OCR
Oxford Cambridge and RSA

Wednesday 21 October 2020 – Morning

A Level Physics B (Advancing Physics)

H557/03 Practical skills in physics

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

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

Centre number						Candidate number				

First name(s) ______________________________

Last name ______________________________

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.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **20** pages.

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

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SECTION A

Answer **all** the questions.

1 This question is about finding the specific thermal capacity of a liquid. An electrical immersion heater connected to a supply unit is placed inside a calorimeter containing a liquid at room temperature, 17 °C. The calorimeter, shown in **Fig. 1.1**, has insulated lid, walls and base. The mass of the liquid is 200 ± 5 g. The temperature of the liquid is measured using a digital thermometer at 30-second intervals for 6 minutes.

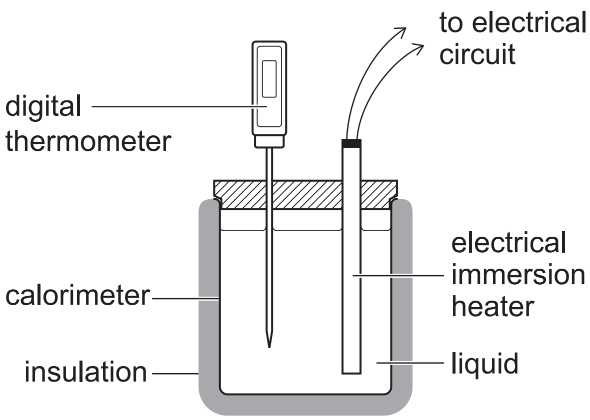

Fig. 1.1

(a) Suggest an improvement, with a reason, to the experimental design.

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.... **[2]**

(b) **(i)** Draw a circuit diagram to represent the apparatus used to calculate the power of the electrical heater. This symbol —□□□— may be used for the electrical heater.

[2]

(ii) The following readings were obtained:

potential difference $V = 10.5 \pm 0.2\,\text{V}$
current $I = 2.3 \pm 0.2\,\text{A}$.

Calculate the power supplied to the heater **per unit mass** of the liquid.
Include the uncertainty in the value.

power per unit mass = ... ± .... W kg^{-1} **[4]**

(c) **Fig. 1.2** shows the temperature–time graph obtained.

