# DEPARTMENT OF HIGHER EDUCATION AND TRAINING
# REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N4
TIME: 3 HOURS
MARKS: 100

APRIL 2014



**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 on completion of each question.
6. ALL formulae should be shown in the answers.
7. Show ALL calculations.
8. Answers should be in blue or black ink.
9. ALL diagrams should be drawn in pencil.
10. The answers where necessary should be rounded off to THREE decimal places.
11. Take g = 9,8 m/s$^2$.
12. Write neatly and legibly.

## QUESTION 1

1.1 Prove by making calculations that a cannon will shoot three times as high when the angle of projection is 60°as when it is 30°. (5)

1.2 Two conveyor belts used to transport luggage at an airport runs parallel to each other but in opposite directions. Belt A has a velocity of 0,8 m/s east and belt B has a velocity of 0,4 m/s west.

Calculate the following:

1.2.1 The velocity of belt A relative to the velocity of belt B.

1.2.2 The velocity of belt B relative to the velocity of belt A.

(2 × 2) (4)

1.3 An aeroplane can travel at 150 km/h in still air. The wind is blowing at 50 km/h from the south-west.

Calculate the following:

1.3.1 The direction in which the pilot must steer in order to travel due north.

1.3.2 The velocity of the aeroplane in relation to the ground.

(3 x 2) (6)
**[15]**

## QUESTION 2

2.1 Define the term *angular displacement.* (2)

2.2 A point on the rim of a wheel with a diameter of 1 250 mm has a velocity of 396 km/h.

Calculate the following:

2.2.1 The revolutions per minute (3)

2.2.2 The angular velocity at which the wheel is turning in rad/s (2)

2.3 The engine of a vehicle develops 40 kW at a speed of 960 r/min.

Calculate the torque developed. (2)
**[9]**

## QUESTION 3

3.1 Define the term *coefficient of friction.* (2)

3.2 A truck that travels on a level road at 60 km/h can be stopped by its brakes in a distance of 51 m. The mass of the truck is 5 tonnes and the resistance against motion is 3 615 N.

Calculate the braking force in kN. (5)

3.3 Calculate the power required to put a mass of 120 kg at a constant velocity of 5 m/s down a plane. The plane makes an angle of 10° horizontally. The frictional force is 350 N. (5)

**[12]**

## QUESTION 4

4.1 Define the term *shearing force.* (2)

4.2 A lever which can turn freely about the turning point is shown in FIGURE 1, on the ADDENDUM (attached). The lever is in equilibrium.

Calculate the distance from load A to the turning point when A = 3B. (2)

4.3 A beam ABCDE with A on the left-hand side is 11 m long, having two supports at B and E. There is a uniformly distributed load of 5 kN/m from C to D. Concentrated or point loads of 3 kN act at points A and C, and another one of 4 kN at point D. The lengths of the various portions are as follows:

AB = 2 m, BC = 2 m, CD = 4 m and DE = 3 m.

Use the information given above and do the following:

4.3.1 Draw the beam described above (1)

4.3.2 Calculate the reactional forces at B and E (4)

4.3.3 Draw the shear force and bending moment diagrams with ALL the main values indicated on the diagrams. (6)

**[15]**

## QUESTION 5

5.1 Define *Pascal's Law.* (2)

5.2 Name TWO types of accumulators. (2)

5.3 The mechanical advantage of the lever is 10. The efficiency is 85%. The diameter of the ram piston is 300 mm and that of the plunger is 30 mm.

Calculate the force exerted by the ram piston if an effort of 150 N is applied to the lever of a hydraulic press. (5)

5.4 The diameter of the ram of an accumulator is 250 mm and its mass is 10 tonnes.

Calculate the following:

5.4.1 The pressure in the fluid (3)

5.4.2 The volume of water stored if the ram is lifted by 3 000 mm (2)

5.5 A two-cylinder waterpump is running at 120 r/min. The diameter of the plunger is 150 mm and the stroke length is 250 mm.

Calculate the following:

5.5.1 The volume of water delivered in litres every second (4)

5.5.2 The pressure needed to pump the water through a height of 30 m. (2)
**[20]**

**QUESTION 6**

6.1 Define *Young's modulus*. (2)

6.2 A force of 4 kN is applied to a square rod with sides of 200 mm and a length of 3 m, as shown in FIGURE 2, ANNEXURE (attached). The change in length after application of the force is 0,6 mm.

