OCR
Oxford Cambridge and RSA

Friday 10 January 2025 – Morning

Level 3 Cambridge Technical in Engineering

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

Time allowed: 1 hour 30 minutes

C302/2501

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

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 page 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 $g\,\text{m}\,\text{s}^{-2}$. 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.

C302/2501   OCR is an exempt Charity   **Turn over**

1

(a) Complete the table of SI derived quantities and their units.

Unit	SI derived quantity
J	energy
Pa	
Hz	
Wb	

[3]

(b) An electrical engineer is installing outdoor lighting in a customer's garden. They measure a suitable length of steel-wire-armoured (SWA) cable.

The diagram shows the end of the cable and part of a steel ruler, marked in mm.
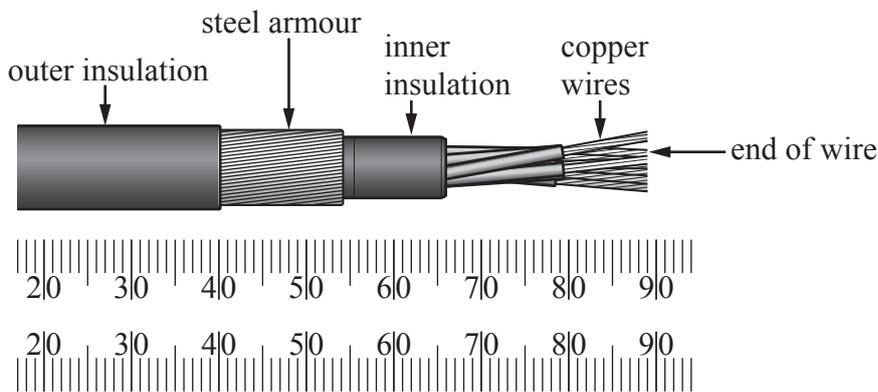
(i) Calculate the total length of outer insulation that has been removed from the end of the cable.

Length = ...mm **[2]**

(ii) On a hot day, the steel ruler expands.

Complete the sentences to describe a measurement made on this day.
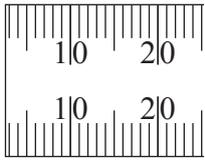
Circle the correct choice of word(s).

The measured length will be **greater than** / **less than** / **the same as** the true length.

The **relative** / **absolute** error will be **greater than** / **less than** / **equal to** zero mm.

[3]

(iii) The diagram shows the end of the steel ruler.

Suggest what absolute correction should be applied to readings from this steel ruler.

Absolute correction = ... mm **[2]**

(c) The cable contains steel armour wires to protect the inner copper wires from being cut-through accidentally, for example, by a garden spade.

Which **two** properties of steel make it suitable for this job?

Tick (✓) **two** boxes.

Property	Tick
ductile	
elastic	
good electrical conductor	
malleable	
strong	

[2]

(d) The engineer installs a waterproof cable in a pond to operate an underwater pump. The diagram shows the left-hand side of the pond.

ground level ——— water level

underwater cable
(extending horizontally
into and out of the page)
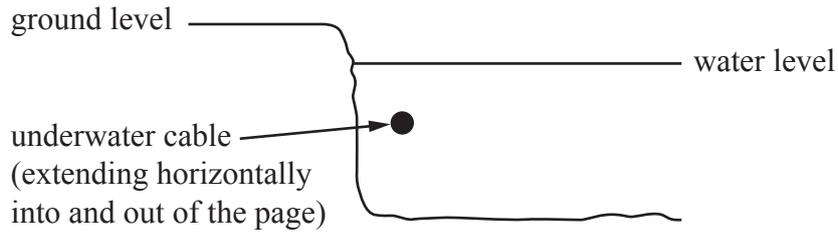
The waterproof cable is horizontal in the water and its position is shown in the diagram.

In which direction(s) does the water pressure act on the cable?

Tick (✓) **one** box.

