DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
ENGINEERING SCIENCE N4
TIME: 3 HOURS
MARKS: 100 NOVEMBER 2013

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 answer. Show ALL the steps in between your answers.
7. Questions must be answered in blue or black ink.
8. ALL the sketches and diagrams must be done 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 X travels at 60 km/h to the west and car Y travels at 100 km/h in a direction N 45° E.

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

1.2 A boy throws a cricket ball at an angle of 15° to the horizontal with an initial velocity of 50 m/s. The path of the ball is that of a projectile.

Calculate the following:

1.2.1 The time to reach the maximum height

1.2.2 The maximum height reached by the ball

1.2.3 The horizontal displacement of the ball

(3 x 2) (6)

1.3 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)
[16]

QUESTION 2

2.1 Define *angular velocity.* (1)

2.2 The wheel of a motorbike has a diameter of 50 cm and accelerates from 4 rad/s to 10 rad/s in 10 seconds.

Calculate the following:

2.2.1 The angular acceleration of the wheel

2.2.2 The angular displacement of the wheel in radians

2.2.3 The number of revolutions completed by the wheel during this time

(3 x 2) (6)

2.3 A force of 600 N is applied to the end of a spanner. The perpendicular distance between the nut and the working line of the force is 30 cm.

Calculate the following:

2.3.1 The torque on the spanner

2.3.2 The work done when the nut is turned through an angle of 60°

(2 x 2) (4)
[11]

Please turn over

QUESTION 3

3.1 A bus is travelling on a horizontal road at a velocity of 126 km/h when the bus driver notices an object in the road. The brakes are applied and the bus is brought to rest over a distance of 150 metres. The frictional resistance is 2 500 N and the bus has a mass of 6 000 kilogram.

Calculate the following:

3.1.1 The retardation of the bus (3)

3.1.2 The time taken to come to a standstill (2)

3.1.3 The braking force of the brakes (2)

3.2 A locomotive is pulling a train with a mass of 150 tons up a hill with an incline of 10° at a constant velocity of 72 km/h. The train experiences a frictional force of 8 000 N.

Calculate the power required by the engine of the locomotive to pull the train. (4)
[11]

QUESTION 4

A light, horizontal beam ABCDE with A on the left hand side is 13 metres long. It is supported at two points, A and D. At B, 6 metres from A, is a point load of 10 kN. At C, 3 metres from B, is a point load if 15 kN. Between A and B is a uniform distributed load of 4 kN/m. D is 2 metres from C.

4.1 Make a neat, labelled diagram of the beam as described above. (1)

4.2 Calculate the reactions of the supports at points A and D and test your answers. (5)

4.3 Draw a shear force diagram and show ALL the main values on the diagram. (4)

4.4 Calculate the bending moments at B and C. (2)

4.5 Draw a neat bending moment diagram and show ALL the main values on the diagram. (3)
[15]

QUESTION 5

5.1 A three-cylinder, single-acting pump has a plunger diameter of 200 mm and a stroke length of 300 mm and is working at a speed of 230 r/min. There is a slip of 15%.

Calculate the volume of water delivered in litres/minute:
(1 000 liter = 1 000 kg = 1 m^3) (4)

5.2 A farmer uses a water pump to pump water out of a dam. The diameter of the plunger is 150 mm and a force of 12 kN is applied to the plunger of the pump. The work done during each delivery stroke is 4 kJ.

Calculate the following:

5.2.1 The stroke length of the plunger (2)

5.2.2 The pressure in the water during ONE delivery stroke (3)

5.2.3 The volume of water delivered during ONE pumping stroke (3)

5.3 The plungers of a three-cylinder, single-acting pump have diameters of 5 cm each and stroke lengths of 15 cm each. The pressure during the delivery stroke is 2 MPa.

Calculate the power required to drive the pump at 150 r/min if the efficiency of the motor is only 80%. (5)

5.4 Define the unit *Pascal* (1)
[18]

QUESTION 6

6.1 Explain the difference between *tensile stress* and *compressive stress.* (2)

6.2 A bar with a square profile of 30 mm x 30 mm, is subjected to a tensile test. A load of 100 kN causes an extension of 0,5 mm. The initial length of the bar was 330 mm.

Calculate the following:

6.2.1 The stress in the bar

6.2.2 The strain of the bar

6.2.3 Young's modulus of elasticity of the material

(3 x 2) (6)

6.3 The steel spoke of a bicycle wheel has a cross-sectional area of 2,5 mm^2 and a length of 400 mm. The nut of the spoke is fastened until the spoke stretches by 0,25 mm.

Calculate the tensile force on the spoke. E for the steel is 300 GPa. (3)

6.4 A tensile test is done on a metal specimen and the following readings are obtained during the test:
Original length = 80 mm
Original diameter = 20 mm

Load in kN	0	10	20	30	40	50
Elongation in mm	0	0,0121	0,0243	0,0361	0,0485	0,0618

6.4.1 Draw the stress-strain graph for these values. (3)

6.4.2 Determine Young's modulus of elasticity for the specimen with the aid of a graph. (2)
[16]

QUESTION 7

7.1 What is the difference between the Kelvin scale and the Celsius scale?

7.2 The surface of the ocean at a certain point has a temperature of 27 °C at a pressure of 1 atmosphere (101,325 kPa). The temperature at the bottom is 10 °C. An air bubble with a diameter of 16 mm is let loose.

Calculate the difference in pressure at the surface and at the bottom of the ocean if the air bubble has a diameter of 42 mm when it reaches the surface of the ocean. (Volume of a sphere = $4/3\pi r^3$ and density of water 1 000 kg/m^3) (4)

7.3 A given mass of chlorine has a volume of 40 cm^3 at 20 °C.

Calculate its volume at 50 °C if the pressure remains constant. (2)

7.4 A patient is supplied with oxygen contained in an oxygen cylinder with a capacity of 40 litres. The cylinder was filled with oxygen at a temperature of 50 °C at a pressure of 380 kPa. Later it is found that the pressure has dropped to 280 kPa and the temperature has decreased to 25 °C as a result of the supply to the patient. The gas constant R = 265 J/kg.K

Calculate the following:

7.4.1 The mass of oxygen that was initially in the container (2)

7.4.2 The mass of oxygen that was used by the patient (3)
[13]

TOTAL: 100