OCR
Oxford Cambridge and RSA

Friday 16 May 2025 – Morning

Level 3 Cambridge Technical in Engineering

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

Time allowed: 1 hour 30 minutes
C302/2506

C302/2506

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

1

(a) Draw lines to match the SI prefixes with their values.

giga (G) •	• 10^{-9}
kilo (k) •	• 10^{-6}
micro (μ) •	• 10^{3}
nano (n) •	• 10^{9}

[3]

(b) A student performs an experiment to find the wavelength of laser light.

They obtain five measurements which are all close together.

(i) Which statement is true? Tick **one** box.

The measurements are accurate but may not be precise. ☐

The measurements are both accurate and precise. ☐

The measurements are precise but may not be accurate. ☐

[1]

(ii) The student's result for the wavelength is 541 nm.

The true value of the wavelength for this laser is 557 nm.

Calculate the percentage error in the student's result.

Percentage error = ...% **[2]**

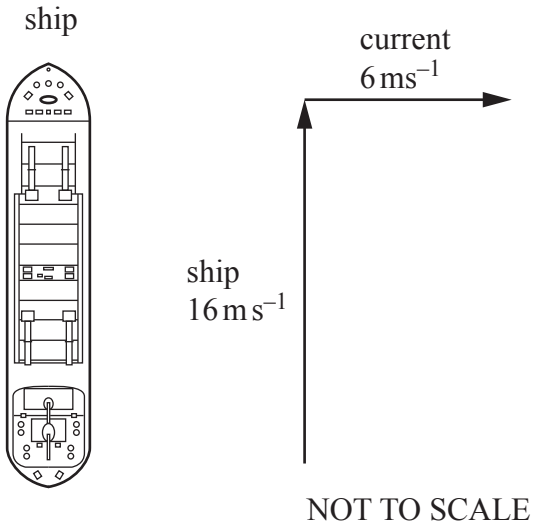
2

(a) Complete the definition of the newton below.

One newton is the force required to .....

..... **[3]**

(b) A container ship is sailing North at a constant $16\,m\,s^{-1}$. The ship is experiencing a constant ocean current of $6\,m\,s^{-1}$ East.



(i) Calculate the magnitude of the resultant velocity of the ship.

Magnitude of resultant velocity = ... $m\,s^{-1}$ **[2]**

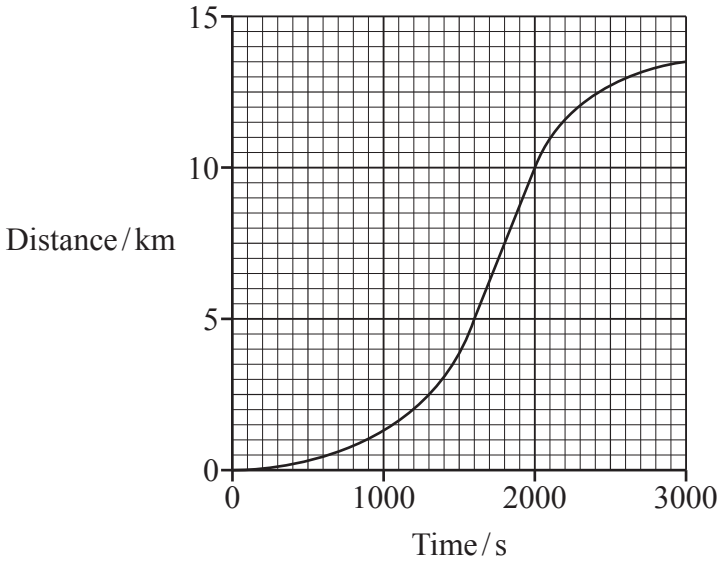
(ii) Earlier in the journey, the resultant force on the ship was 16.7×10^6 N.

The total mass of the ship including load is 1.6×10^8 kg.

Calculate the acceleration of the ship. Give the unit for your answer.

Acceleration = ... Unit ..... **[3]**

The graph shows the distance the ship has travelled in the time since leaving port.