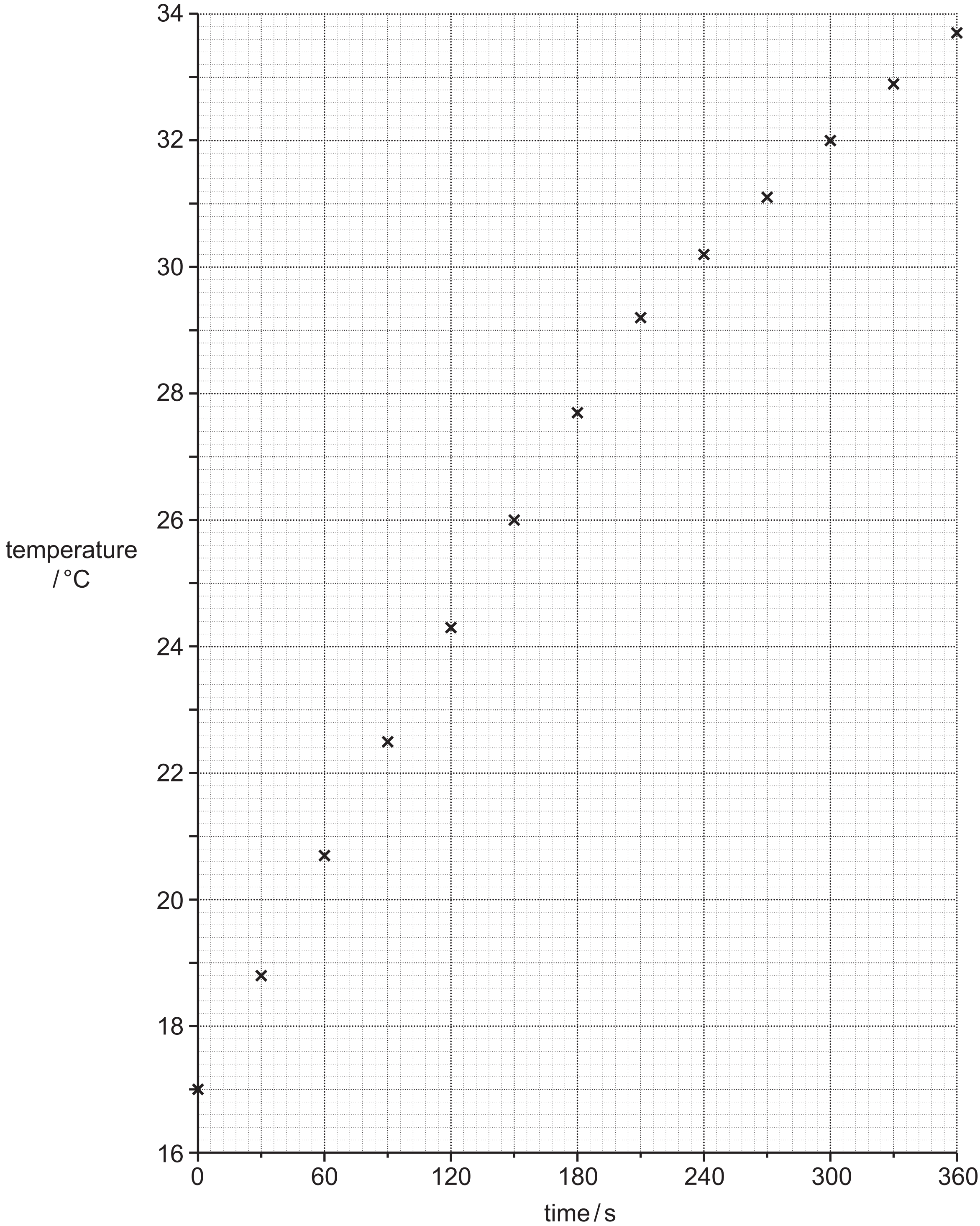

Fig. 1.2

(i) Explain the shape of the graph in **Fig. 1.2**.

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.... **[2]**

(ii) Draw a straight line of best fit through the initial linear section of **Fig. 1.2**. **[1]**

(iii) Show that the relationship between the gradient of the linear section and the specific thermal capacity, *c*, takes the form

$$gradient = \frac{Z}{c}$$

where *Z* is a constant.

[2]

(iv) Use the linear part of **Fig. 1.2** to find the specific thermal capacity of the liquid.

c = ... $\mathrm{J\,kg^{-1}\,K^{-1}}$ **[3]**

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Question 2 begins on page 7

2 This question is about calibrating a light meter to measure the intensity of light emitted by a torch.

(a) Light intensity is measured in $W\,m^{-2}$, and can be calculated using the equation

$$Intensity = \frac{E}{At}$$

where E is the radiant energy passing through a surface in time t and A is the cross-sectional area of the surface.

The beam from a torch, shown in **Fig. 2.1**, has a conical shape. At a distance, x, the intensity of light is L. Show that at a distance of $2x$, the intensity will be reduced to $\frac{L}{4}$.

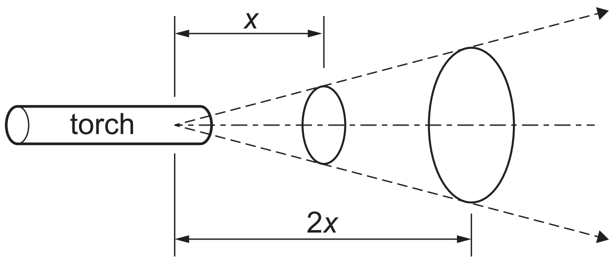

Fig. 2.1

[2]

(b) An LDR is placed in a potential divider circuit as shown in **Fig. 2.2**.

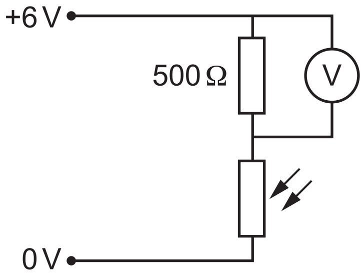

Fig. 2.2

(i) Explain why the output reading on the voltmeter will increase as light intensity increases.

