higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

1 August 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 State each of the following laws fully:

1.1.1 Boyle's gas law. Show the graph as well as the relevant equation. (3)

1.1.2 Newton's third law. Give a relevant example in the form of a scenario. (3)

1.2 Define each of the following:

1.2.1 Bending moment (1)

1.2.2 Elasticity (2)

1.2.3 Angular acceleration (1)

1.3 Name TWO types of stresses. (2)

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

An aeroplane flies at 280 km/h directly W35°N to Hoedspruit Air Force Base. It then blown off course by a southwesterly wind of 170 km/h. (2)

1.5 Name TWO hydraulic accumulators. (2)

[16]

QUESTION 2: KINEMATICS

2.1 An aeroplane flies at 200 km/h east while subjected to a southwesterly wind of 112 km/h.

Determine the resultant velocity.

2.2 The velocity of object P is 120 km/h east while that of object Q relative to P is 234,307 km/h W33,671° N. The direction of object Q is N30°W.

Determine the velocity of object Q.

2.3 It took a cannon 6 seconds after it had been launched from the ground at a velocity of 420 m/s to hit an enemy tank at a horizontal distance of 1295 m.

Determine the angle at which the cannon was launched.

(3 × 4) **[12]**

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 (3.1.1–3.2.2) in the ANSWER BOOK.

3.1 The flywheel of a drill machine uniformly rotates from 280 r/min to 50 r/min in 2 seconds.

3.1.1 The angular retardation of the flywheel is …

A -19,167 rad/s2.
B -24,086 rad/s2.
C -24,086 rad/s2.
D -416,182 rad/s2.

3.1.2 The number of revolutions made during this retardation is …

A 1,999.
B 7,238.
C 2,75.
D 4,343.

(2 × 2) (4)

3.2 A machine has a torque of 350 Nm at its spindle. The diameter of the spindle is 0,74 m and its rotational frequency is 130 per minute.

3.2.1 The magnitude of the load around the spindle is …

A 884,821 N.
B 726,213 N.
C 945,956 N.
D 744,286 N.

3.2.2 The work done by the machine during 35 seconds is …

A 50,248 kJ.
B 61,942 kJ.
C 44,562 kJ.
D 55,312 kJ.

(2 × 2) (4)
[8]

QUESTION 4: DYNAMICS

4.1 A car with a mass of 1 200 kg is travelling on a horizontal plane at 120 km/h in a 60 km/h zone. The driver notices a speed trap 30 m away and applies the brakes so that the car moves at 60 km/h through the speed trap. The resistance to motion on the plane is 0,183 N/kg.

Determine each of the following:

4.1.1 Deceleration of the car (2)

4.1.2 Braking force on the car (3)

4.1.3 Time taken to reach the speed trap after the brakes were applied. (2)

4.1.4 Kinetic energy of the car after having moved 20 m after the brakes had been applied (2)

[9]

QUESTION 5: STATICS

5.1 Study DIAGRAM 1 below to answer the questions.

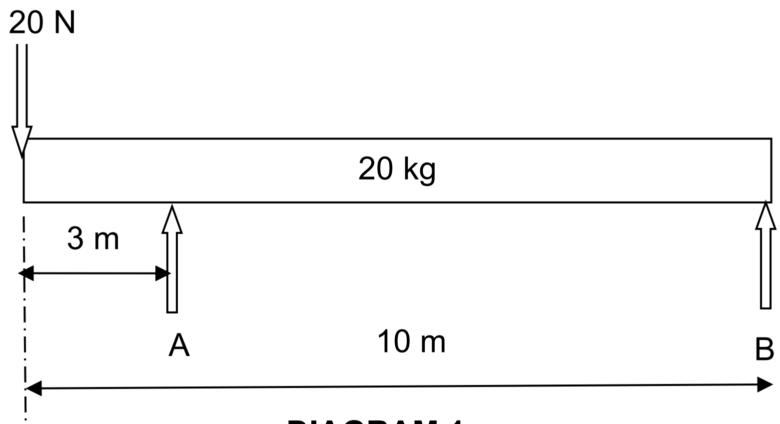

DIAGRAM 1

5.1.1 Determine the magnitudes of the supports A and B. (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 Study DIAGRAM 2 below to determine the position of the distance of the lamina from AB (y value). The hole in the triangle has a diameter of 20 mm.