Calculate the following:

6.2.1 The stress

6.2.2 The strain

6.2.3 Young's modulus

(3 × 2) (6)

6.3 The following results were obtained in a tensile test on a round bar with a cross-sectional area of 1,5 $cm^2$. The original length of the bar was 20 cm.

| LOAD (kN) | 1,33 | 4,23 | 6,67 | 8,45 |
|---|---|---|---|---|
| EXTENSION (mm) | 0,015 | 0,049 | 0,073 | 0,098 |

6.3.1 Calculate the stress for each load and the strain for each elongation. (2)

6.3.2 Draw the stress-strain graph for the values obtained in QUESTION 6.3.1. (3)

6.3.3 Use the graph to calculate Young's Modulus of elasticity for the material of the bar. (1)
**[14]**

**QUESTION 7**

7.1 Define *coefficient of linear expansion.* (2)

7.2 A square metal plate with sides 2,5 m long has a hole with a diameter of 850 mm in the centre. The temperature of the plate is 20 °C. The linear coefficient of expansion of the metal is 12,5 x $10^{-6}$/°C.

Calculate the following:

7.2.1 The temperature of the metal plate if it is heated until the sides are 2,52 m long.

7.2.2 The diameter of the hole at this temperature.

(3 × 2) (6)

7.3 A rigid container has a capacity of 0,097 $m^3$ and is filled with oxygen at a pressure of 500 kPa and a temperature of 25 °C. Later it is found that the pressure has dropped to 350 kPa and the temperature has decreased to 20 °C as a result of a leak.

Calculate the following:

7.3.1 The mass of oxygen that was initially in the container if the gas constant is 297 J/kg.K. (3)

7.3.2 The mass of oxygen that leaked out. (4)

**[15]**

**TOTAL: 100**

**ADDENDUM**

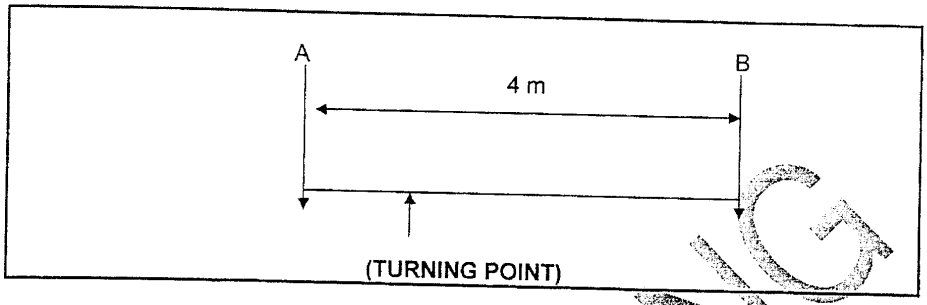


FIGURE 1

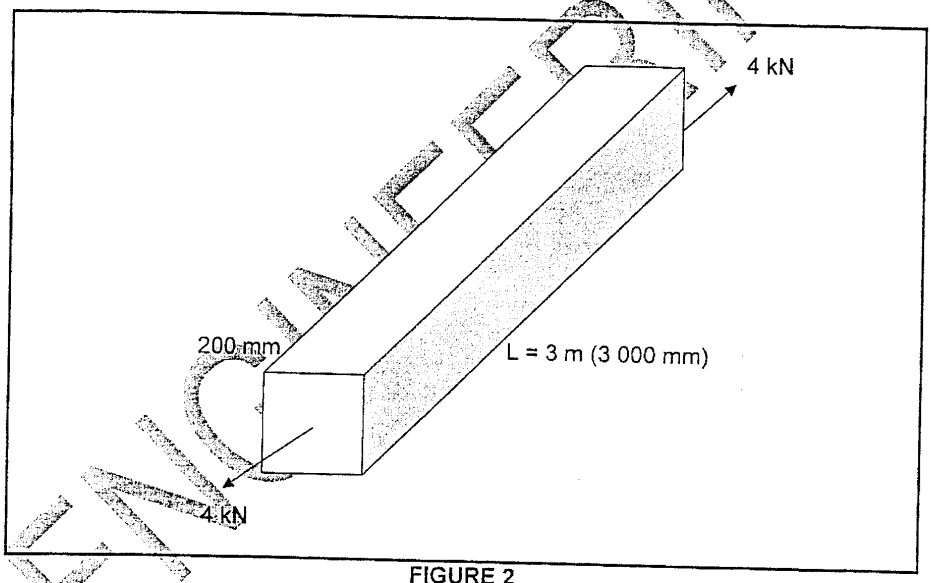


FIGURE 2