(iii) Use the graph to find the maximum speed of the ship in $m\,s^{-1}$.

Maximum speed = ... $m\,s^{-1}$ **[4]**

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3

(a) State Ohm's law.

.....

.....

.....

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

(b) An electric fan heater is used on a building site.

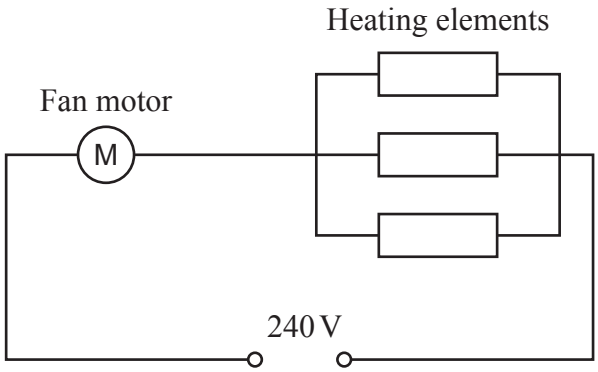
The heater's performance is described using the term **kilowatt-hour**.

State the quantity that can be measured in kilowatt-hours.

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

(c) The heater contains three identical resistors (heating elements) that turn electrical energy into heat, as well as a fan to blow the hot air into the room.

The circuit diagram for the heater is shown below



Each heating element has resistance 126 Ω.

The current through each element is 1.79 A.

(i) Calculate the power dissipated in **one** heating element.

Power = ... W **[2]**

(ii) What device could be used to measure the current?

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

(d) The fan motor has resistance 5.0 Ω.

Calculate the total resistance in the circuit.

Resistance = ... Ω **[3]**

(e) Which statement correctly describes the efficiency of the heater?

Tick **one** box.

Almost all the input power is transferred to useful outputs, so the efficiency is probably over 90%. ☐

Energy is conserved so the efficiency is exactly 100%. ☐

Most of the input power is wasted in the motor so the efficiency is probably below 10%. ☐

The output power is likely to be more than the input power, so the efficiency is over 100%. ☐

[1]

4 This question is about a steel cable used to suspend a lift in a tall building.

(a) The Young's modulus of steel is very high.
Explain why this makes it a good choice of material for a lift cable.

.....

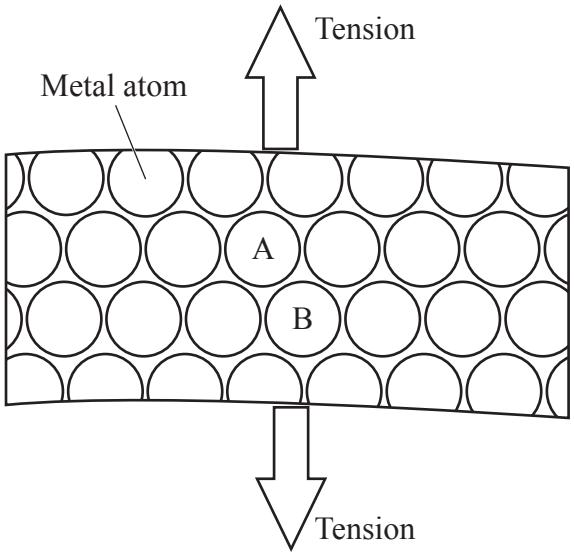
.....

.....

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

The diagram shows part of the atomic structure of the metal cable.

Tension is applied to the cable as shown.



(b) State what happens to the separation of the atoms, A and B in the diagram, when

(i) the tension is applied,

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

(ii) the tension is released.

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

(c) Which statement correctly describes the forces between atoms A and B?

Tick **one** box.

