



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/52

February/March 2024

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 [].

DC (PQ/SW) 331329/2
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[Turn over

- 1 Fig. 1.1 shows a thin cylindrical metal rod of length L .



Fig. 1.1

One end of the rod is hit with a hammer. A stationary sound wave is set up within the rod. The rod vibrates at its resonant frequency f .

A microphone placed at the other end of the rod detects the sound wave emitted from the rod. The frequency of the detected sound is also f .

A number of rods of different length are available.

It is suggested that f is related to L by the relationship

$$2fL^n = \sqrt{\frac{E}{\rho}}$$

where ρ is the density of the metal, and E and n are constants.

Plan a laboratory experiment to test the relationship between f and L .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for E and n .

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 an electrical circuit.

A power supply with negligible internal resistance is connected to six resistors, each of resistance Z , and a resistor of resistance R , as shown in Fig. 2.1.

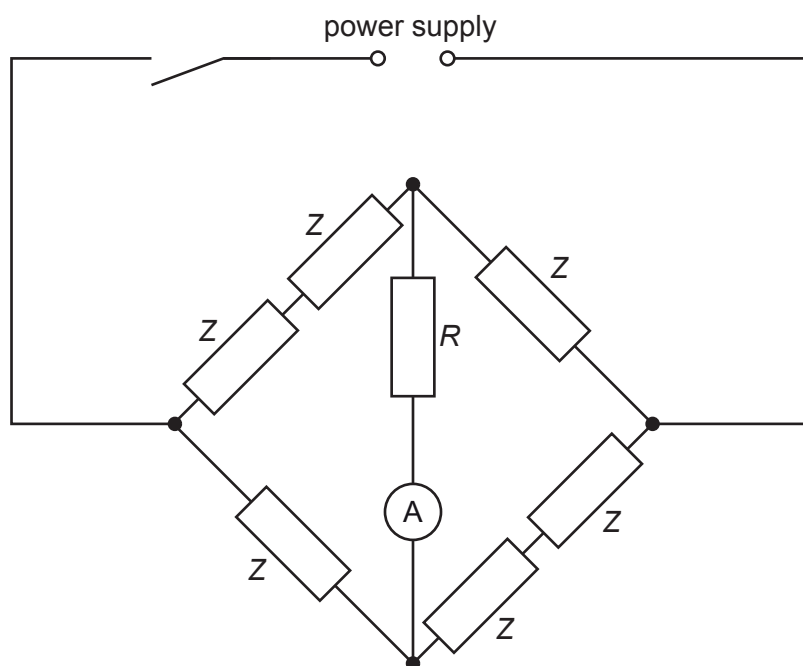


Fig. 2.1

The current measured by the ammeter is I .

The experiment is repeated for different values of R .

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

$$E = 3IR + 4IZ$$

where E is the electromotive force (e.m.f.) of the power supply.

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

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

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

Table 2.1

$R/\text{k}\Omega$	$I/\mu\text{A}$	$\frac{1}{I}/\text{A}^{-1}$
1.25	225 ± 5	
2.55	185 ± 5	
3.90	160 ± 5	
5.25	140 ± 5	
6.55	125 ± 5	
7.80	115 ± 5	

Calculate and record values of $\frac{1}{I}/\text{A}^{-1}$ in Table 2.1.

