



# Cambridge International AS & A Level

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**PHYSICS**

**9702/51**

Paper 5 Planning, Analysis and Evaluation

**October/November 2021**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

## INSTRUCTIONS

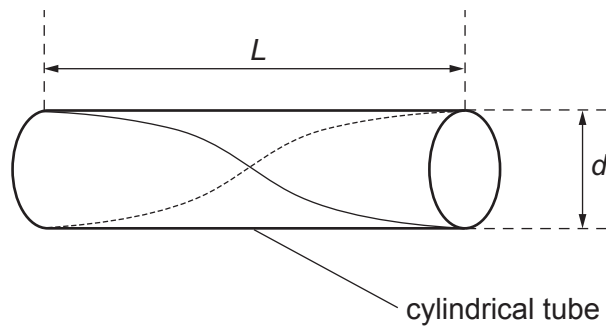
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction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

## INFORMATION

- 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.

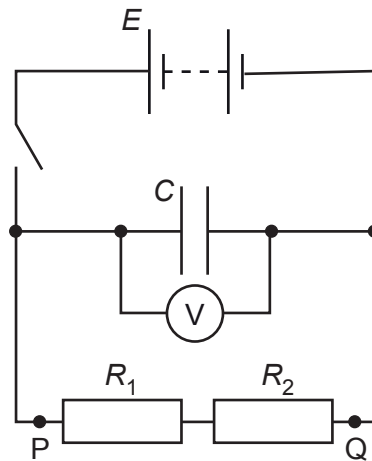


Fig. 2.1

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]

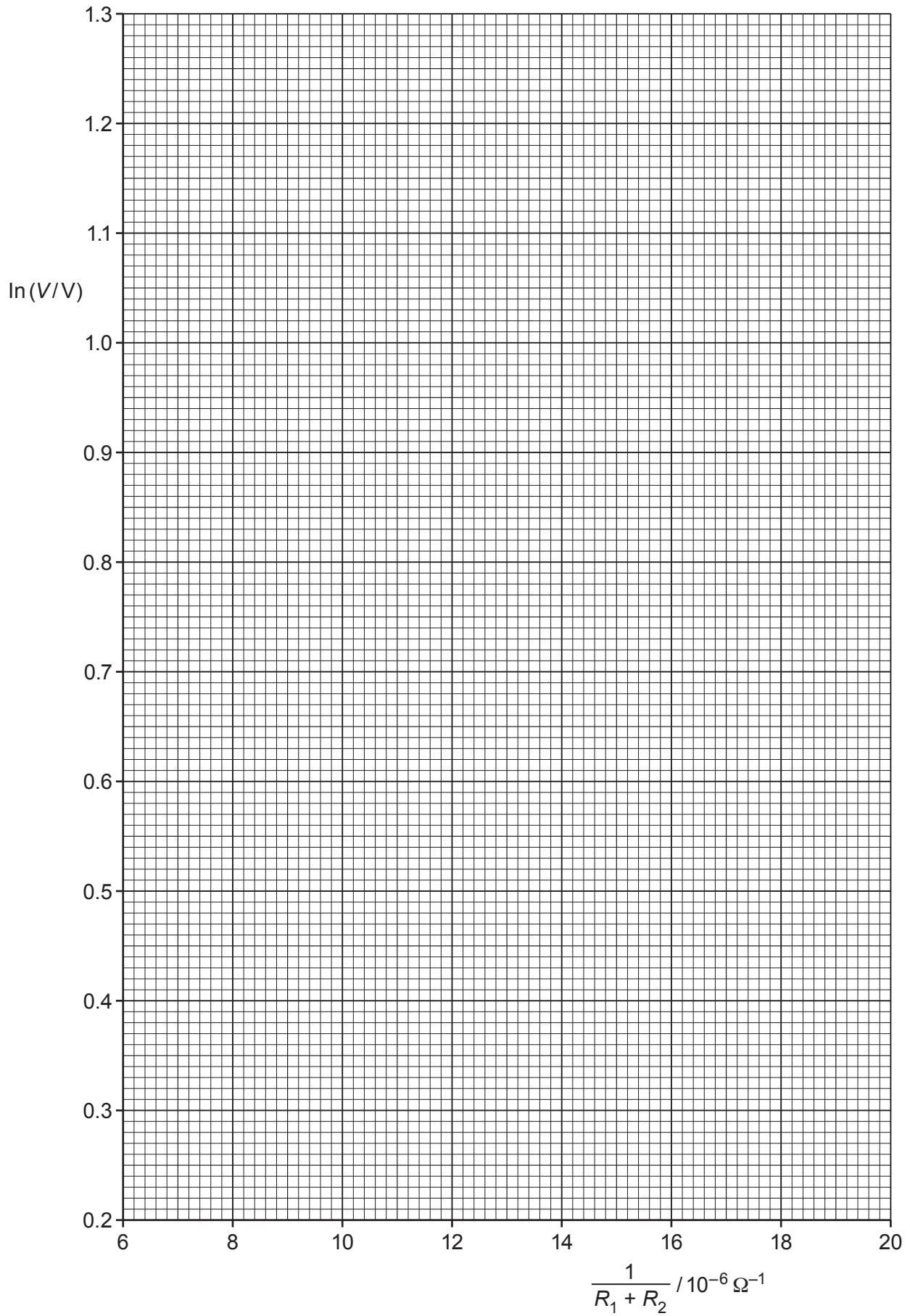
(c) (i) Plot a graph of  $\ln(V/V)$  against  $\frac{1}{R_1 + R_2}/10^{-6}\Omega^{-1}$ .

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  $5.0\text{V}$  at time  $t = 60\text{s}$ .

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

[Total: 15]