There are no forces between the atoms. ☐

The atoms attract one another. ☐

The atoms both attract and repel one another and those forces are balanced. ☐

The atoms both attract and repel one another, but the attraction is stronger. ☐

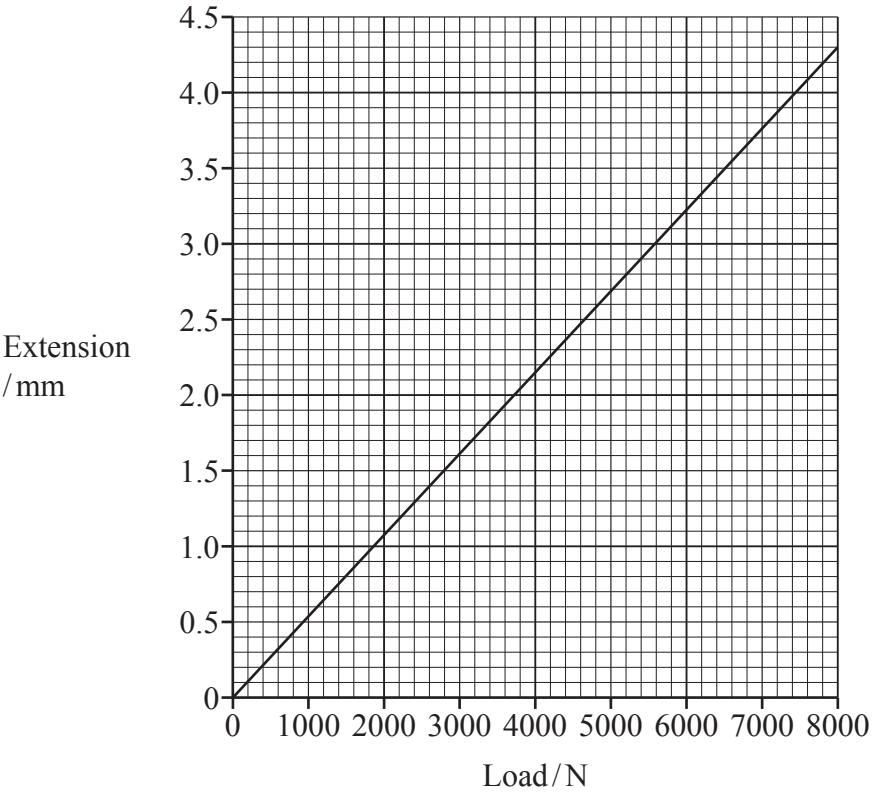
The atoms both attract and repel one another, but the repulsion is stronger. ☐

The atoms repel one another. ☐

[1]

When the lift is carrying passengers, the cable stretches slightly.

The graph shows the extension of the lift cable for different loads.



(d) Calculate the strain energy in the cable when the load is 6000 N.

Strain energy = ... J **[4]**

(e) The manufacturer uses destructive testing when evaluating its lift cables.

Describe **two** features of destructive testing.

1 .....

.....

2 .....

.....

[2]

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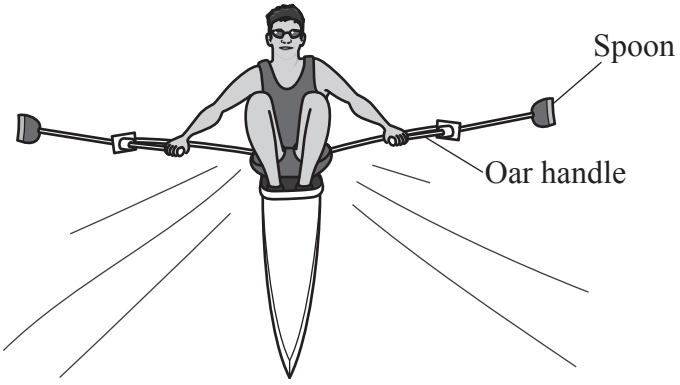
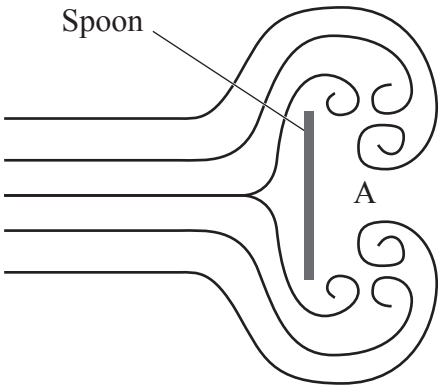
5 The image shows a person rowing a boat with oars.



