higher education
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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

3 April 2019 (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. Sketches must be large, neat and fully labelled.
5. Use $g = 9{,}8\ m/s^2$.
6. Write neatly and legibly.

QUESTION 1: GENERAL

1.1 1.1.1 State Pascal's law in full. (2)

1.1.2 Give a relevant example of Newton's second law of motion in the form of a scenario.

NOTE: Do NOT state the law. (2)

1.2 Define the following.

1.2.1 Strain on a material due to external force. (2)

1.2.2 Shear force (1)

1.3 Name TWO types of hydraulic accumulators. (2)

1.4 Draw a complete triangular velocity vector diagram of the following:

A flight sergeant flies directly east to Hoedspruit Air Force Base at 280 km/h. She is then blown off course by a south-westerly wind of 170 km/h. (2)

1.5 Draw a detailed stress strain graph from the data below taken from the tensile test of iron material at Iscor.

NOTE: Use scale 10 mm = 25 MPa for the y-axis and 10 mm = 2×10^{-4} for the x-axis. (3)

Stress (MPa)	**0**	**50,9**	**101,9**	**152,8**	**203,8**	**254,7**	**305,7**	**300,6**	**290,4**
Strain ($\times 10^{-4}$)	**0**	**2,5**	**5,1**	**7,2**	**10,2**	**12,8**	**15,3**	**18,4**	**20,2**

[14]

QUESTION 2: KINEMATICS

2.1 A plane takes off from Wonderboom airbase in a direction N 40° W at a speed of 360 km/h. It is then blown off course by a wind of 120 km/h from a direction W 30°S.

Determine the resultant velocity with its direction. (5)

2.2 Two vehicles start moving simultaneously, vehicle P at 270 km/h W 33° N and vehicle Q at 220 km/h directly east.

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

2.3 A rocket is launched from a canon on the ground at an angle to hit an office 220 m above the ground in a building.

Determine the angle of projection necessary to hit the office. (4)

[13]

QUESTION 3: ANGULAR MOTION

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 (3.1.1–3.2.3) in the ANSWER BOOK.

3.1 A racing car with mass of 1,8 tons races around a circular track with a diameter of 120 m at a speed of 280 km/h and covers a distance of 45 m.

3.1.1 The angular displacement of the car is …

A 0,835 rad.
B 0,750 rad.
C 0,735 rad.
D 0,850 rad.

3.1.2 The angular velocity of the car is …

A 1,532 rad/s.
B 1,256 rad/s.
C 1,296 rad/s.
D 1,523 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 13,5 rad/s.

3.2.1 The power exerted is …

A 2 218 W.
B 3 078 W.
C 2 583 W.
D 3 218 W. (2)

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

A 2 304 W.
B 3 310 W.
C 3 274 W.
D 2 303 W. (2)

3.2.3 The angular velocity of the machine is …

A 13,5 rad/s.
B 10,55 rad/s.
C 12,5 rad/s.
D 12,662 rad/s. (1)

[9]

QUESTION 4: DYNAMICS

A motorcar of 1 200 kg is at rest at the top of a 15 m frictionless slope of 28° to the ground. When the brakes of the motorcar are loosened, it slides on its own down the hill to the bottom and immediately moves onto the horizontal road on its own until it comes to rest after 20 m.

Determine the following:

4.1 Potential energy of the motorcar at the top of the slope (2)

4.2 Velocity of the motorcar after it has moved 8 m down the slope. Use the applications of the conservation of energy for this calculation. (4)

4.3 Deceleration of the motorcar on the horizontal road (3)

4.4 Kinetic energy after moving 20 m on the horizontal road (1)
[10]

QUESTION 5: STATICS

5.1 A beam with a mass of 20 kg has a length of 10 m and is supported by A and B which are 7 m apart. B is 3 m from the right end of the beam. There is also a concentrated load of 30 N on this right end of the beam.