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.... **[2]**

Fig. 2.3 shows a graph of intensity against $\frac{1}{x^2}$.

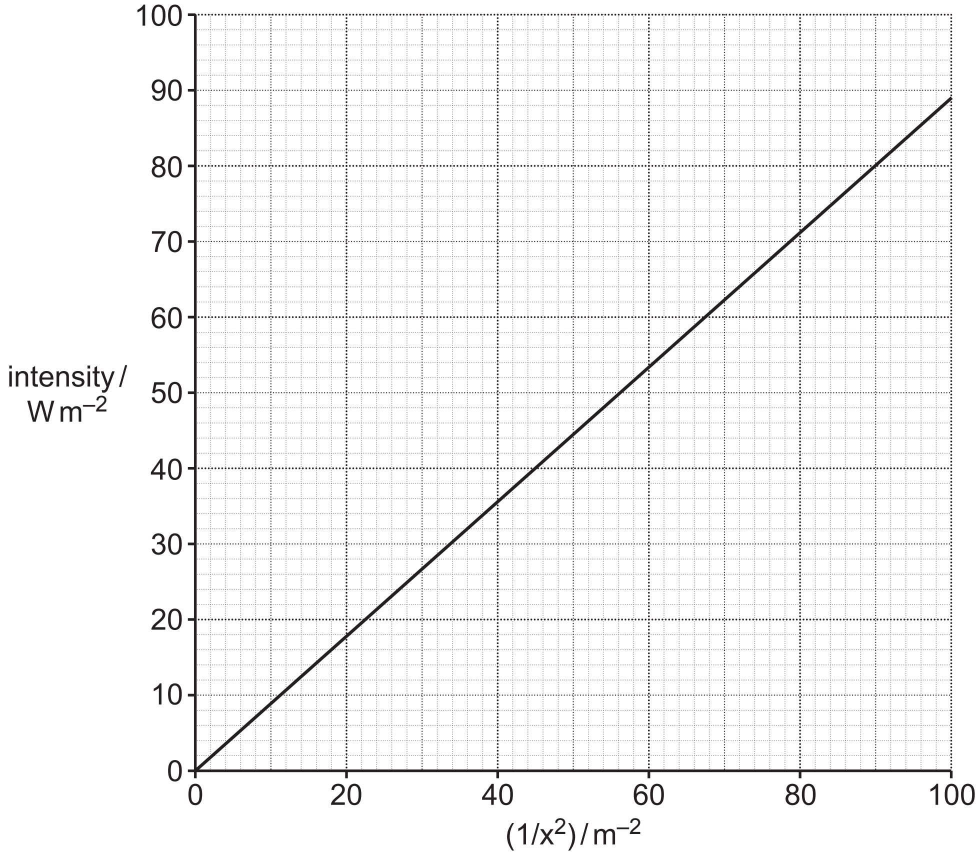
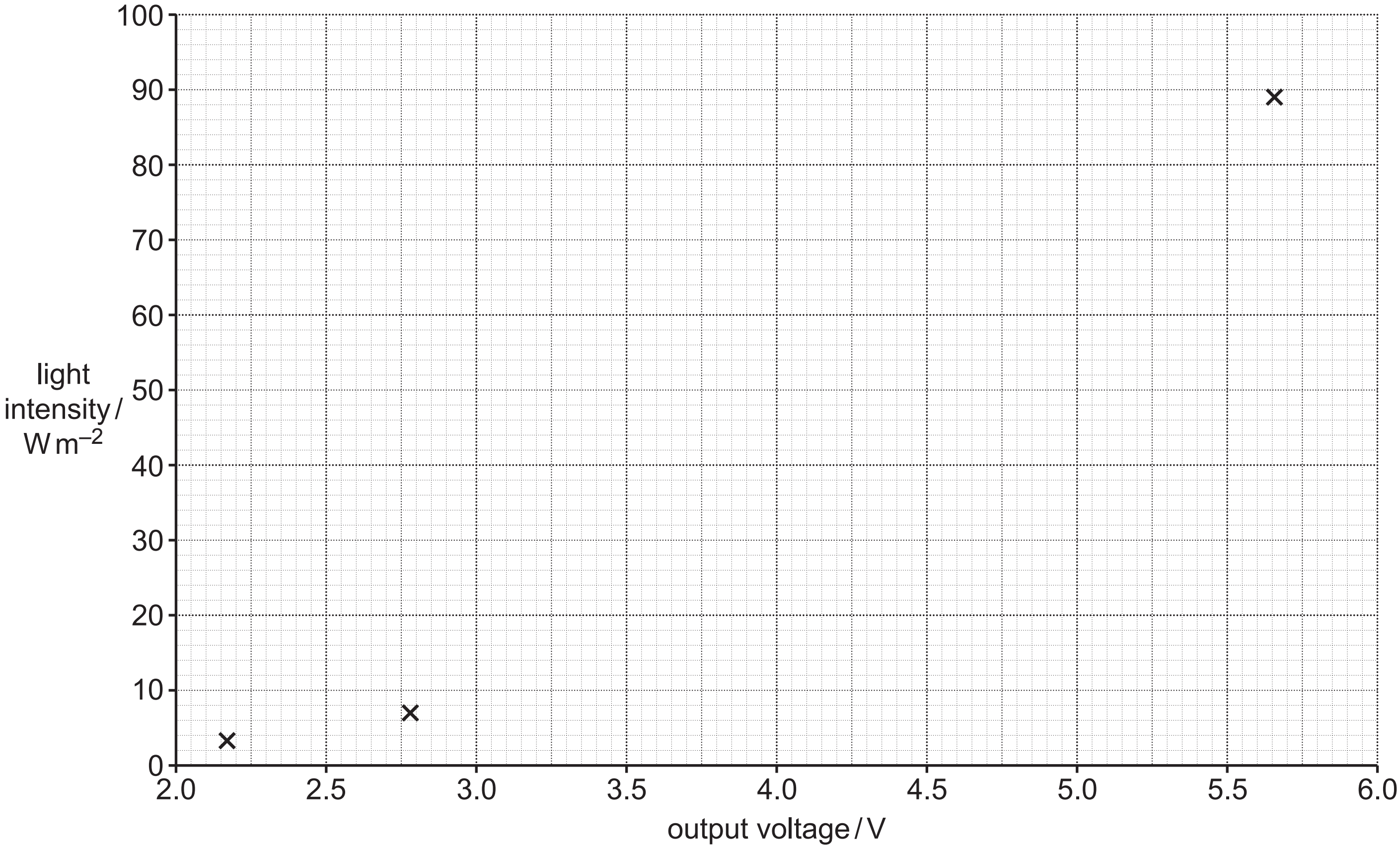


