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9702/51

October/November 2022

1 hour 15 minutes

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [].

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[Turn over

- 1 A thin copper sheet is suspended from a small hole near the top of the sheet and placed in a magnetic field, as shown in Fig. 1.1.

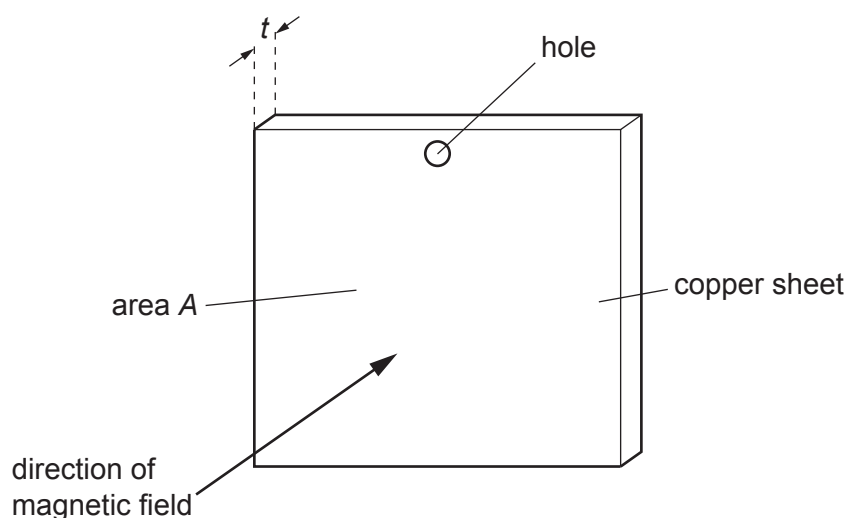


Fig. 1.1 (not to scale)

The sheet has area A and thickness t .

The sheet is displaced from its equilibrium position through a horizontal distance s_0 and then released so that it oscillates perpendicular to the direction of the magnetic field. The horizontal distance s of the sheet from its equilibrium position is measured after five complete oscillations.

It is suggested that s is related to A by the relationship

$$s = s_0 e^{-ABKt}$$

where B is the magnetic flux density of the field and K is a constant.

Plan a laboratory experiment to test the relationship between s and A .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine a value for K .

In your plan you should include:

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any safety precautions to be taken.

Diagram

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- 2 A student investigates a circuit containing resistors and a metal wire as shown in Fig. 2.1.

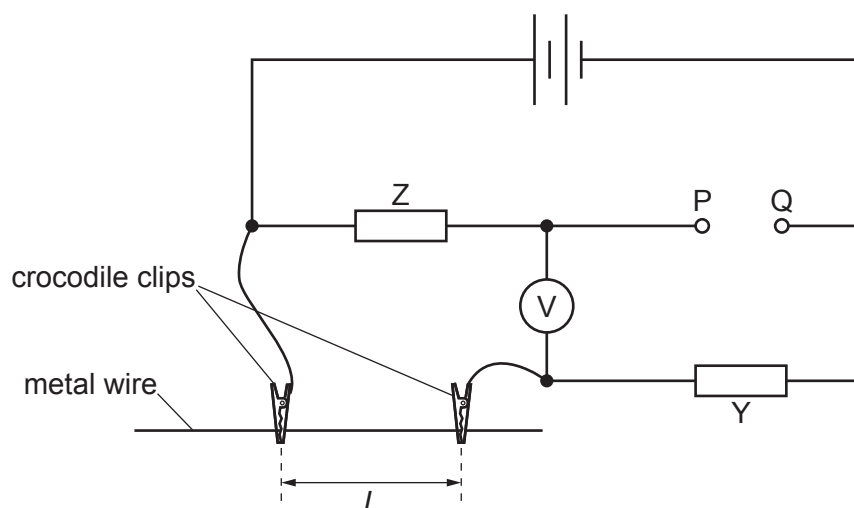


Fig. 2.1

Resistors Y and Z have resistances Y and Z respectively.

The student connects a resistor of resistance R between P and Q.

The student then adjusts the length of the wire between the crocodile clips until the voltmeter reads zero. The student measures the length L of wire between the crocodile clips.

The student repeats the experiment with different values of R .

It is suggested that L and R are related by the equation

$$\frac{Z}{R} = \frac{4\rho L}{\pi Y d^2}$$

where d is the diameter of the wire and ρ is the resistivity of the metal.

- (a) A graph is plotted of L on the y -axis against $\frac{1}{R}$ on the x -axis.

Determine an expression for the gradient.

gradient = [1]

(b) Values of R and L are given in Table 2.1.

Each resistance value R has a percentage uncertainty of $\pm 5\%$.

Table 2.1

R/Ω	$\frac{1}{R}/10^{-3}\Omega^{-1}$	L/cm
22		71.0
27		57.5
33		45.0
39		36.5
47		27.5
54		23.0

Calculate and record values of $\frac{1}{R}/10^{-3}\Omega^{-1}$ in Table 2.1.

