higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T590**(E)**(M31)T
APRIL EXAMINATION

NATIONAL CERTIFICATE

ENGINEERING SCIENCE N4

(15070434)

31 March 2016 (X-Paper)
09:00–12:00

This question paper consists of 6 pages and 1 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.
5. Rule off across the page after each section.
6. ALL formulas and calculations should be shown in the answers.
7. Answers should be in blue or black ink.
8. ALL diagrams should be in pencil.
9. Take $g = 9{,}8\ m/s^2$
10. Determine the answers correctly to THREE decimal digits where necessary.
11. Write neatly and legibly.

QUESTION 1

1.1 An object is projected at such an angle that the range (horisontal displacement) is three times the maximum height reached. The initial velocity of the object is 270 m/s.

Calculate the angle that the object is projected at. (5)

1.2 Two speedboats leave Port Elizabeth harbour simultaneously. Boat Q travels South at 104 km/h and Boat P travels South-West at 127 km/h.

Calculate the velocity of boat Q relative to the velocity of boat P in magnitude and direction. (5)

1.3 A light aircraft with airspeed of 300 km/h takes off at OR Tambo airport in a direction of South 33° West. The aircraft is blown off course by heavy wind blowing at 138 km/h from a direction North 49° West.

Calculate the resultant velocity of the aircraft in magnitude and direction. (5)
[15]

QUESTION 2

2.1 A race car with a mass of 1 ton races around a curve with a radius of 37 m at a speed of 120 km/h.

Calculate the following.

2.1.1 The angular velocity of the race car in rad/s. (3)

2.1.2 The angular displacement in radians if the length of the curve is 47 m. (2)

2.2 The torque on a driver pulley, which is driven by a motor, is 750 N.m. The power output of the driver pulley is 75 kW.

Calculate the rotational frequency of the motor in r/s. (4)
[9]

QUESTION 3

3.1 A truck that travels on a level road at 90 km/h can stop in a distance of 27m using only its brakes.

Calculate the velocity from which it can be brought to a stop in the same distance, when descending a hill with an angle of $\text{Sin}^{-1}(1/25)$.

NOTE: The coefficient of friction remains constant. (7)

3.2 Calculate the power that is needed to pull a mass of 160 kg at a constant velocity of 7 m/s down a plane which makes an angle of 13° with the horisontal.

The frictional force is 400 N. (5)
[12]

QUESTION 4

A light, uniform beam ABCDE is 8 m long and is supported by two supports, each 1 m from the end. Consider the following loads that the beam carries and then answer the questions that follow.

- A concentrated or point load of 25 kN at the left end
- A concentrated or point load of 35 kN 2 m from the right end
- A concentrated or point load of 35 kN at the right end
- A uniformly distributed load of 5 kN/m across the first 6 m from the left end

4.1 Make a neat labelled drawing of the beam described above. (2)

4.2 Calculate the reaction forces at the supports. (3)

4.3 Calculate the bending moments at the points where there are supports and also 6 m from the left end. (3)

4.4 Draw a diagram showing the shearing force and bending moments and show ALL the main or principal values on the diagram.

NOTE: NO marks will be allocated if main or principal values are NOT indicated on the diagrams. (5)

4.5 Determine the magnitude of the maximum bending moment and its position. (2)
[15]

QUESTION 5

5.1 Describe the function of a hydraulic accumulator. (2)

5.2 Name TWO types of accumulators except for the one mentioned in QUESTION 5.1. (1)

5.3 The following data refers to a single-acting hydraulic jack.

Diameter of the piston	=	12,5% of the diameter of the ram
Plunger stroke length	=	100 mm
Mechanical advantage on the lever	=	25
Efficiency	=	85%

Calculate the following.

5.3.1 The force that needs to be applied to the lever to lift a load of 6 tons. (6)

5.3.2 The number of pumping strokes needed to lift the load if there is no slip. (3)

5.4 A force of 43 kN is applied to the plunger of a water pump. The diameter of the plunger is 22 cm. The work done during the delivery stroke is 15 kJ.

Calculate the following.

5.4.1 The stroke length of the plunger. (2)

5.4.2 The pressure in the water during the delivery stroke. (2)

5.4.3 The volume of water displaced in ℓ/s if the pump is running at 400 r/min with a slip of 13%. (4)

[20]

QUESTION 6

6.1 Write down the ratio between the coefficients of area expansion and volume expansion. (2)

6.2 Mercury with a volume of 400 mm^3 is in a glass flask at a temperature of 16 °C. The linear expansion coefficient of mercury is 7×10^{-5}/°C and the linear expansion coefficient of the glass is 10×10^{-6}/°C.

Calculate the following.

