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higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T620**(E)**(M27)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

27 March 2013 (X-Paper)
09:00–12:00

Calculators may be used.

This question paper consists of 6 pages 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. Number the answers according to the numbering system used in this question paper.
4. Subsections of questions should be kept together. Draw a line after each question.
5. ALL formulae should be shown in the answer. Show all the steps in-between your answers.
6. Answers should be in blue or black ink.
7. ALL the sketches and diagrams should be done in pencil in the ANSWER BOOK.
8. Take g = 9,8 m/s^2.
9. Write neatly and legibly.

QUESTION 1

1.1 A small passenger boat, the 'Sunshine', leaves Cape Town harbour at a velocity of 80 km/h in a north-westerly direction. A freight ship, 'The Carrier', leaves Cape Town harbour simultaneously at a velocity of 50 km/h in a direction west 30° south.

Calculate the velocity (in magnitude and direction) of the 'Sunshine' relative to the velocity of 'The Carrier'. (5)

1.2 A canoeist is rowing on the Vaal dam at a velocity of 4 m/s in a northerly direction. A wind of 3 m/s suddenly starts blowing in a south-easterly direction.

Calculate the resultant velocity of the canoe in magnitude and direction. (5)

1.3 A soccer player kicks a ball at an angle of 20° to the horizontal. The initial velocity of the ball is 20 m/s. The soccer ball travels the path of a projectile.

Calculate the following:

1.3.1 The time taken by the ball to reach the maximum height (2)

1.3.2 The maximum height reached by the ball (2)

1.3.3 The horizontal displacement of the ball (3)

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QUESTION 2

2.1 Explain the difference between linear velocity and angular velocity. (2)

2.2 A point on the circumference of a wheel of a locomotive has a velocity of 108 km/h. The diameter of the wheel is 80 cm. The velocity of the point on the wheel increases to 126 km/h during 50 seconds.

Calculate the following:

2.2.1 The initial and final angular velocities of the point on the wheel in rad/s (2)

2.2.2 The angular acceleration of the wheel (2)

2.2.3 The angular displacement of the wheel in radians during the acceleration (2)

2.3 A force of 50 N is applied to the end of a door handle in order to open the door. The effective length of the door handle is 15 cm.

Calculate the following:

2.3.1 The torque on the door handle (2)

2.3.2 The work done on the door handle when it is turned through an angle of 45° (3)

[13]

QUESTION 3

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

3.2 A tractor is pulling a trailer with a mass of 4 ton up a hill with an incline of 5° at a constant velocity of 36 km/h. The trailer is experiencing a tractive resistance of 6 000 N.

Calculate the power required by the engine of the tractor if the efficiency of the engine is only 75%. (5)

3.3 A cyclist is travelling on a horizontal road at 10 m/s when noticing a stop sign 100 metres ahead. The brakes are applied and the bicycle comes to rest next to the stop sign. The resistance against motion is 5 newtons and the mass of the cyclist and bicycle is 75 kg.

Calculate the following:

3.3.1 The acceleration of the cyclist (2)

3.3.2 The total breaking force required to bring the bicycle to a standstill (3)

[12]

QUESTION 4

A light, horizontal beam ABCDE with A at the left-hand side is 12 metres long. It is supported at two points, A and D. A and D are 10 metres apart. At B, 5 metres from A, is a concentrated load of 10 kN. A concentrated load of 6 kN is at C, 4 metres to the right of B. A concentrated load of 5 kN is at E, at the right end of the beam. There is a uniformly distributed load of 5 kN/m between points A and B.

4.1 Make a neat, labelled diagram of the beam as described above.

(**HINT:** Draw this diagram on a separate page and draw the diagrams in QUESTION 4.4 and QUESTION 4.6 below the diagram.) (1)

4.2 Calculate the reactions of the supports at points A and D and test your answers. (3)

4.3 Calculate the bending-moments at B, C, D and at a point, F, halfway between A and B. (3)

4.4 Draw a shear-force diagram and show ALL the main values on the diagram. (3)

4.5 Calculate the magnitude of the maximum bending moment. (4)

4.6 Draw a neat bending-moment diagram and show ALL the main values on the diagram. (2)

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QUESTION 5

5.1 Define the unit *pascal.* (1)

5.2 The plungers of a three-cylinder, single-acting pump have diameters of 6 cm each and stroke lengths of 20 cm each. The pressure during the delivery stroke is 1,2 MPa.

Calculate the following:

5.2.1 The power required to drive the pump at 150 r/min if the efficiency of the motor is only 75% (5)

5.2.2 The volume of water delivered per minute if there is a 2% slip (3)

5.3 A simple-acting hydraulic jack with a lever is used to lift car engines in a workshop. The information below refers to the jack:

Diameter of ram cylinder	=	100 mm
Stroke length of the plunge	=	40 mm
Diameter of the plunger	=	20 mm
Mechanical advantage of the lever	=	15

Calculate the following:

5.3.1 The effort that must be applied to the handle to lift an engine of 1 ton if the efficiency of the handle is only 80% (3)

5.3.2 The number of strokes needed by the plunger to lift the load by 500 mm if there is a slip of 6% (3)

[15]

QUESTION 6

6.1 Name TWO types of stresses found in materials. (2)

6.2 A steel pillar with a diameter of 40 cm is used to support part of a balcony. The pillar is subjected to a stress of 8 MPa.

Calculate the maximum load allowed on the steel pillar. (3)

6.3 A square cast-iron bar is placed under 50 kN pressure.

6.3.1 Calculate the dimensions of the bar if the stress in the bar is not to exceed 300 kN. (3)

6.3.2 If the bar has a length of 20 cm before the load is applied, and a final length of 20,002 cm after the load is applied, then calculate the strain in the bar. (2)

6.4 Write down the positions of the following:

6.4.1 The centroid of a thin circular plate with a radius *r*, resting on a point on its circumference (1)

6.4.2 The centre of gravity of a solid cube with a volume of $V = l^3$ (2)

[13]

QUESTION 7

7.1 Define *Boyle's law* and write down an equation to correspond with this law. (2)

7.2 Define *Charles' law* and write down an equation to correspond with this law. (2)

7.3 A solid steel ball with a volume of 50 cm^3 is at a temperature of 20 °C and has to increase to 50,6 cm^3 to be able to fit through a hole.

Calculate to which temperature the ball has to be heated to in order to fit through the hole. The steel has a linear coefficient of expansion of 12×10^{-6} /K. (3)

7.4 A given mass of chlorine gas has a volume of 40 cm^3 at 20 °C. Calculate its volume at 50 °C if the pressure remains constant. (3)

7.5 The density of oxygen is 1,42 kg/m^3 at standard temperature and pressure (STP). Calculate the density of oxygen at 30 °C and a pressure of $0,9 \times 10^5$ Pa.
The gas constant, R for oxygen is 261,311J/kgK. (4)

[14]

TOTAL: 100

ENGINEERING SCIENCE N4

FORMULA SHEET

Any applicable formula may also be used.

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