Direction(s)	Tick
A and E only	
A, B, C, D and E only	
All directions shown	
E only	
None of the directions shown	

A
H   B
G   C
F   D
E
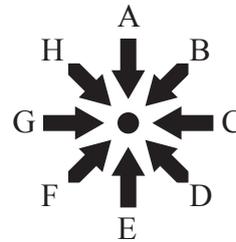
[1]

2 This question is about some fairground rides.

(a) The graph shows how the displacement of a car on a fairground ride changes with time.
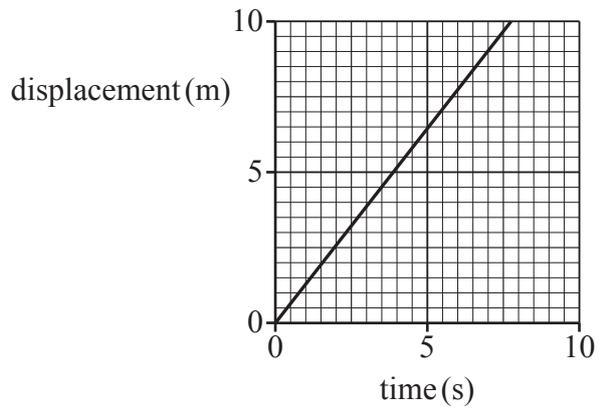
Use the graph to find the velocity of the ride.

Include the unit in your answer.

Velocity = ... Unit .... **[3]**

Turn over

(b) The diagram shows a pirate ship ride. The dashed lines mark the centre of the pirate ship, which moves from A through B to C and back again.
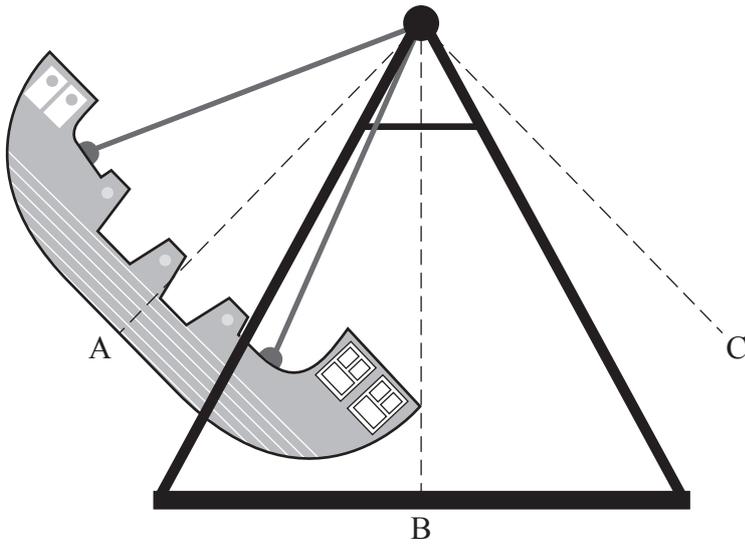
The graph shows how the displacement of the pirate ship varies with time as it moves from position A to its equilibrium position B.
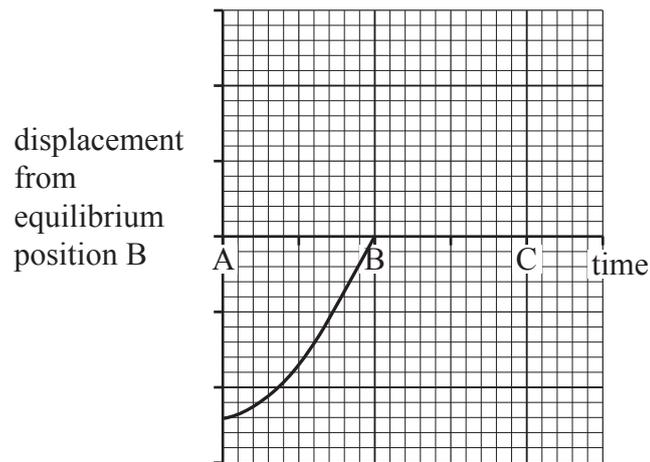
(i) Define **displacement**.

....

....

