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Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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APRIL EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

2 April 2015 (Y-Paper)
13:00–16:00

This question paper consists of 7 pages and a formula 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. ALL formulae should be shown in the answers. Show ALL calculations.
5. Answers should be in blue or black ink.
6. ALL diagrams should be in pencil.
7. Subsections of questions should be kept together.
8. Rule OFF across the page after each section.
9. Determine the answers correctly to THREE decimal digits where necessary.
10. Take $g = 9{,}8\ m/s^2$.
11. Write neatly and legibly.

QUESTION 1

1.1 An object is projected vertically upwards from ground level and reaches the ground again after 10 seconds.

Calculate:

1.1.1 The velocity of projection from ground level (2)

1.1.2 The maximum height reached by the object (3)

1.2 The velocity of an aeroplane in still air is 350 km/h. The pilot wants to fly directly east, but experiences a cross-wind of 50 km/h from the north.

Calculate the resultant velocity of the aeroplane in magnitude and direction. (4)

1.3 During an air show aeroplane A flies due North at 900 km/h and aeroplane B flies West 15° South at 850 km/h.

Calculate the velocity of A relative to the velocity of B in magnitude and direction. (5)

[14]

QUESTION 2

2.1 Define angular acceleration. (1)

2.2 The spin drier of a washing machine rotating at 800 r/min slows down uniformly to 300 r/min in 30 revolutions.

Calculate:

2.2.1 The angular displacement of the spin drier (2)

2.2.2 The angular acceleration (3)

2.2.3 The time required to turn through 30 revolutions (2)

2.3 A force of 200 N is applied to the end of a spanner. The perpendicular distance between the nut and the working line of the force is 0,6 m.

Calculate:

2.3.1 The torque (1)

2.3.2 The work done when the nut is turned through an angle of 60° (3)

[12]

QUESTION 3

3.1 Define Newton's first law of motion. (1)

3.2 A train with a mass of 150 Mg is attached to a locomotive with a draw bar. The train is uniformly accelerated from rest on a horizontal track. The resistance to motion is 6 N per Mg of the mass of the train. The force in the draw bar is 33 kN.

Calculate:

3.2.1 The acceleration of the train (3)

3.2.2 The work done over a distance of 2 km (2)

3.3 A ball with a mass of 6 kg rolls from rest down a frictionless incline of 1 : 20, over a distance of 20 m.

Calculate:

3.3.1 The loss in potential energy

3.3.2 The velocity of the ball after 20 m by making use of the law of the conservation of energy.

(2 × 3) (6)

[12]

QUESTION 4

4.1 A beam ABCDE, with A on the left-hand side, is 10 m long and simply supported at A and D. D is 2 m from E. Point loads of 50 N and 30 N are at B (2 m from A) and E respectively. An evenly distributed load of 2 N/m is between A and D. C is a point half way between B and D.

4.1.1 Make a neat labelled drawing of the beam. (1)

4.1.2 Calculate the reaction forces at supports A and D. (4)

4.1.3 Calculate the bending moments at B, C and D. (3)

4.1.4 Draw the shearing force and bending moment diagrams with the main values indicated on the diagrams. (6)

4.2 Calculate the position of the centroid from MO of the lamina shown in FIGURE 1.

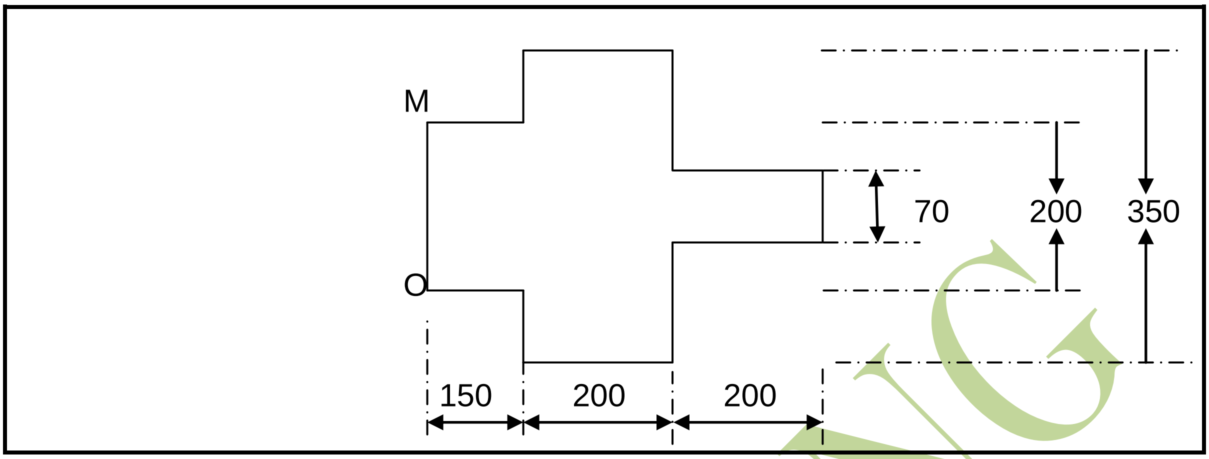

FIGURE 1

(4)
[18]

QUESTION 5

5.1 The ram of a hydraulic lift exerts a force of 25 kN when a force of 400 N is applied to the plunger. The diameter of the plunger is 75 mm.