Fig. 2.3

A student collects the data shown in the table below. There was no background illumination present.

Distance / cm	Voltage output / V	Light Intensity / W m^{-2}
10	5.66	89
20	4.69	
30	3.75	
40	2.78	7
50	2.17	3.5

(ii) Use the graph in **Fig. 2.3** to complete the third column and then plot the points and complete the calibration curve in **Fig. 2.4**. **[3]**



100
90
80
70
60
50
40
30
20
10
0
light intensity / W m–2
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
output voltage / V

Fig. 2.4

(c)* Use the calibration plots in this question to find the distance of the torch from the light meter in the following two cases:

- the voltmeter in **Fig. 2.2** reads 5.0 V
- the voltmeter in **Fig. 2.2** reads 5.0 V when the torch shines on it in a room with a constant level of background illumination equal to the intensity from the source at a distance of 25.0 cm.

Make your method clear.

Explain how a calibration curve yielding the intensity of the *light from the torch* in the scenario with background illumination would differ from **Fig. 2.4**, the calibration curve of the light incident on the light meter with no background illumination. **[6]**

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Additional answer space if required

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3 The speed of sound can be measured using the resonance of air in a tube. A loudspeaker is placed above the open end of a hollow glass tube with the other end immersed in water as shown in **Fig. 3.1**.

The loudspeaker is connected to a signal generator set at a frequency of 480 Hz with an audible volume. The height of the column of air is changed by moving the glass tube up and down, until maximum volume of sound is heard.

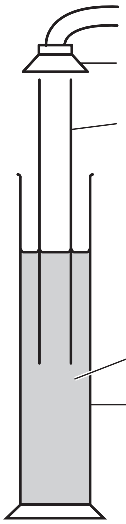

Fig. 3.1

(a) (i) Explain how a standing wave is formed in the tube.