NOTE: Supports A and B: A = 43,143 N; B = 182,857 N

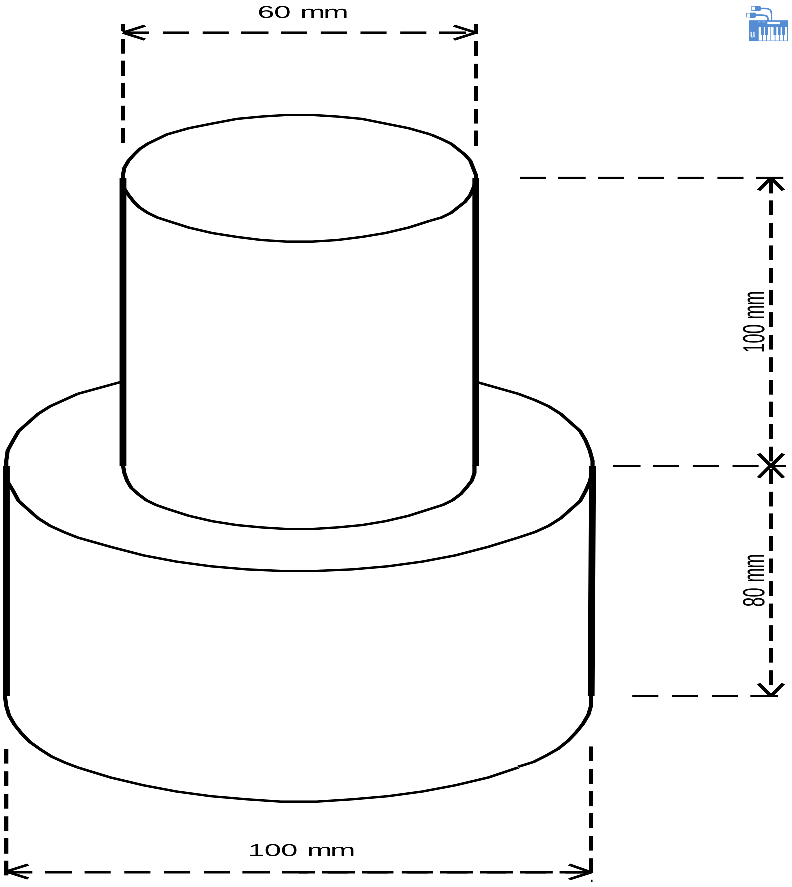
5.1.1 Draw a neat, detailed sketch of the beam. (2)

5.1.2 Draw a neat, detailed shear force diagram. (2)

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

5.1.4 Draw a detailed bending moment diagram. (3)

5.2 From the FIGURE below, determine the position of the centre of gravity, Y (from the bottom upwards).



(5)
[15]

QUESTION 6: HYDRAULICS

6.1 An effort force of 310 N is applied to the lever of a hydraulic press, and the stroke length of the plunger is 120 mm. The mechanical advantage of the lever is 20. The diameter of the plunger is a third of that of the ram.

Determine the following:

6.1.1 Load of the object lifted by the ram if the efficiency is 93% (5)

6.1.2 Number of operating strokes if the object in QUESTION 6.1.1 is lifted for 410 mm. The diameter of the ram is 360 mm and the efficiency of the hydraulic press is 93%. (3)

6.2 Water with a volume of 8 m^3 per minute is pumped at an efficiency of 87% into a local community dam with a height of 42 m.

Calculate the pump required to pump this water. (4)

6.3 The plunger piston of a three-cylinder, single-acting piston has a diameter of 210 mm and a stroke length of 480 mm. It pumps water at a speed of 444 r/min. There is slip of 11,5%.

Calculate the volume of water delivered in litre/s. (3)
[15]

QUESTION 7: STRESS AND STRAIN

7.1 A square bar with sides of 40 mm and a length of 800 mm is machined to a diameter of 30 mm and a length of 520 mm. The stress in the round surface is due to a tensile stress of 380 MPa.

Young's modulus of elasticity of the material of the bar is 116 GPa.

Determine the following:

7.1.1 Stress in the square surface

7.1.2 Total extension of the bar

(2 × 3) (6)

7.2 A bar with a diameter 35 mm and a length of 650 mm is subjected to a tensile force of 80 kN which causes elongation of 0,311 mm.

Determine the following:

7.2.1 Stress in the bar

7.2.2 Strain

(2 × 2) (4)
[10]

QUESTION 8: HEAT

8.1 The temperature of 25 °C of a 3 m rod rises by 380 °C while the length of the rod increases to 3,024 m.

8.1.1 Determine, by means of calculation, the linear coefficient of expansion of the material of the rod. (2)

8.1.2 Which material was used for the rod? (1)

8.2 A cylindrical tank contains 12 kg of air at 170 kPa at temperature of 21 °C. When more air is added to the tank the pressure rises to 310 kPa at a temperature of 35 °C. The gas constant is 287 J/kgK.

Determine the amount of air added to the tank (in kg). Also determine the original volume and the final volume of the gas in the tank. (6)

8.3 A cylinder contains 0,208 m^3 of gas at a pressure of 1 850 kPa and a temperature of 20 °C. The temperature decreases to 2 °C while the volume remains constant.

Determine the following:

8.3.1 Pressure at 2 °C (2)

8.3.2 Pressure when the volume changes to 0,089 m^3 while the temperature changes to 2 °C (3)

[14]

TOTAL: 100

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FORMULA SHEET (Useful information)

Any applicable formula may also be used.

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

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

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

$$\theta = 2\pi n$$

$$S = R\theta$$

$$\omega = 2\pi N$$

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

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

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

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

$$v = \omega R$$

$$v = \pi D n$$

$$a = \alpha R$$

$$\tau = FR$$

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

$$P = 2\pi n T$$

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

$$P = T\omega$$

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

$$v = u + at$$

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

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

$$P = Fv$$

$$F_a = ma$$

$$E_p = mgh$$

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

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

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

$$m = \rho \times vol$$

$$P = \rho g h$$

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

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

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

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

$$Q = mc\Delta t$$

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

$$\beta = 2\alpha$$

$$\gamma = 3\alpha$$

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

$$PV = mRT$$

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

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

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

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

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

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

Centroid of half circle 0.424r

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

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

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
Heat value of hydrogen	140 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 aluminum	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