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Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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APRIL 2011

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

6 April (X-Paper)
09:00 – 12:00

Calculators may be used.

This question paper consists of 6 pages, 1 diagram sheet and a 1-page 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. Subsections of questions must be kept together.
4. Rule off on completion of each question.
5. ALL formulae used must be shown. Show ALL intermediate steps.
6. Questions must be answered in blue or black ink.
7. ALL the sketches and diagrams must be done in pencil in the ANSWER BOOK.
8. Number the answers correctly according to the numbering system used in this question paper.
9. Take $g = 9,8\ m/s^2$.
10. Write neatly and legibly.

QUESTION 1

1.1 A light aircraft is 60 km north east from OR Tambo International Airport and it flies north for six hours at a velocity of 96 km/h.

Determine its position (displacement) with reference to OR Tambo International Airport in magnitude and direction. (6)

1.2 In a gold mine shaft, a depth of 233 m, hoist K descends at 6,48 km/h and hoist L ascends at 5,04 km/h.

Calculate the following:

1.2.1 The velocity of hoist K relative to the velocity of hoist L in magnitude and direction (2)

1.2.2 The velocity of hoist L relative to the velocity of hoist K in magnitude and direction (2)

1.3 A stone is thrown at a velocity of 42 m/s at an angle of 26° to the horizontal.

Calculate the following:

1.3.1 The maximum height that the stone reaches (3)

1.3.2 The horizontal displacement of the stone (2)
[15]

QUESTION 2

2.1 Define *angular velocity.* (2)

2.2 A point on the rim of a wheel with a diameter of 1,76 m has a velocity of 396 km/h.

Calculate the following:

2.2.1 The rotational frequency of the wheel in revolutions per minute (3)

2.2.2 The angular velocity of the wheel in rad/s (2)

2.2.3 The number of revolutions made by the wheel during 36 minutes (2)
[9]

QUESTION 3

3.1 Define Newton's first law of motion. (2)

3.2 Calculate the power required to pull a mass of 160 kg at a constant velocity of 360 km/h down a plane which makes an angle of 25° with the horizontal. The friction force is 728 N. (5)

3.3 A motorbike is travelling on a horizontal road at a velocity of 60 km/h. The mass of the motorbike is 800 kg and the resistance to motion is 510 N. The motorbike stops over a distance of 40 m when the brakes are applied.

Calculate the following:

3.3.1 The deceleration of the motorbike (2)

3.3.2 The braking force of the motorbike (3)

[12]

QUESTION 4

4.1 Explain the difference between centroid and centre of gravity. (2)

4.2 A light, uniform beam ABCDE is 7 m long and is supported by two supports as shown in FIGURE 1, DIAGRAM SHEET 1 (attached).

Calculate the following:

4.2.1 The reaction forces of supports at B and D (3)

4.2.2 The bending moments at points B, C and D (3)

4.2.3 The magnitude of the maximum bending moment and its position (2)

4.2.4 Draw a shearing force and bending moment diagrams and show ALL the principal values or main values on the diagrams. (NO marks will be allocated if principal values or main values are not indicated on the diagrams.) (5)

[15]

QUESTION 5

5.1 Define the unit *pascal*. (2)

5.2 Define *Pascal's law*. (2)

5.3 The following data refers to a single-acting hydraulic press:

- Area of plunger = 25 % of ram area
- Stroke of plunger = 0,161 m
- Force applied to the plunger = 560 N
- Area of the ram piston = 0,524 m^2

Neglect ALL the losses.

Calculate the following:

5.3.1 The volume of liquid displaced by the plunger in 12 pumping strokes (2)

5.3.2 The distance moved by the ram piston in mm after 1 pumping stroke of the plunger (3)

5.3.3 The force exerted by the ram piston (2)

5.3.4 The mechanical advantage of the press (2)

5.3.5 The fluid pressure in the liquid (2)

5.4 A 3 cylinder, single-acting pump is pumping water. The plunger piston has a diameter of 171 mm and a stroke length of 300 mm and runs at a speed of 230 r/min. There is a slip of 16%.

