OCR
Oxford Cambridge and RSA

Wednesday 15 May 2024 – Morning

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825/05873 Unit 2: Science for engineering

Time allowed: 1 hour 30 minutes
C302/2406

C302/2406

You must have:
- the Formula Booklet for Level 3 Cambridge Technical in Engineering (inside this document)
- a ruler (cm/mm)
- a protractor
- a scientific calculator

05822 – 02

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

Date of birth | D | D | M | M | Y | Y | Y | Y |

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give your final answers to a degree of accuracy that is appropriate to the context.
- The acceleration due to gravity is denoted by g m s^{-2}. When a numerical value is needed use g = 9.8 unless a different value is specified in the question.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- This document has **16** pages.

ADVICE
- Read each question carefully before you start your answer.

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1

(a) Which of these are SI base units?

Tick (✓) **three** boxes.

Ampere	☐
Coulomb	☐
Hour	☐
Metre	☐
Second	☐
Volt	☐

[3]

(b) An engineer measures the viscosity of a motor oil at room temperature.

The measurement is 300 ± 10 mPa s.

(i) Complete the sentence below.

Choose **one** word from the following list.

accuracy **correction** **reliability** **uncertainty**

The ..... of the measured value is ± 10 mPa s.

[1]

(ii) The true value of the viscosity is expected to lie within a range of values.

State the likely range of values for the true value of the viscosity, in mPa s.

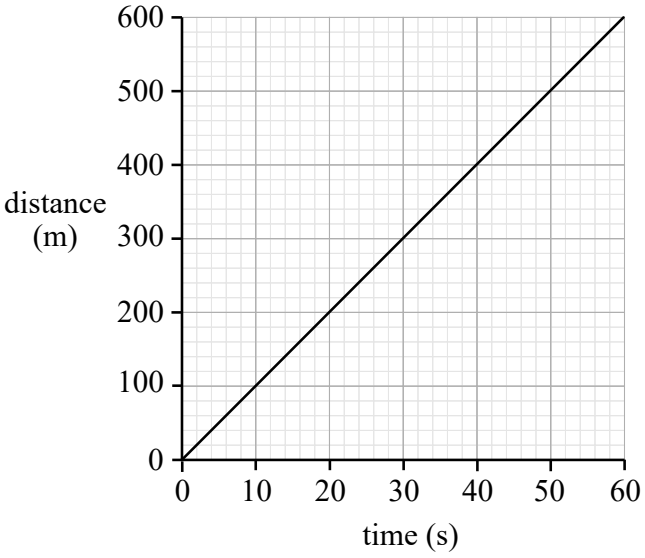
From ..... to ..... mPa s.

[1]

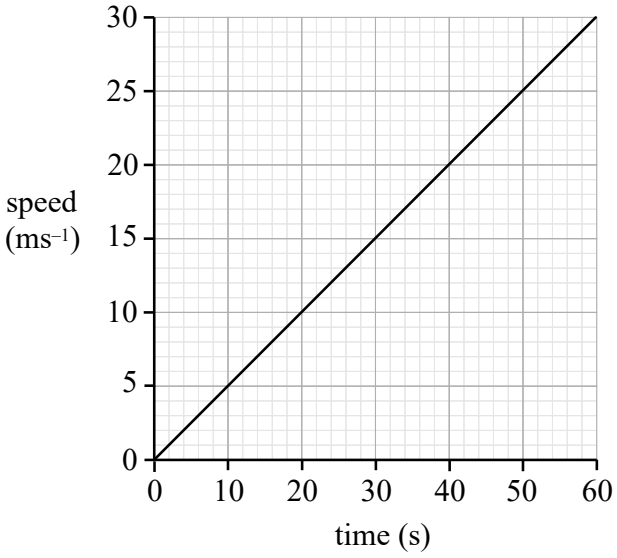
2

(a) Graphs **X** and **Y** below represent two different car journeys in different ways.

Graph **X**



Graph **Y**



The table below contains statements about the two car journeys.

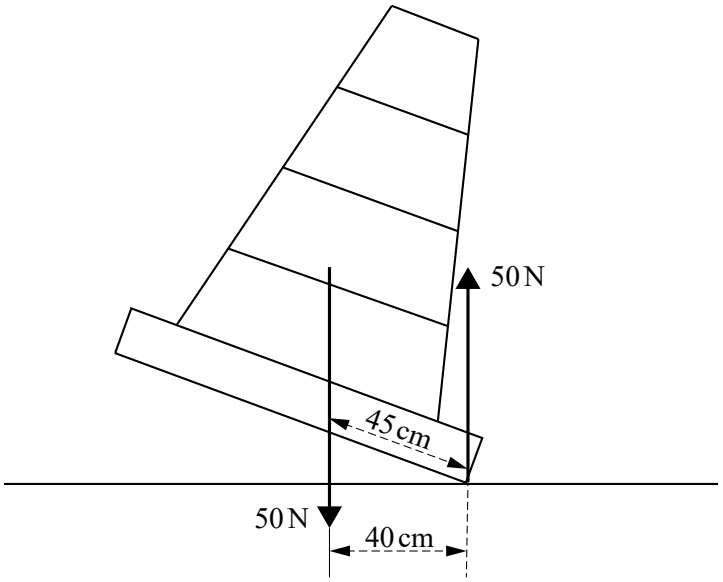
The statements can be true for one, both or neither journey.