6.2.1 The increase in volume of the mercury when it is heated to a temperature of 51 °C. (2)

6.2.2 The overflow of mercury in a 400 mm^3 flask when it is full at 16 °C and then heated to a temperature of 51 °C. (4)

6.3 The volume of carbon monoxide gas at a temperature of 5 °C and a pressure of 185 kPa is 0,26m^3.

Calculate the following:

6.3.1 The final temperature (t_2) in °C. (1)

6.3.2 The volume of carbon monoxide gas when its temperature decreases by 28 °C and the pressure is kept constant. (3)

6.3.3 The mass of carbon monoxide if the gas constant is 288 J/kg. (3)

[15]

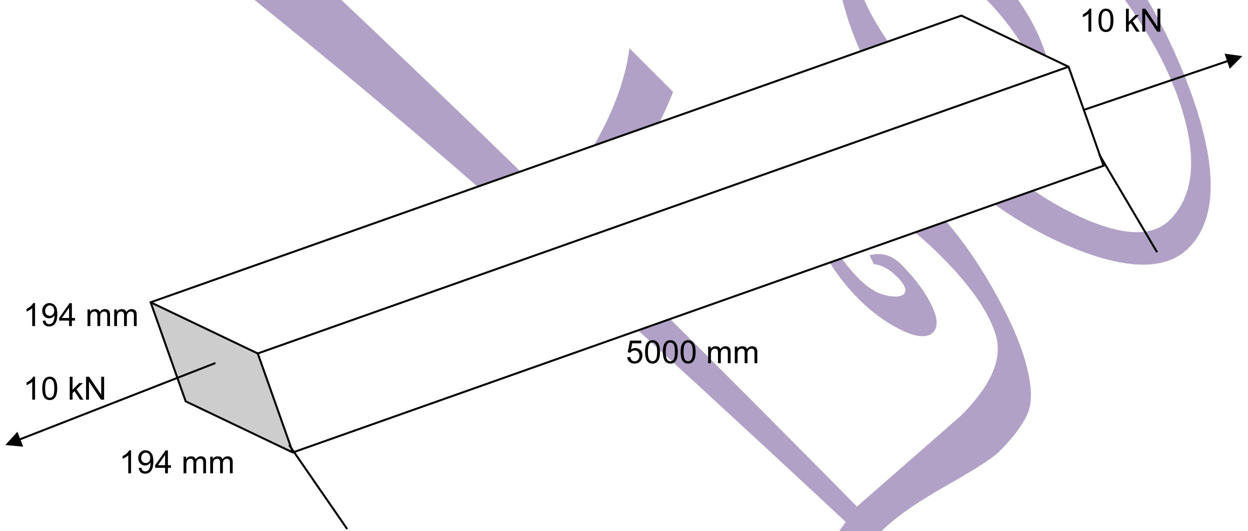
QUESTION 7

7.1 Define *Hooke's law.* (2)

7.2 The ratio between the outside diameter and the inside diameter of a pipe is 3,2 and the length is 720 mm when the pipe is not subjected to a load (force). When a tensile load or force of 312 kN is applied to the pipe, the length increases by 0,138 mm. Young's modulus of elasticity for the pipe is 200 GPa.

Calculate the outside and the inside diameters of the pipe. (7)

7.3 The diagram below shows a tensile load of 10 kN that is applied to a square bar with 194 mm sides and a length of 5 m. The change in length is 0,231 mm.



Calculate the following.

7.3.1 The stress (2)

7.3.2 The strain (2)

7.3.3 Young's modulus of elasticity (1)

[14]

TOTAL: 100

FORMULA SHEET

Any other applicable formula may also be used.

$S = \frac{u+v}{\mathbf{2}}$ x t	$a = \alpha R$	$H.V = \frac{F_p}{F_h} = M.A$
$V = \frac{s}{t}$	$v = \Pi DN$	$AV = mgh = WD$
$v = u + at$	$T = FR$	$Q = mc\Delta t$
$s = ut + \frac{1}{2}at^2$	$AV = T\Theta = WD$	$\Delta l = {}_{lo}\alpha\Delta t$
$v^2 = u^2 + 2as$	$P = 2\Pi NT$	$\beta = 2\alpha$
$v_g = \frac{u+v}{2}$	$P = T\omega$	$\gamma = 3\alpha$
$\omega = 2\Pi N$	$P = Fv$	$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$
$\omega = \frac{\Theta}{t}$	$F_a = ma$	$PV = mRT$
$\Theta = \frac{\omega_2 + \omega_1}{2}$ x t	$E_p = mgh$	$\epsilon = \frac{x}{l}$
$\omega_2 = \omega_1 + \frac{1}{2}\alpha t$	$E_k = \frac{1}{2}mv^2$	$E = \frac{\sigma}{\varepsilon}$
$v = \omega R$	$P = \frac{F}{A}$	$\sigma = \frac{F}{A}$
$\Theta = 2\Pi n$	$m = p \; x \; vol$	$E = \frac{F\,l}{Ax}$
$S = R\Theta$	$P = pgh$	$y = \frac{A_1 y_1 -+ A_2 y_2 -+ \ldots\ldots}{A_T}$
$\alpha = \frac{(\omega_2)^2 - (\omega_1)^2}{2\Theta}$	$\frac{W_r}{F_p} = \frac{D^2}{d^2}$	$y = \frac{V_1 y_1 -+ V_2 y_2 -+ \ldots\ldots\ldots}{V_T}$