.... **[2]**

(ii) Draw a curve on the graph above to show the displacement of the ship as it continues from position B to position C. **[2]**

(iii) Sketch on the axes below a graph to show the velocity of the ship as it moves from positions A to B to C.

velocity

A   B   C time

[3]

3

(a) The diagram shows a circuit with a 6 V cell, a capacitor, *C*, and a switch, *S*.
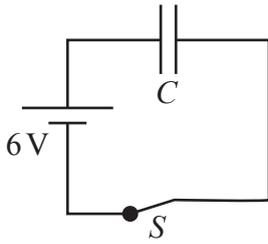
When the switch is closed there is an electric current in the wire.

(i) Define electric current.

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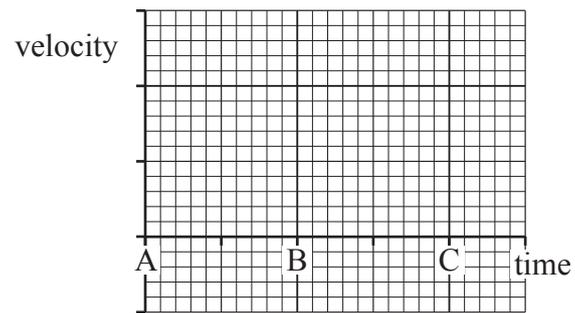
.... **[2]**

(ii) An average current of 1.3 mA flows for 1 minute until the capacitor is fully charged.

Calculate the charge stored on the capacitor. Give your answer in mC.

Charge = ... mC **[3]**

(iii) State why the potential difference between the plates when the capacitor is fully charged is 6 V.

....

.... **[1]**

(iv) The distance between the two plates of the capacitor is 20 cm.

Calculate the electric field strength, in $V\,m^{-1}$, between the plates.

Field strength = ... $V\,m^{-1}$ **[2]**

(b) The charged capacitor is then discharged through a resistor.

Sketch on the axes below the graph of potential difference across the capacitor against time, as the capacitor is discharged.

The time constant, τ, for the capacitor and resistor is 1.0 s.
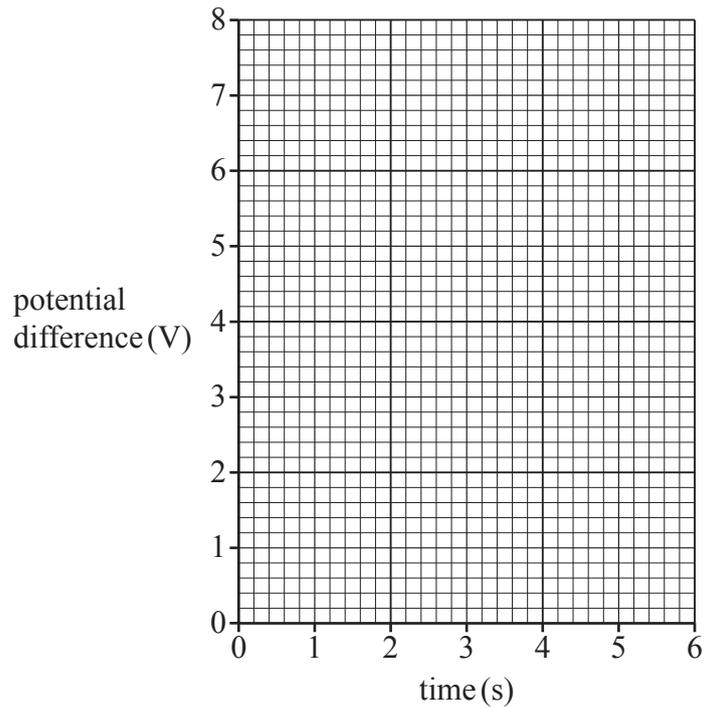
[3]