(1 000 litres = 1 000 kg = 1 m^3 of water)

Calculate the volume of water delivered in litres/minute. (5)

[20]

QUESTION 6

6.1 What is the difference between the Kelvin scale and the Celsius scale? (2)

6.2 The surface of seawater at a certain point has a temperature of 27 °C at a pressure of 1 atmosphere (101,325 kPa). The temperature at the bottom of the sea is 10 °C. An air bubble with a diameter of 16 mm is let loose. Calculate the depth of the ocean at this point if the bubble has a diameter of 42 mm when it reaches the surface.

Volume of sphere = $4/3\,\pi r^3$

HINT: Calculate the difference in pressure at the top and the bottom, and then use the relevant formula to determine the depth.
Density of water = 1 000 kg/ m^3 (7)

6.3 A square metal plate with sides 3,5 m long is at a temperature of 31 °C. It has a hole of 920 mm in the centre. The linear coefficient of expansion of the metal is $14{,}5 \times 10^{-6}$ /°C.

Calculate the following:

6.3.1 The temperature of the metal plate if it is heated until the sides are 3,57 m long each (3)

6.3.2 The diameter of the hole at the final temperature (3)
[15]

QUESTION 7

The following results were obtained by means of a tensile test on a carbon steel specimen, having an original diameter of 33 mm and an original length of 50 mm (gauge length).

At the limit of proportionality the load was 91 kN and the extension is 0,0443 mm. The load at an upper yield point was 105 kN and the maximum load recorded was 185 kN. When the two pieces were fitted together after fracture, the length was measured and determined as 70 mm. The neck diameter was 15 mm.

7.1 Draw a neat, labelled load/extension diagram to demonstrate the above information. (3)

Calculate the following:

7.2 The stress at the limit of proportionality (2)

7.3 Young's modulus of elasticity for carbon steel (2)

7.4 The maximum tensile stress in the specimen (2)

7.5 The percentage elongation of the specimen (2)

7.6 The percentage decrease in the cross section area (3)
[14]

TOTAL: 100

DIAGRAM SHEET 1

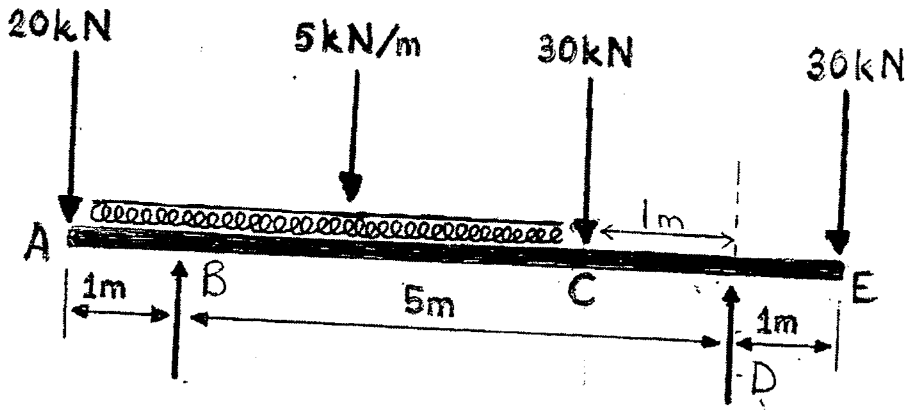

FIGURE 1

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FORMULA SHEET

Any applicable formula may also be used.

$S = \frac{u + v}{2} \times t$

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

$v = u + at$

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

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

$v_g = \frac{u + v}{2}$

$\omega = 2\pi N$

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

$\theta = \frac{\omega_2 + \omega_1}{2} \times t$

$\omega_2 = \omega_1 + \alpha t$

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

$v = \omega R$

$\theta = 2\pi n$

$S = R\theta$

$\alpha = \frac{\omega_2^2 - \omega_1^2}{2\theta}$

$a = \alpha R$

$v = \pi DN$

$T = FR$

$AV = T\theta = WD$

$P = 2\pi NT$

$P = Fv$

$P = T\omega$

$F_a = ma$

$E_p = mgh$

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

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

$m = \rho \times vol$

$P = \rho gh$

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

$W.D. = P \times V = A.V.$

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

$AV = mgh = WD$

$Q = mc\Delta t$

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

$\beta = 2\alpha$

$\gamma = 3\alpha$

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

$PV = mRT$

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

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

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

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

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

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