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.... **[4]**

(ii) The shortest height of the air column for maximum volume is recorded as L_1. The air just above the tube is also vibrating and this extends the length of the standing wave by x, the 'end correction', such that:

$$L_1 + x = \frac{\lambda}{4}.$$

Show that:

$$L_1 = \frac{v}{4f} - x$$

[1]

(b) A student records the value of L_1 for different values of frequency and plots a graph of L_1 against 1/frequency as shown in **Fig. 3.2**.

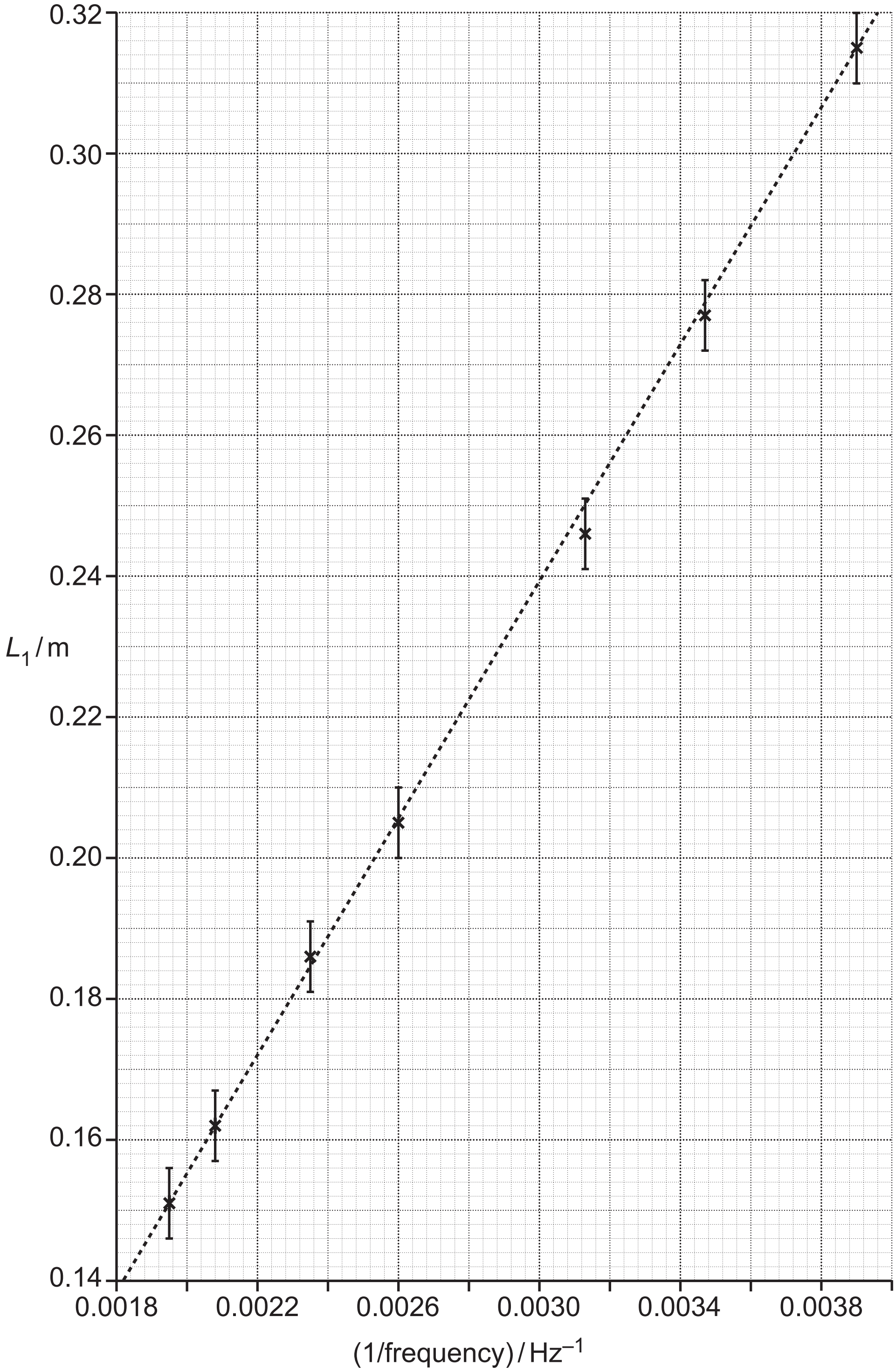
(i) The gradient of the line is 83 m s^{-1}. Calculate the speed of sound in air. Calculate the percentage uncertainty in your result by taking a 'worst-fit' line from the graph.

