higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

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09:00–12:00

This question paper consists of 9 pages, 1 formula sheet and 1 information sheet.

100Q1A2006

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. Use g= 9,8 m/s^2.
6. Write neatly and legibly.

SECTION A: GENERAL

QUESTION 1

1.1 Discuss any scenario in which Newton's first law of motion is applicable. (2)

NOTE: Do not state the law

1.2 Define each of the following:

1.2.1 Angular acceleration

1.2.2 Stress

(2 × 2) (4)

1.3 Show the relationship:

1.3.1 Between the linear, area, and the volume coefficient of expansions. (2)

1.3.2 Between volume, pressure, and temperature in the combination of Bayles' and Charles' gas laws. (1)

1.3 State Hooke's law. (1)

[10]

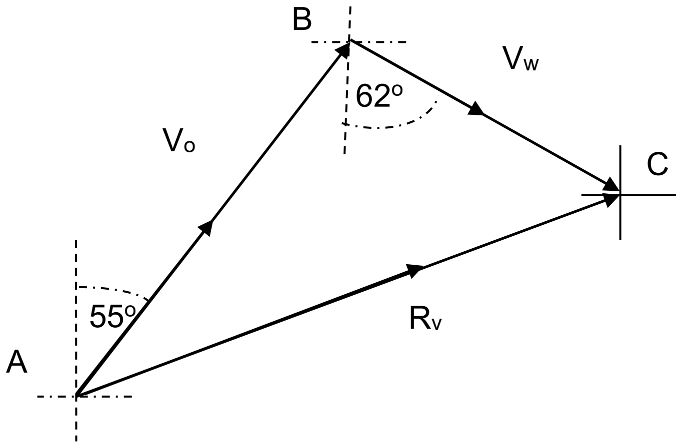
QUESTION 2

Various options are given as possible answers to the following questions Choose the correct answer and write only the letter (A–D) next to the question number (2.1–2.9) in the ANSWER BOOK.

2.1 The direction of a southwesterly wind is …

A N 45° W.
B S 45°E.
C N 45°E.
D S 45°W. (1)

2.2



The above sketch represents a plane flying at 140 km/h N55°E blown off-course by a wind of 80 km/h at E28°S.

NOTE: Vo: velocity of object/plane; V_w: velocity of the wind; R_v: resultant velocity.

2.2.1 The correct magnitude of the resultant velocity of the plane is …

A 87,470 km/h.
B 169,499 km/h.
C 190,183 km/h.
D 124,434 km/h. (2)

2.2.2 The correct direction of the resultant velocity of the plane is …

A E22,012°N
B N77,012°E
C E22,012° N
D E67,998°N (2)

2.3 When a gardener mowing a lawn starts pushing the mower with three times as much force as previously, therefore producing three times as much acceleration, it is an example of the application of …

A Newton's first law of motion.
B Newton's second law of motion.
C Newton's third law of motion.
D the law of conservation of energy. (1)

2.4 When a canon is projected on the moon, it will keep moving nonstop unless it hits another object on the way. This is an application of …

A the law of conservation of energy.
B Newton's first law of motion.
C Newton's second law of motion.
D Newton's third law of motion. (1)

2.5 ONE of the following is a characteristic of liquid:

A Liquid takes the shape of its container.
B Liquid depends on a pressure.
C Water and hydraulic fluid can be used once.
D Liquid has no definite volume. (1)

2.6 The kelvin equivalent of 80 °C is …

A 243 K.
B 273 K.
C 13 K.
D 353 K. (1)

2.7 Boyle's gas law:

A At a constant temperature, the pressure exerted on a gas is directly proportional to the volume.
B At a constant pressure the volume is directly proportional to the temperature.
C At a constant temperature the pressure is inversely proportional to the volume.
D At a constant pressure the volume is inversely proportional to the temperature. (1)

2.8 A stress of 5 kPa would be exerted on a surface area of square bar with sides 0,5 m by a force of …

A 982 N.
B 1250 N.
C 393 N.
D 3927 N. (2)

2.9 A square container with a volume of $0,238 \times 10^{-3} m^3$ and a temperature of 100 K expands and increases its volume by $1,05 \times 10^{-4}$ m^3 while the temperature rises by 150 K. Therefore, the coefficient of volume expansion of the square container is …

A $26,471 \times 10^{-4}$ /K
B $29,412 \times 10^{-4}$ /K
C 88235×10^{-4} /K
D $44,118 \times 10^{-4}$ /K (2)

[14]

TOTAL SECTION A: 24

SECTION B

QUESTION 3: KINEMATICS

3.1 A missile launched from the beach hit an approaching war ship on a horizontal plane 55 km away at sea. The missile was launched at 520 km/h and at 50° from the ground.

Investigate the total time in minutes it took the missile to hit the warship. (4)

3.2 A fighter plane Q flies at 250 km/h east while the velocity of fighter plane P is 210 km/h W53°S.

Determine the velocity of fighter lane $_PV_Q$. (5)

[9]

QUESTION 4: ANGULAR MOTION

4.1 Calculate the rotational frequency made by the wheels of a train in r/min if it moves at the velocity of 280 km/h. The diameter of the wheel of the train is 720 mm. (2)

4.2 The speed of a flywheel increases from 444 r/min to 2 840 r/min in 0,58 minutes.

Calculate each of the following:

4.2.1 Angular acceleration of the flywheel (3)

4.2.2 Number of revolutions made during this acceleration (3)

[8]

QUESTION 5: DYNAMICS

A vehicle with a mass of 980 kg accelerates uniformly up a slope of 1:45 from 6 m/s to 21 m/s within 35 seconds. The resistance to motion is 0,459 N/kg.