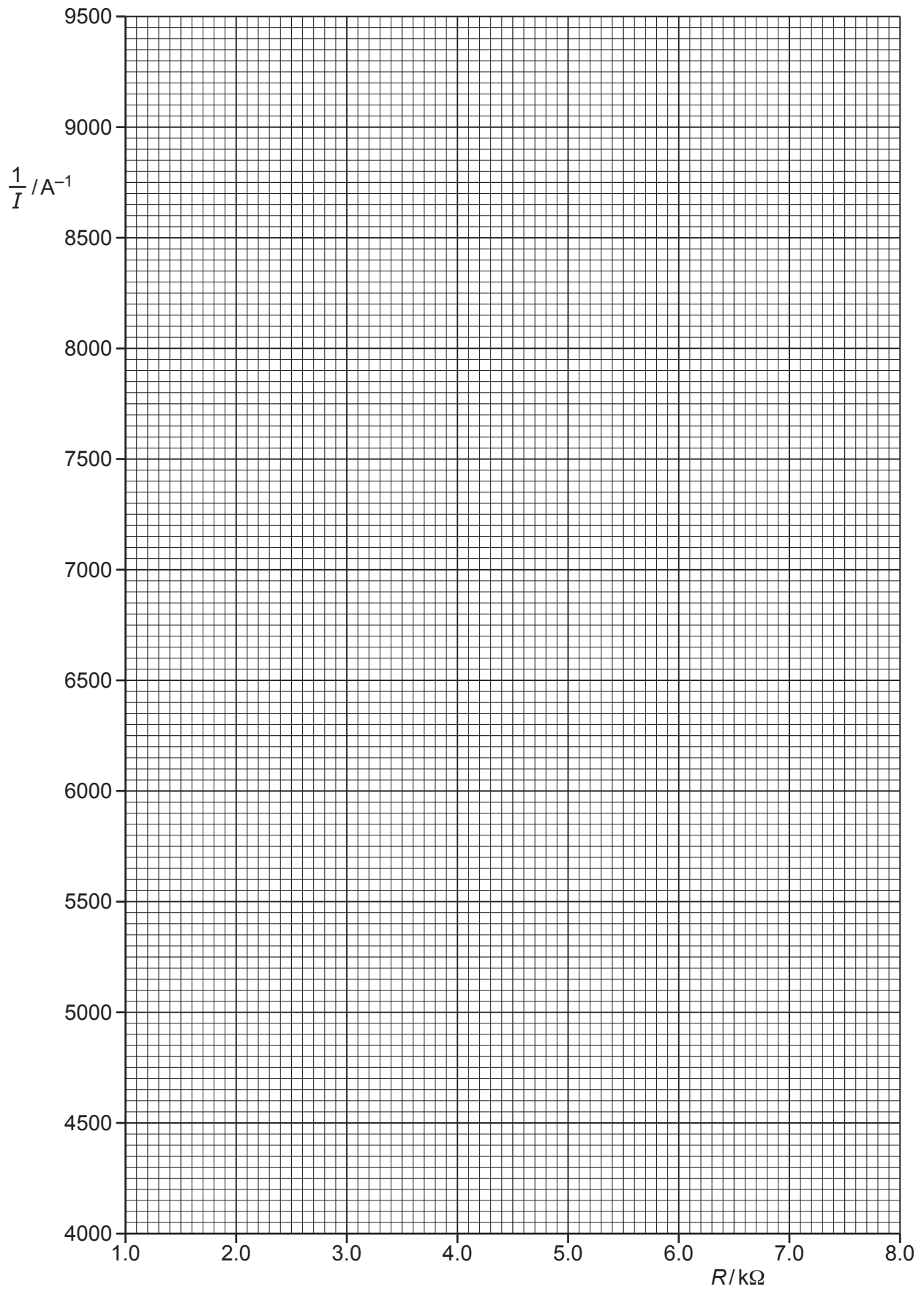
Include the absolute uncertainties in $\frac{1}{I}$. [2]

(c) (i) Plot a graph of $\frac{1}{I}/\text{A}^{-1}$ against $R/\text{k}\Omega$. Include error bars for $\frac{1}{I}$. [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]



- (iv) Determine the y -intercept of the line of best fit. Include the absolute uncertainty in your answer.

y -intercept = [2]

- (d) (i) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of E and Z . Include appropriate units.

E =

Z = [2]

- (ii) Determine the percentage uncertainty in Z .

percentage uncertainty in Z = % [1]

- (e) The experiment is repeated. Determine the resistance R that gives a value of I of 0.10 mA.

R = Ω [1]

[Total: 15]