4

(a) A steel beam is used in constructing a house. The beam supports the brickwork above a door opening. The beam is supported at both ends on brick pillars.
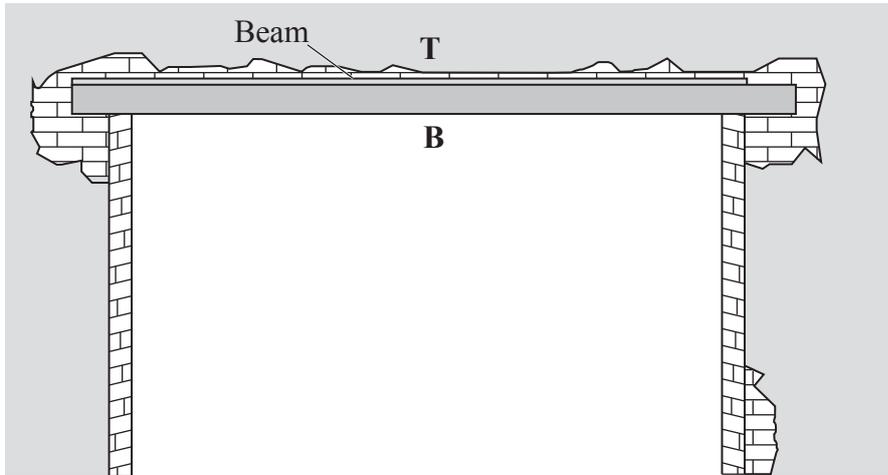
(i) Use words from the list to complete the sentence describing the forces on the beam.

compressive   **rotational**   **tensile**   **torsional**

The top surface of the beam (**T**) experiences .... forces;

the bottom surface of the beam (**B**) experiences .... forces.

[2]

(ii) The beam changes shape a very small amount in response to these forces.

Which word describes the change in shape of the beam?

Tick (✓) **one** box.

deformation ☐

dislocation ☐

extension ☐

load ☐

[1]

(b) A steel beam experiences tensile stress of 600 MPa.

Calculate the strain.

Young's modulus of steel is 210 GPa.

Give your answer as a **percentage** with **2** significant figures.

Strain = ...% **[4]**

(c) At the end of the manufacturing process destructive tests are carried out on sample beams.

Describe **one** benefit of destructive testing.

....

.... **[1]**

Turn over

5 Oil is a viscous liquid used as a lubricant in car engines.

There are two main ways to describe the viscosity of oil: dynamic viscosity and kinematic viscosity.

(a)

(i) Complete the formula to give the definition of dynamic viscosity.

Use words from the list below.

Density gradient   **Force gradient**   **Shear force**

Shear strain   **Shear stress**   **Velocity gradient**

Dynamic viscosity = $\dfrac{...}{...}$

[2]

(ii) Describe the difference between kinematic and dynamic viscosity.

....

.... [1]

(b) The graph shows how the kinematic viscosity of the oil changes with temperature.
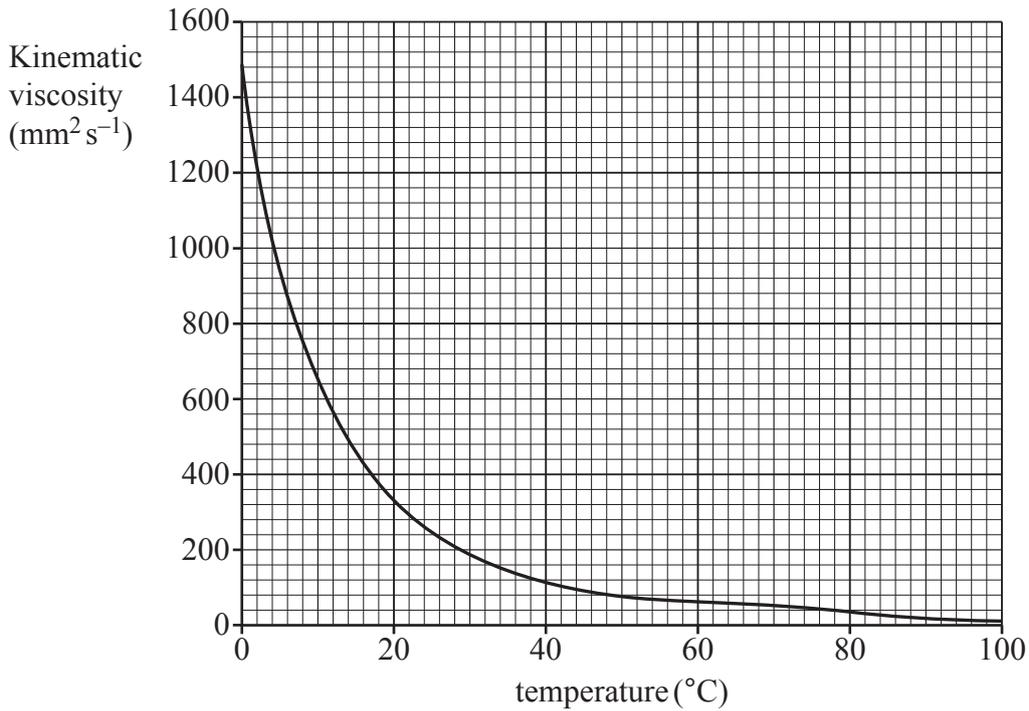
State the change in kinematic viscosity of the oil when the temperature increases from 15 °C to 45 °C.