Calculate each of the following:

5.1 Acceleration of the vehicle (2)

5.2 Accelerating force of the vehicle (2)

5.3 Total force (4)

[8]

QUESTION 6: STATICS

6.1 A beam of 10 m is supported by A and B which are 10 m apart. A is on the left side of the beam. The beam carries a 50 N/m distributed load of 5 m on the left side and a concentrated load of 40 N at 2 m from the right.

NOTE: A = 94,5 N, B = 195,5 N

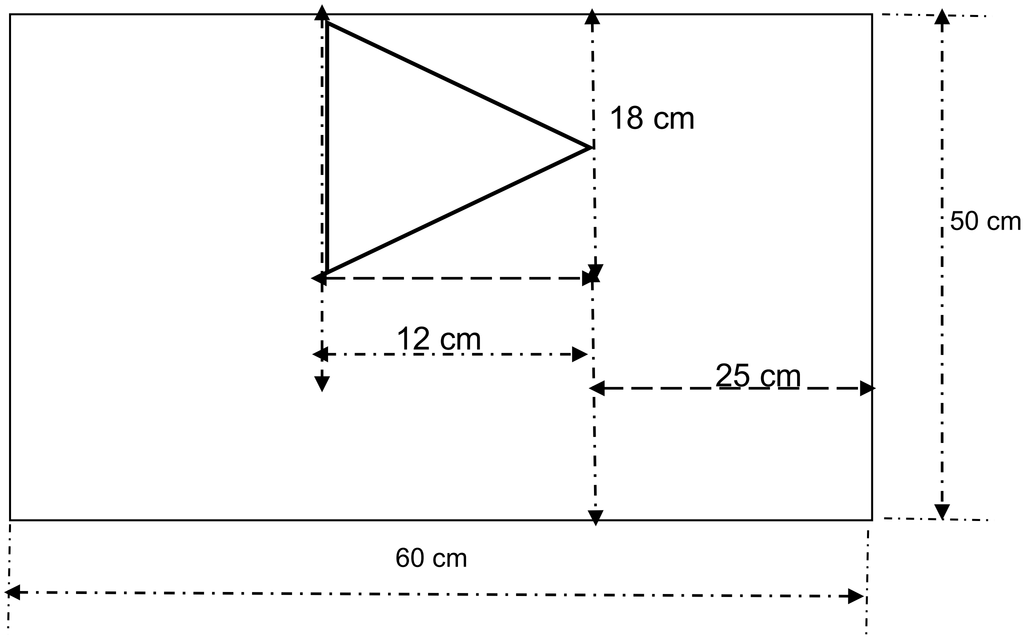
6.1.1 Draw a detailed, labelled sketch of the beam. (2)

6.1.2 Draw a detailed shear force diagram. (2)

6.1.3 Draw a detailed bending-moment diagram. (3)

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

6.2 A rectangular lamina of dimensions 60 cm × 50 cm with a triangular whole of a base of 18 cm is shown below.



Determine the position of the centre of the lamina from the y-axis. (X) (5)

[15]

TOTAL SECTION B: 40

SECTION C

QUESTION 7: HYDRAULICS

7.1 An irrigation system fills an empty circular dam with a diameter of 50 m and a height of 28 m with a pressure of 250 kPa.

Determine each of the following:

7.1.1 Amount of work needed to fill the dam to capacity (3)

7.1.2 Time in hours it will take to drain the dam if a power of 840 kW was applied (2)

7.2 The diameter of a ram is thrice that of a plunger with a stroke length of 110 mm. The mechanical advantage of the lever is 22.

Calculate the force needed to be applied by the lever/handle to lift a load of 2,2 Mg if the efficiency is 91%. (5)

7.3 A double-cylinder single-action piston pump with a diameter of 70 mm and a stroke length of 150 mm is designed to deliver water at a rate of 0,027 litres/second.

Determine the operating speed in r/min if the efficiency is 94%. (4)

[14]

QUESTION 8: STRESS, STRAIN, AND YOUNG'S MODULUS OF ELASTICITY

8.1 A round bar with a diameter of 32 mm and a length of 820 mm is subjected to a tensile force of 52,332 kN and therefore increases its length by 0,621 mm.

Calculate each of the following:

8.1.1 Stress obtained by the bar (3)

8.1.2 Strain (2)

8.1.3 Young's modulus of elasticity of the material of the bar (2)

8.2 A cage with a mass of 1,8 ton is lowered down a hole by a wire with diameter of 5 mm and a length of 50 m. The wire ultimately stretches by 8 mm.

Investigate Young's modulus for the material of the wire. (3)
[10]

QUESTION 9: HEAT

9.1 A container with dimensions of 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:

9.1.1 Expansion in length of the longest side (2)

9.1.2 Increase in volume of the container (3)

9.2 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 pressure remains constant.

Determine each of the following:

9.2.1 Volume at 2 °C (2)

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

9.2.3 Name the type of gas law applied in QUESTION 9.2.2 and give a reason for your answer. (2)
[12]

TOTAL SECTION C: 36
GRAND TOTAL: 100

ENGINEERING SCIENCE N4

FORMULA SHEET

Any applicable formula may also be used.

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

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

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

$\theta = 2\pi n$

$S = R\theta$

$\omega = 2\pi N$

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

$\omega_2 = \omega_1 + \alpha t$

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

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

$v = \omega R$

$v = \pi D n$

$a = \alpha R$

$\tau = FR$

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

$P = 2\pi n T$

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

$P = T\omega$

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

$v = u + at$

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

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

$P = Fv$

$F_a = ma$

$E_p = mgh$

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

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

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

$m = \rho \times vol$

$P = \rho g h$

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

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

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

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

$Q = mc\Delta t$

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

$\beta = 2\alpha$

$\gamma = 3\alpha$

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

$PV = mRT$

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

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

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

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

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

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

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 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