DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

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

APRIL 2012

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers correctly 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 used, should be shown in the answer. Show ALL the steps in between.
7. Questions should be answer in blue or black ink.
8. ALL the diagrams should be in pencil.
9. Take $g = 9{,}8\ m/s^2$.
10. Write neatly and legibly.

QUESTION 1

1.1 Two cars leave a fork in a road simultaneously. Car V travels at 60 km/h to the west and car W travels at 100 km/h in a direction N 45° E.

Calculate the relative velocity of car W with respect to car V in magnitude and direction. (5)

1.2 A cyclist is cycling at 8 m/s to his destination due north. There is a wind blowing at 3 m/s from the south-east. Calculate the resultant velocity of the cyclist in magnitude and direction. (5)

1.3 A bullet is fired from a rifle at an angle of 20° to the horizontal with an initial velocity of 250 m/s.

Calculate the following:

1.3.1 The time for the bullet to reach the maximum height (3)

1.3.2 The maximum height reached by the bullet (2)

1.3.3 The horizontal displacement of the bullet (2)
[17]

QUESTION 2

2.1 Define *angular acceleration.* (1)

2.2 The spindle of a washing machine rotates at 800 r/min and slows down to 300 r/min during 30 revolutions.

Calculate the following:

2.2.1 The angular displacement in radians (2)

2.2.2 The angular acceleration (3)

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

2.3 The wheel of a locomotive has a diameter of 450 mm, and the locomotive is travelling at 90 km/h. Calculate the angular velocity of the wheel. (2)
[10]

QUESTION 3

3.1 The engine of a truck exerts a force of 70 kN on the truck as it travels up an incline of 1°. The truck experiences a resistance of 60 N per ton of the weight of the truck. The total mass of the truck and its engine is 240 ton.

Calculate the following:

3.1.1 The acceleration of the truck (4)

3.1.2 The braking force that would be required on the return journey to prevent the acceleration exceeding 0,02 m/s^2 (3)

3.2 Calculate the power required to pull a mass of 200 kg at a constant velocity of 4 m/s on a horizontal plane. The kinetic coefficient of friction is 0,8. (3)
[10]

QUESTION 4

4.1 A light horizontal beam ABCD, is 7,5 m long. The distance between A and B is 3 m, the distance between B and C is 3 m and the distance between C and D is 1,5 m. The beam uniformly distributed load of 60 kN/m between A and B, a uniformly distributed load 20 kN/m between B and C and a concentrated load of 100 kN at D. The beam is supported at A and C.

4.1.1 Draw a neat labelled diagram of the beam and then calculate the reaction forces at the supports. (4)

4.1.2 Calculate the bending moments at B, C, E (a point halfway between A and B) and F (a point halfway between B and C). (4)

4.1.3 Draw a shear force diagram and a bending moment diagram and indicate ALL the values on the diagrams. (6)

4.2 Define the term *centre of gravity.* (1)
[15]

QUESTION 5

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

5.2 The diameter of the ram piston of a press is 125 mm and that of the plunger is 25 mm. The mechanical advantage on the plunger is 16. The stroke length of the plunger is 50 mm.

Calculate the following:

5.2.1 The effort that has to be applied to the handle in order to lift a load of 500 kg (3)

5.2.2 The distance the load will be raised after 50 strokes of the plunger (3)

5.2.3 The work done by the press to lift the load of 500 kg after 50 strokes. The efficiency of the press is only 80%. (3)

5.3 The plungers of a three-cylinder pump have diameters of 75 mm and stroke lengths of 250 mm. The pressure during a delivery stroke is 750 kPa. Calculate the power required to drive the pump at 150 r/min if the efficiency of the motor is 75%. (5)

5.4 A hydraulic accumulator has to deliver water at a pressure of 2,8 MPa. Calculate the mass of the ballast if the ram has a diameter of 300 mm. (3)
[19]

QUESTION 6

6.1 Define *Young's Modulus of Elasticity* of a material. (2)

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

Calculate the following:

6.2.1 The stress (2)

6.2.2 The strain (2)

6.2.3 Young's Modulus of elasticity for the material (2)

6.3 A lift has a mass of 600 kg and is designed for a maximum upward acceleration of 3,2 m/s^2. If the cross-sectional area of the cable is 3 cm^2, and the maximum tension may not exceed 40 MPa, calculate the maximum load, in kilogram, that the lift may carry. (5)
[13]

QUESTION 7

7.1 Define the *coefficient of linear expansion* of a substance. (2)

7.2 The area of a brass plate is 1 cm^2 at 0 °C and 1,004 cm^2 at 100 °C. Calculate the coefficient of linear expansion of brass. (3)

7.3 A glass flask is completely filled with 100 ml alcohol and heated from 15 °C to 40 °C. 6,05 ml alcohol overflows in the process. The coefficient of linear expansion of glass is 9 x 10^{-6}/°C. Calculate the coefficient of cubic expansion of alcohol. (5)

7.4 The volume of 2 grams of nitrogen at 27 °C is 0,002 m^3.

Calculate the following:

7.4.1 The pressure of the gas if the gas constant for nitrogen is 297 J/kgK. (3)

7.4.2 The final volume if the pressure doubles and the temperature increases to 125 °C. (3)

[16]

TOTAL: 100