Change in kinematic viscosity = ... mm^2 s^{-1} **[1]**

(c) The oil helps to prevent the engine from getting too hot by absorbing heat energy from the engine.

The specific heat capacity of the oil is 2180 J kg^{-1} K^{-1}.

Calculate the heat energy absorbed by 1.0 kg of the oil when its temperature increases from 10 °C to 40 °C.

Energy absorbed = ... J **[2]**

Turn over

6 A heating engineer is called out to a house because one of the central heating radiators feels cold at the top.
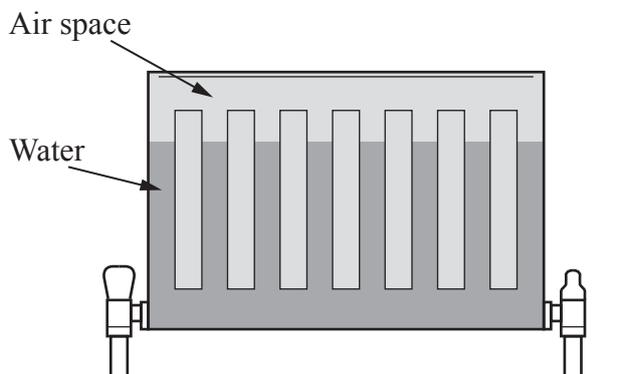
(a) The engineer determines that there is air trapped above the water inside the radiator, as shown in the diagram below.

(i) There are 0.1 moles of air at 50 °C taking up 0.002 m³ in the radiator.

Calculate the pressure of the air.

Molar gas constant, $R = 8.3\,\text{J}\,\text{K}^{-1}\,\text{mol}^{-1}$

Air pressure = ... Pa **[3]**

(ii) Explain what happens to the volume of air if the pressure is doubled but the temperature remains the same.

....

.... **[2]**

(b) The engineer wants to find out if the heating system is effective.

They measure the energy put into the heating system by the boiler over 1 hour.

The energy input to the heating system is 1.2 kWh.

(i) Use the non-flow energy equation to calculate the energy transferred out of the heating system and into the surroundings.

Assume the initial and final energy of the heating system is the same.

Give your answer in megajoules (MJ).

Energy transferred = ... MJ **[3]**

(ii) The internal energy of the system is made up of which two parts?

Tick (✓) **two** boxes.

Energy	Tick
Elastic energy of the particles.	
Kinetic energy of the particles.	
Latent energy of the particles.	
Potential energy of the particles.	
Thermal energy of the particles.	

[2]

(iii) The pressure gauge on the boiler reads 1.3 bar.

Atmospheric pressure is 101 kPa.

1 bar = 100 kPa

Calculate the absolute pressure in the boiler.

Absolute pressure = ... kPa **[2]**

END OF QUESTION PAPER

EXTRA ANSWER SPACE

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

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