speed of sound = ... m s^{-1}

percentage uncertainty = ... % **[4]**

(ii) The end correction is approximately equal to 0.3 D, where D is the diameter of the tube. What is the approximate diameter of the tube used in this experiment?

D = ... m **[2]**



0.32
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
L_1 / m
0.0018
0.0022
0.0026
0.0030
0.0034
0.0038
(1/frequency) / Hz^{-1}

Fig. 3.2

SECTION B

Answer **all** the questions.

4 This is a question about transformers. A student performs an experiment to investigate transformers using the apparatus shown in **Fig. 4.1**.

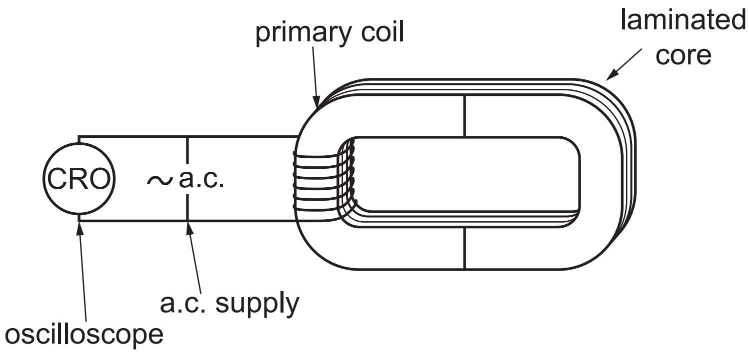


Fig. 4.1

The student connects an oscilloscope as shown in **Fig. 4.1**, to measure the input voltage to the primary coil of the transformer. The screen of the oscilloscope is shown in **Fig. 4.2**:

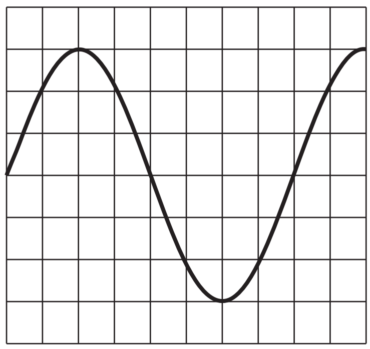


Fig. 4.2

(a) The oscilloscope has the following settings: 500 mV / div on the vertical scale and 2.5 ms / div on the horizontal scale. Use **Fig. 4.2** to calculate the following values for the input coil:

(i) peak potential difference V

V = ... V **[1]**

(ii) frequency f

f = ... Hz **[1]**

(b) A secondary coil is added to the right-hand side of the C-core shown in **Fig. 4.1**.

Fig. 4.3 shows the p.d.s across the primary and secondary coils. The scale settings are unchanged.

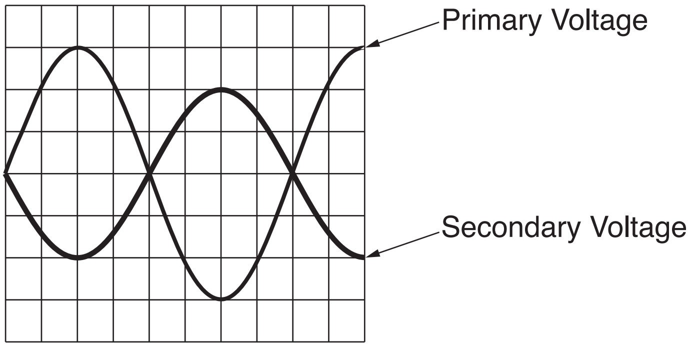


Fig. 4.3

The student suggests that the turns ratio $\frac{N_1}{N_2}$ is $\frac{3}{2}$.