Tick (✓) **one** box on each row.

Statement	**Graph X only**	**Graph Y only**	**Both graphs**	**Neither graph**
The car is travelling at constant speed.				
20 s after the journey started, the speed is 10 ms^{-1}.				
The car slows down during the journey.				
40 s after the journey started, the distance travelled is 400 m.				

[4]

(b) A traffic cone is tipped to one side as shown in the diagram, and then released.



(i) Explain how the diagram shows that a couple is acting.

.....

.....

..... **[2]**

(ii) Calculate the torque of the couple acting in the diagram above.

Give your answer in Nm.

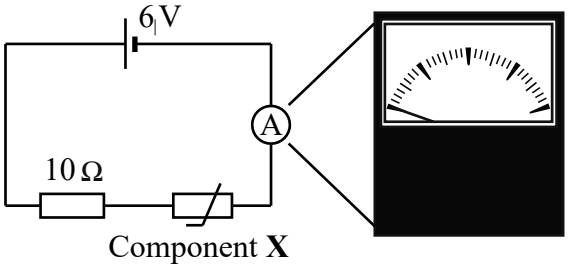
Use the equation:

torque of a couple = force × perpendicular distance between the forces.

torque = ... Nm **[2]**

3 The diagram shows the circuit for a simple temperature sensor.

The meter has no values marked on the scale.



(a) To use the sensor, values need to be written on the scale of the meter.

State the measurement term that best describes this process.

..... **[1]**

(b)

(i) State the name of component **X**.

..... **[1]**

(ii) On the axes below, sketch the variation of resistance with temperature for component **X**.

[2]

The sensor circuit is placed first in a fridge known to be at 0 °C and then in steam at 100 °C to mark the scale.

(c) At 0 °C, component **X** has resistance 40 Ω.

Calculate the current in the circuit.

current = ... A **[3]**

(d) The 10 Ω resistor is made from a 0.40 m length of wire.

(i) The resistivity of the wire material is 1.5×10^{-6} Ωm.

Calculate the cross-sectional area of the wire.

cross-sectional area = ... m^2 **[3]**

(ii) Explain why the 10 Ω resistor must be made from a material that has a low temperature coefficient of resistance.

.....

.....

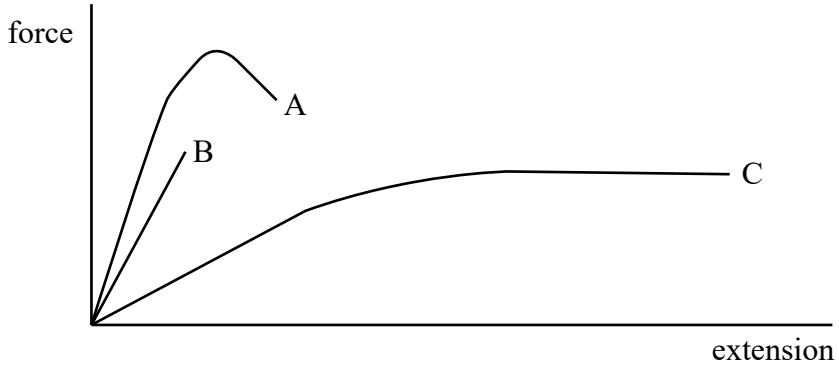
.....

.....

..... **[2]**

4

(a) The graph below shows the force–extension for three different materials (A, B and C).



State whether A, B or C shows the typical behaviour of a material that is:

(i) brittle.

..... **[1]**

(ii) polymeric.

..... **[1]**

(b) Complete the sentence below.

Choose **two** words/phrases from the following list.

elastic limit **force** **strain** **stress** **ultimate tensile stress** **yield point**

A brittle material can only withstand a relatively small .....

before it reaches its ..... .

[2]

(c)

(i) State the SI derived unit for stress.

..... **[1]**

(ii) What is the unit for strain?

Tick (✓) **one** box.

kilogram	☐
metre	☐
newton	☐
no unit	☐

[1]

(d) The properties of materials are affected by the type and arrangement of the atoms they are made from.

(i) Explain the term **equilibrium separation** of the atoms in a material.

.....

.....

..... **[2]**

(ii) The equilibrium separation and atomic mass affect the material's density.

A cube of aluminium 15 cm on each side has mass 9.1 kg.

Calculate the density of aluminium in kg m^{-3}.

density = ... kg m^{-3} **[3]**

5

(a) Give the state of a fluid which is:

(i) compressible.

