



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/51

October/November 2021

1 hour 15 minutes

You must answer on the question paper.

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 [].

This document has 8 pages.

- 1 A student investigates stationary sound waves in cylindrical tubes. Fig. 1.1 shows a stationary wave pattern in a tube which is open at both ends.

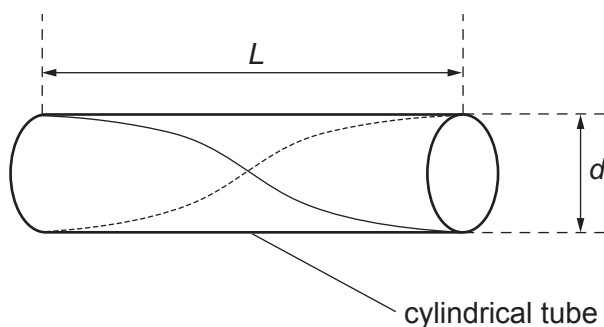


Fig. 1.1

The tube has length L and diameter d . The frequency of the sound for the stationary wave pattern shown is f .

There are a number of different tubes available.

It is suggested that the relationship between f and d is

$$\frac{v}{f} = 2L + kd$$

where v is the speed of sound in air and k is a constant.

Design a laboratory experiment to test the relationship between f and d . Explain how your results could be used to determine values for k and v .

You should draw a diagram, on page 3, showing the arrangement of your equipment. In your account you should pay particular attention to:

- 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 the discharge of a capacitor in the circuit shown in Fig. 2.1.

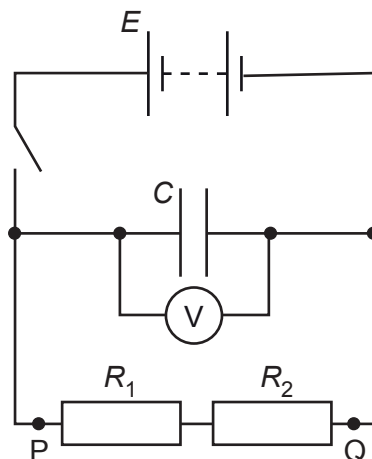


Fig. 2.1

The student closes the switch and charges the capacitor.

The switch is opened and a stop-watch is started. The capacitor discharges through the two resistors of resistance R_1 and R_2 connected between P and Q. At a fixed time t the potential difference V across the capacitor is measured.

The experiment is repeated for different values of R_1 and R_2 .

It is suggested that V , R_1 and R_2 are related by the equation

$$\ln\left(\frac{V}{E}\right) = -\frac{t}{C(R_1 + R_2)}$$

where E is the electromotive force (e.m.f.) of the battery and C is the capacitance of the capacitor.

- (a) A graph is plotted of $\ln V$ on the y -axis against $\frac{1}{R_1 + R_2}$ on the x -axis.

Determine expressions for the gradient and y -intercept.

gradient =

y -intercept =

[1]

(b) Values of R_1 , R_2 , V and $\ln V$ are given in Table 2.1.

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

Table 2.1

$R_1/\text{k}\Omega$	$R_2/\text{k}\Omega$	$(R_1 + R_2)/\text{k}\Omega$	$\frac{1}{R_1 + R_2}/10^{-6}\Omega^{-1}$	V/V	$\ln(V/V)$
22	33			1.28	0.247
22	47			1.98	0.683
22	68			2.87	1.054
33	47			2.39	0.871
33	68			3.28	1.188
47	68			3.55	1.267

Calculate and record values of $(R_1 + R_2)/\text{k}\Omega$ and $\frac{1}{R_1 + R_2}/10^{-6}\Omega^{-1}$ in Table 2.1.