HINT: h= 77,942 mm

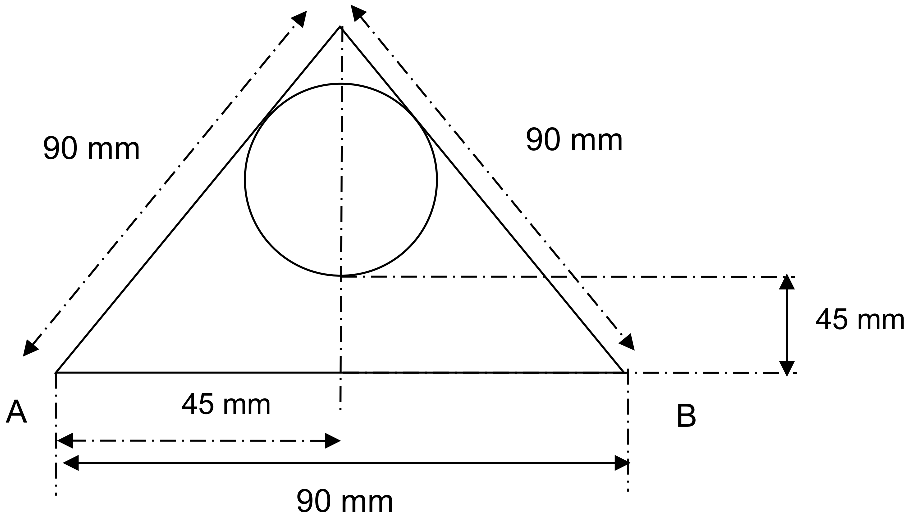

DIAGRAM 2 (5)

[15]

QUESTION 6: HYDRAULICS

6.1 An effort of 210 N is applied to the lever of a hydraulic press. The stroke length of the plunger is 120 mm. The mechanical advantage of the lever is 18. The diameters of the plunger and the ram are 110 mm and 290 mm respectively.

Determine each of the following:

6.1.1 Mass 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 and the efficiency is 93% (3)

6.2 The diameter of the piston of a water pump is 210 mm. The water pump delivers 0,412 m^3 of water per operating stroke. The operating force on the piston is 7,5 kN.

Determine each of the following:

6.2.1 Stroke length (3)

6.2.2 Work done per operating stroke (2)

6.3 Calculate the height of a circular dam with a diameter of 20 m if 250,248 kJ of work is needed to pump ALL the water from the dam using irrigation sprinklers with a pressure of 380 Pa. (3)

[16]

QUESTION 7: STRESS AND STRAIN

7.1 During a tensile test on a round bar with an original diameter of 30 mm and an original length of 100 mm, the gauge length was 111,310 mm and the neck diameter was 21,22 mm at fracture. Young's modulus of elasticity of the material of the bar is 210 GPa.

Determine each of the following:

7.1.1 Percentage extension of gauge length

7.1.2 Percentage reduction in area of gauge length

(2 × 3) (6)

7.2 When a tensile test of 90 kN was done on a round bar with a diameter of 80 mm and a length of 0,981 m the extension length was 0,1181 mm.

Determine each of the following:

7.1.1 Stress caused

7.1.2 Strain acquired

7.1.3 Young's modulus of elasticity of the material of the bar

(3 × 2) (6)

[12]

QUESTION 8: HEAT

8.1 A container with dimensions 500 mm × 200 mm × 600 mm at 20 °C is heated and the temperature changes by 245 °C. The linear coefficient of expansion of the material of the container is 12,5 × 10-6/K.

Determine each of the following:

8.1.1 Expansion in length of the longest side (3)

8.1.2 Increase in volume of the container (2)

8.2 A cylinder at a temperature of 20 °C contains 0,208 m^3 of gas at a pressure of 1850 kPa. The temperature then decreases to 2 °C while the volume remains constant.

Determine each of the following:

8.2.1 Pressure at 2 °C (2)

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

8.3 Name the type of gas law applied in QUESTION 8.2.2 and give a reason for the answer. (2)

[12]

TOTAL: 100

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FORMULA SHEET

Any other applicable formula may also be used.

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

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

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

$\theta = 2\pi n$

$S = R\theta$

$\omega = 2\pi N$

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

$\omega_2 = \omega_1 + \alpha t$

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

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

$v = \omega R$

$v = \pi D n$

$a = \alpha R$

$\tau = FR$

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

$P = 2\pi n T$

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

$P = T\omega$

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

$v = u + at$

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

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

$P = Fv$

$F_a = ma$

$E_p = mgh$

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

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

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

$m = \rho \times vol$

$P = \rho g h$

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

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

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

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

$Q = mc\Delta t$

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

$\beta = 2\alpha$

$\gamma = 3\alpha$

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

$PV = mRT$

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

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

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

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

$\overline{y} = \frac{A_1 y_1 \pm A_2 y_2 \ldots}{A_1 \pm A_2 \ldots}$

$\overline{y} = \frac{v_1 y_1 \pm v_2 y_2 \ldots}{v_1 \pm v_2 \ldots}$

Centroid of half-circle: 0.424

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

Centre of gravity of 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 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