..... **[1]**

(ii) incompressible.

..... **[1]**

(b) The table shows five measurements of pressure in a compressible fluid.

The mean of the measurements is 100 kPa.

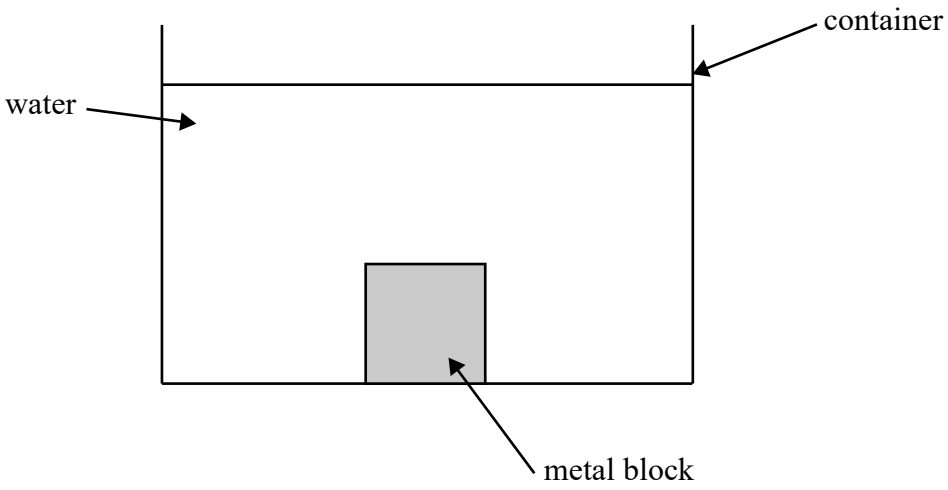
Calculate the standard deviation of the measurements.

You can use the two empty rows to help with your calculations.

	1	**2**	**3**	**4**	**5**
Pressure reading/kPa	101	104	98	99	98

standard deviation = ... **[3]**

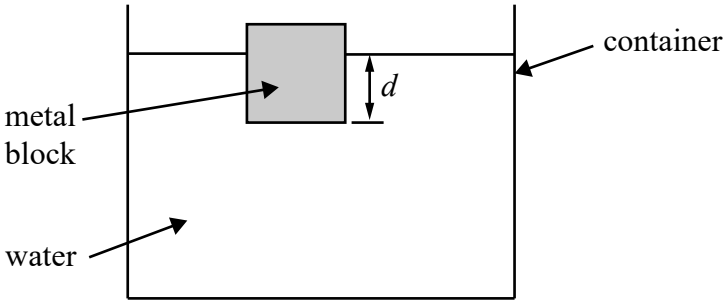
(c) The diagram shows a cubic metal block submerged in water.



Draw arrows on each side of the block to show the relative size and direction of the water pressure acting on the block.

[4]

(d) A different cubic metal block of mass 86 kg floats in the water as shown in the diagram.



The cross-sectional area of the block is 0.20 m^2.

The density of water is 1000 kg m^{-3}.

The block is submerged to a depth, d m.

Use Archimedes' principle to calculate the value of d.

d = ... m **[3]**

6

(a)

(i) State how to convert temperature in °C to kelvin.

..... **[1]**

(ii) Complete the sentence below.

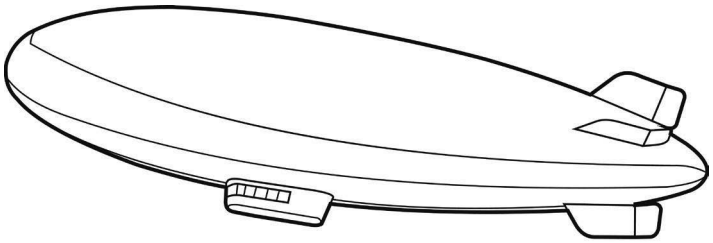
On the kelvin scale, absolute zero is the temperature at which all substances

have .....

..... **[2]**

Giant airships have been proposed as a way of carrying cargos too heavy for drones or helicopters to inaccessible areas where planes cannot land.

(b) A rigid airship has a fixed volume of 3000 m^3 and contains helium at a pressure of 110 kPa when the outside temperature is 320 K.



Use the characteristic gas equation to calculate the mass of helium in the airship.

The specific gas constant for helium is 2080 $JK^{-1}kg^{-1}$.

Give your answer to **3** significant figures.

mass = ... kg **[4]**

(c) When the airship is hovering at an altitude of 1000 m, the temperature is 280 K.

Complete the calculation below using the Pressure law to find the new pressure, p_2.

$$\frac{\square}{320} = \frac{p_2}{\square}$$

new pressure p_2 = ... kPa **[3]**

(d) Although the airship is rigid, the outer skin does deform slightly in flight.

The skin deforms elastically.

Explain the difference between elastic and plastic deformation of a material.

.....

.....

..... **[2]**

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use these lined pages. You must write the question numbers clearly in the margin.

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