Include the absolute uncertainties in $(R_1 + R_2)$ and $\frac{1}{R_1 + R_2}$. [2]

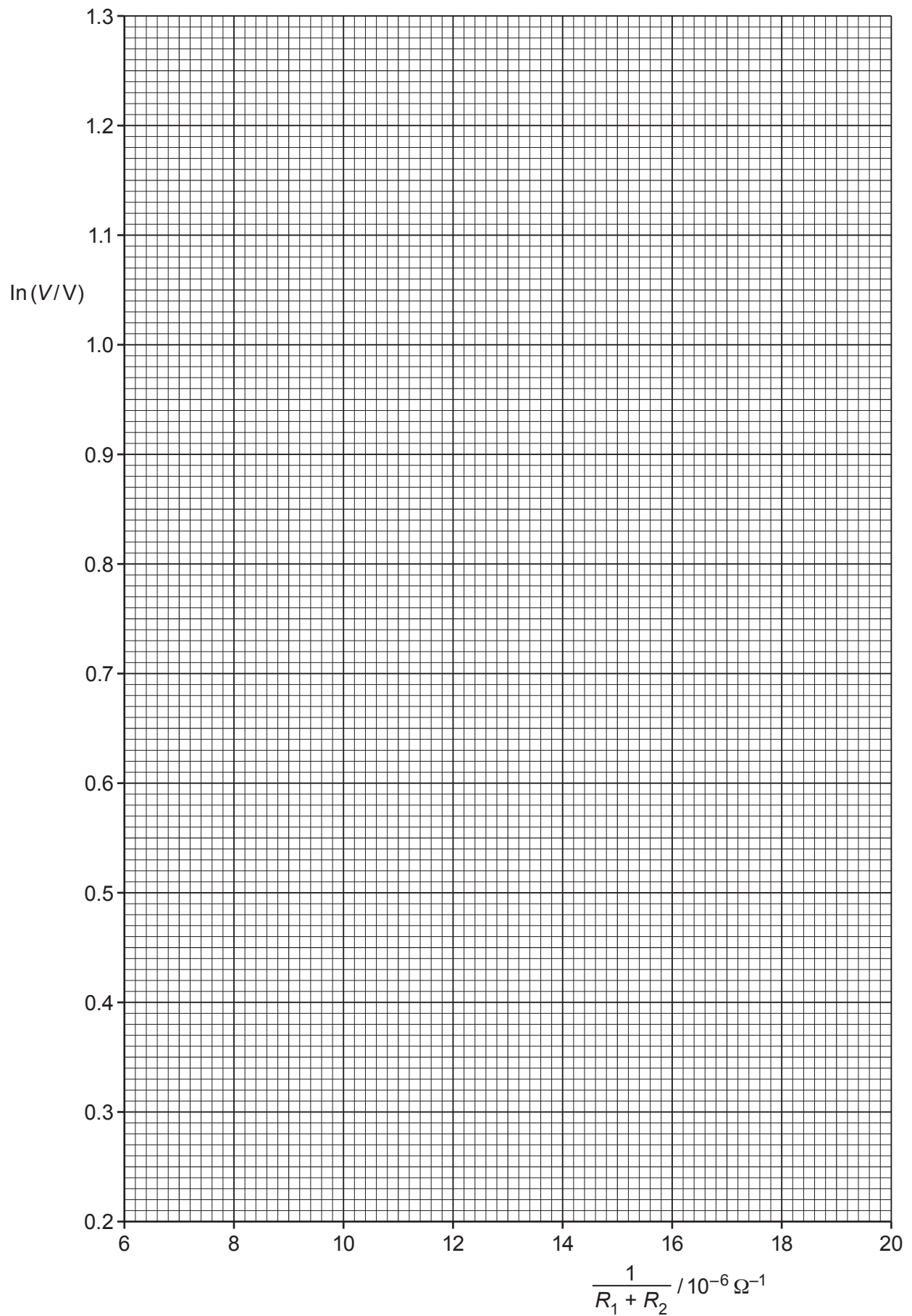
(c) (i) Plot a graph of $\ln(V/V)$ against $\frac{1}{R_1 + R_2}/10^{-6}\Omega^{-1}$.

Include error bars for $\frac{1}{R_1 + R_2}$. [2]

(ii) Draw the straight line of best fit and a worst acceptable straight line on your graph. Both lines should be clearly labelled. [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 C and E . Include appropriate units.

Data: $t = (60 \pm 1)\text{s}$

$C = \dots\dots\dots$

$E = \dots\dots\dots$ [2]

- (ii) Determine the percentage uncertainty in C .

percentage uncertainty = % [1]

- (e) The experiment is repeated using the same capacitor. Determine the value of $(R_1 + R_2)$ that would give a value of V of 5.0 V at time $t = 60\text{ s}$.

$(R_1 + R_2) = \dots\dots\dots \Omega$ [1]

[Total: 15]