Include the absolute uncertainties in $\frac{1}{R}$. [2]

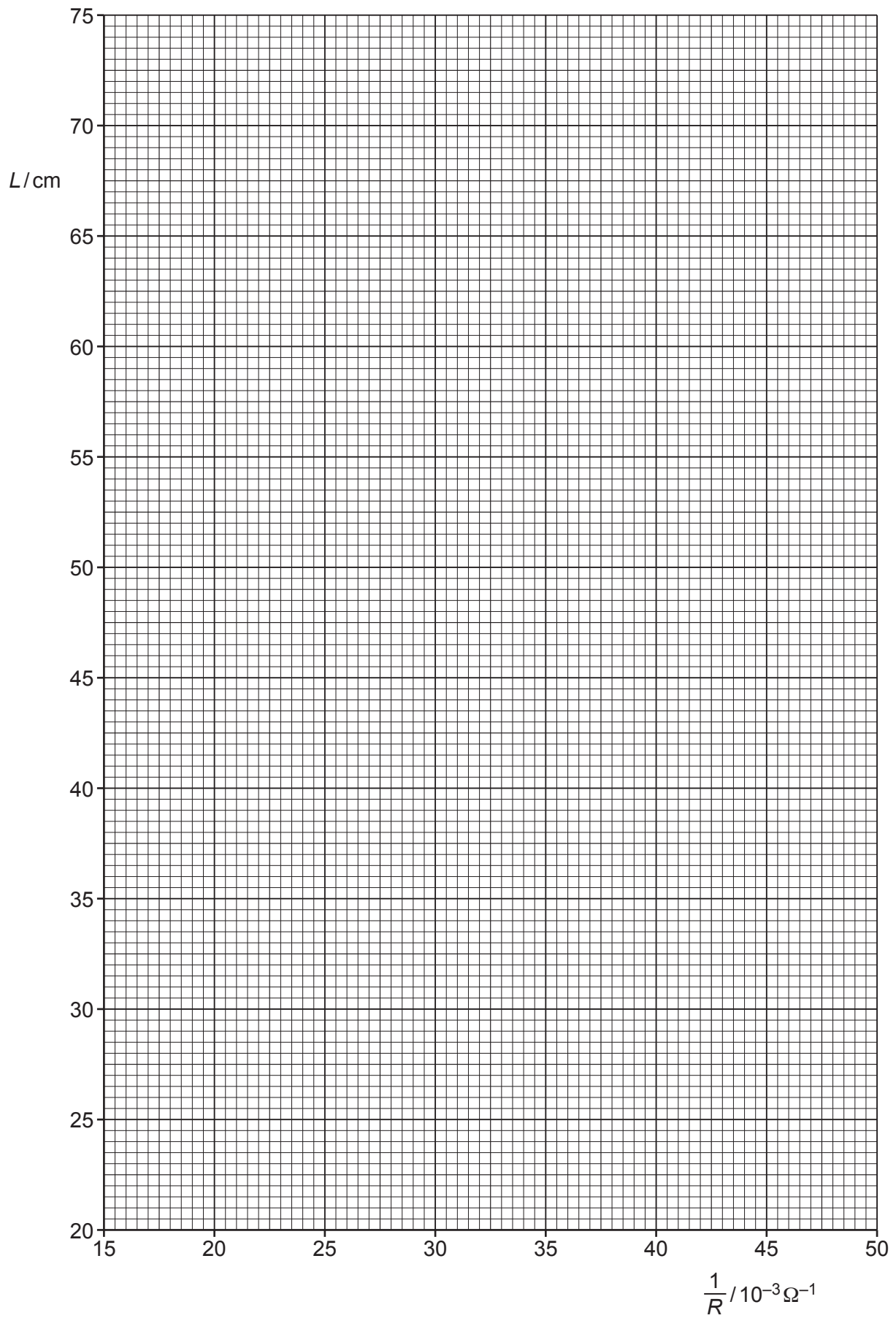
(c) (i) Plot a graph of L/cm against $\frac{1}{R}/10^{-3}\Omega^{-1}$.

Include error bars for $\frac{1}{R}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Label both lines. [2]

(iii) Determine the gradient of the line of best fit. Include the absolute uncertainty in your answer.

gradient = [2]



- (d) The student measures the diameter of the wire. The student's values are:

0.263 mm 0.262 mm 0.263 mm 0.257 mm 0.262 mm 0.259 mm.

Determine the average diameter d . Include the absolute uncertainty in d .

$d = \dots\dots\dots$ mm [1]

- (e) (i) Resistors Y and Z each have a resistance of $22\,\Omega \pm 5\%$.

Using your answers to (a), (c)(iii) and (d), determine the value of ρ . Include an appropriate unit.

$\rho = \dots\dots\dots$ [2]

- (ii) Determine the percentage uncertainty in ρ .

percentage uncertainty in $\rho = \dots\dots\dots$ % [1]

- (f) Determine the resistance R that would give a value of L of 95.0 cm. Include the absolute uncertainty in your answer.

$R = \dots\dots\dots$ Ω [2]

[Total: 15]