPa.

Calculate the increase in the volume of the cylinder. (2)

8.2 A circular copper disc has a radius of 0,44 m at 22 °C. The linear expansion coefficient of the copper material is 20×10^{-6} /°C.

Calculate the increase in the volume of the cylinder:

8.2.1 The increase in the diameter of the disc if the final temperature is increased to 84 °C (3)

8.2.2 The increase in the area of the disc if the final temperature is raised to 140 °C (2)

8.3 0,61 kg of nitrogen at an absolute pressure of 100 kPa and with a volume of 521 litres has a temperature of 27 °C.

Calculate the gas constant for nitrogen. (3)
[10]

TOTAL: 100

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FORMULA SHEET

Any applicable formula may also be used.

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

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

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

$$\theta = 2\pi n$$

$$S = R\theta$$

$$\omega = 2\pi N$$

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

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

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

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

$$v = \omega R$$

$$v = \pi D n$$

$$a = \alpha R$$

$$\tau = FR$$

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

$$P = 2\pi n T$$

$$P = Fv$$

$$P = T\omega$$

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

$$v = u + at$$

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

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

$$P = Fv$$

$$F_a = ma$$

$$E_p = mgh$$

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

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

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

$$m = \rho \times vol$$

$$P = \rho g h$$

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

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

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

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

$$Q = mc\Delta t$$

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

$$\beta = 2\alpha$$

$$\gamma = 3\alpha$$

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

$$PV = mRT$$

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

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

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

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

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

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

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