(i) Use **Fig. 4.3** to explain the student's reasoning.

[2]

(ii) The actual ratio of turns for the transformer is $\frac{5}{4}$. Suggest and explain a reason for this difference.

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.... **[2]**

(c) The current in the primary coil is I_1 and the current in the secondary coil is I_2. Show that the maximum current in the secondary coil is given by the relationship

$$\frac{I_1 N_1}{N_2} = I_2 .$$

State any assumptions you make.

Assumption(s): ....

.... **[2]**

(d) The student alters the turns ratio to $\frac{5}{7}$. N_2 is now 200 turns. The peak output emf is 2.0 V.

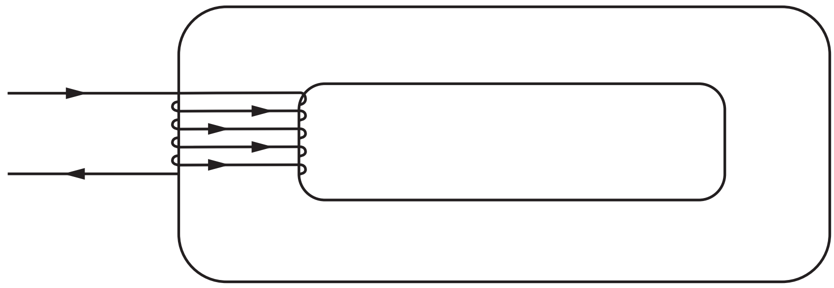
The frequency of the supply is unchanged.

(i) Estimate the maximum flux through the secondary coil.

maximum flux = ... Wb **[3]**

The student now uses a different set of C-cores which have a greater overall length.

(ii) Complete the diagram by adding two lines which represent the flux in the core at the instant shown.



[2]

(iii) State the effect of increasing the length of the magnetic circuit of the transformer.

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.... **[1]**

Another student has a faulty set of apparatus such that the C-cores do not fully meet on one side as shown in **Fig. 4.4**.

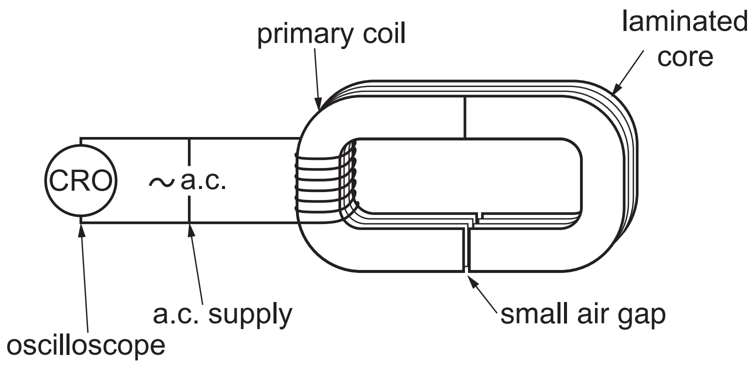

Fig. 4.4

(iv) Explain how a small air gap affects the magnetic circuit in **Fig. 4.4** and why the core is made of vertically stacked laminated sheets rather than a solid block of iron or horizontally stacked laminated sheets as shown in **Fig. 4.5**. **[6]**

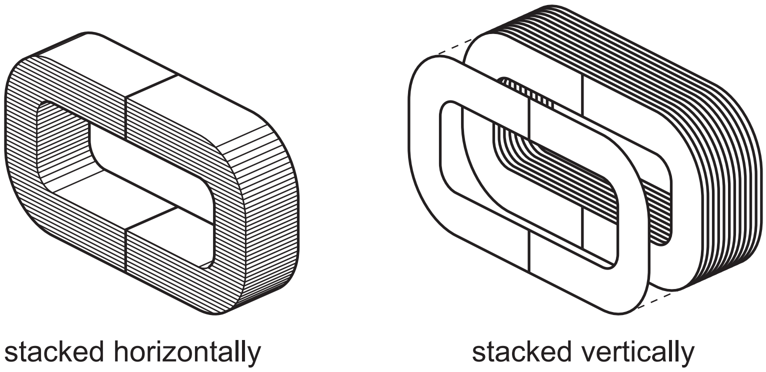

Fig. 4.5

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END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).