The end of the oar, called the spoon, enters the water.

The diagram shows the flow of water around the spoon.



(a) What **one word** describes the flow at point A?

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

(b) Describe the motion of water particles at point A.

.....

.....

.....

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

(c) Engineers can improve rowing performance by changing the shape of the spoon.

The table shows data for two spoon designs.

	Old Design	New Design
Water pressure / Pa	5740	5960
Spoon area / m^2	0.1150	0.1280

Calculate the increase in force when changing to the new design.

Increase in force = ... N **[4]**

(d) The dynamic viscosity of water is 1.31 mPa s at 10 °C.

State how you know that water is **not** an ideal fluid.

.....

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

(e) What other property of water is needed to calculate its kinematic viscosity?

Tick **one** box.

Density ☐

Mass ☐

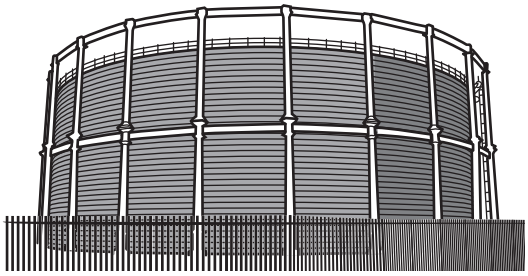
Pressure ☐

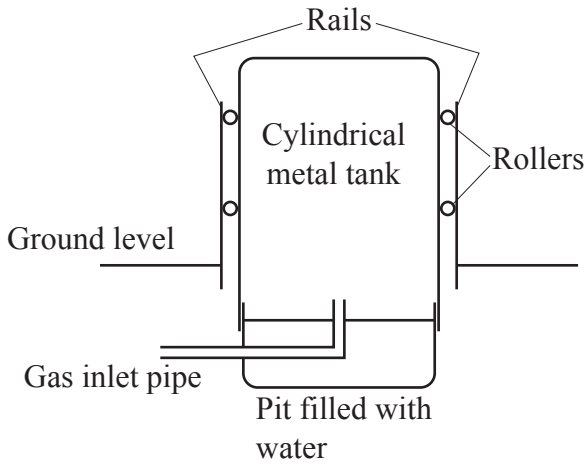
Shear stress ☐

Velocity gradient ☐

[1]

6 Gas storage is important for a country's energy security. In the 20th century, gas was stored in large cylindrical metal tanks called 'gasometers' like the one shown in the image below.





When gas is pumped into the gasometer, the cylindrical metal tank slides up the vertical rails on rollers. When the tank moves, the gas remains sealed inside by a pit of water below ground level.

(a) A gasometer has a volume of 50 000 m^3 and holds gas at pressure 4000 Pa.
The temperature of the gas and surroundings is 15 °C (288 K).
Calculate the number of moles of gas in the tank.

Molar gas constant = 8.31 $J K^{-1} mol^{-1}$

Moles of gas = ... **[3]**

(b) More gas is added to the tank.
The tank rises and the volume increases.
The pressure does not change because it is caused by the weight of the tank above.

Explain why the volume must increase if gas is added to the tank.
Use the ideal gas law in your explanation.
Assume the outside temperature stays the same.

.....

.....

.....

.....

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

(c) On a cold day, the gas temperature falls to 5 °C.
The pressure does not change.
Calculate the decrease in volume of the gas.

Decrease in volume = ... m^3 **[4]**

(d) On a different cold day, the tank moves downwards by 0.60 m.

The radius of the tank is 25 m.

The amount of gas in the tank remains the same.

The tank in part (a) had volume 50 000 m^3 and temperature 288 K.

Calculate the temperature of the gas in kelvin.

Temperature = ... K **[3]**

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.