Calculate:

5.1.1 The fluid pressure (3)

5.1.2 The diameter of the ram cylinder (2)

5.2 The force on the plunger of a water pump is 20 kN and the work done during a delivery stroke is 3 kJ. The diameter of the plunger is 150 mm.

Calculate:

5.2.1 The pressure during a delivery stroke (3)

5.2.2 The volume of water displaced during a delivery stroke (2)

5.2.3 The stroke length (2)

5.3 A hydraulic lift is used together with an accumulator and a single-acting hydraulic pump. The ram has a diameter of 250 mm and the pump supplies 100 litres of water per minute. The lift needs 250 litres of water to lift 2 m.

Calculate:

5.3.1 The volume of water to be supplied by the accumulator to lift 2 m in 20 seconds

5.3.2 The descent of the accumulator piston during the 20 seconds

(2 × 2) (4)
[16]

QUESTION 6

6.1 Define Young's modulus of elasticity. (2)

6.2 An elastic rod is 5 m long and has a 1,5 cm^2 cross-sectional area. The rod stretches 0,075 mm when a mass of 350 kg is attached to its free end.

Calculate:

6.2.1 The stress

6.2.2 The strain

6.2.3 Young's modulus for the material

(3 × 2) (6)

6.3 Two plates 12 mm thick and 75 mm wide are joined together by means of a single rivet of 20 mm diameter. The safe tensile stress in the plates is 350 MPa.

Calculate the shear stress in the rivet.

Use the formula:

$$\sigma_t(w-d)t = N\frac{\pi d^2}{4}\tau$$

where
w = width of plate
d = diameter of rivet
t = plate thickness
τ = shear stress
σ_t = tensile stress
N = number of rivets (4)

[12]

QUESTION 7

7.1 Define Boyle's law. (2)

7.2 A square metal plate 300 mm × 300 mm is at a temperature of 20 °C.

Calculate the increase in area if its temperature rises to 90 °C. The coefficient of linear expansion of the metal is 20×10^{-6}/°C. (3)

7.3 The temperature of a copper bar with a diameter of 50 mm and a length of 1 m is increased by 95 °C. The increase in volume is 9 513 mm^3.

Calculate:

7.3.1 The percentage increase in volume (3)

7.3.2 The coefficient of linear expansion of the copper (2)

7.4 The volume of 1 mole of oxygen is 22,5 litres at 20 °C at a pressure of 1×10^5 Pa.

Calculate:

7.4.1 The pressure required to compress 1 mole of oxygen into a 5 litre container at a temperature of 150 °C?

7.4.2 The maximum temperature permitted to hold this mass of oxygen in the 5 litre container if the pressure is not to exceed $3,5 \times 10^5$ Pa?

(2 × 3) (6)

[16]

TOTAL: 100

ENGINEERING SCIENCE N4

FORMULA SHEET

Any applicable formula may also be used.

$S = \frac{u+v}{2} \times t$	$a = \alpha R$	$H.V. = \frac{F_p}{F_h} = M.A.$
$\overline{V} = \frac{s}{t}$	$v = \pi DN$	$AV = mgh = WD$
$v = u + at$	$T = FR$	$Q = mc\Delta t$
$s = ut + \frac{1}{2}at^2$	$AV = T\theta = WD$	$\Delta l = l_o \alpha \Delta t$
$v^2 = u^2 + 2as$	$P = 2\pi NT$	$\beta = 2\alpha$
$v_g = \frac{u+v}{2}$	$P = Fv$	$\gamma = 3\alpha$
$\omega = 2\pi N$	$P = T\omega$	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
$\omega = \frac{\theta}{t}$	$F_a = ma$	$PV = mRT$
$\theta = \frac{\omega_2 + \omega_1}{2} \times t$	$E_p = mgh$	$\in = \frac{x}{l}$
$\omega_2 = \omega_1 + \alpha t$	$E_k = \frac{1}{2}mv^2$	$E = \frac{\sigma}{\in}$
$\theta = \omega_1 t + \frac{1}{2}\alpha t^2$	$P = \frac{F}{A}$	$\sigma = \frac{F}{A}$
$v = \omega R$	$m = \rho \times vol$	$E = \frac{Fl}{Ax}$
$\theta = 2\pi n$	$P = \rho gh$	$\bar{y} = \frac{A_1y_1 \pm A_2y_2 \ldots}{A_1 \pm A_2 \ldots}$
$S = R\theta$	$\frac{W_r}{F_p} = \frac{D^2}{d^2}$	$\bar{y} = \frac{v_1y_1 \pm v_2y_2 \ldots}{v_1 \pm v_2 \ldots}$
$\alpha = \frac{\omega_2^2 - \omega_1^2}{2\theta}$	$W.D. = P \times V = A.V.$	