Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

5395960624

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.

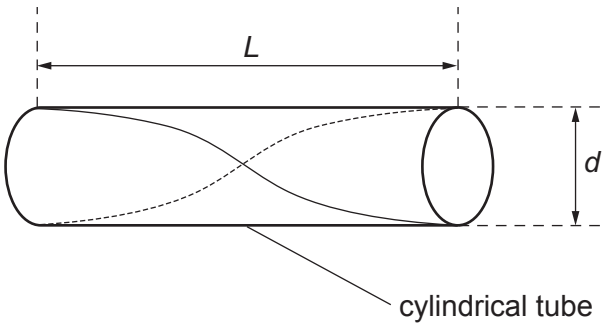

Fig. 1.1

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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[15]

2 A student investigates the discharge of a capacitor in the circuit shown in Fig. 2.1.

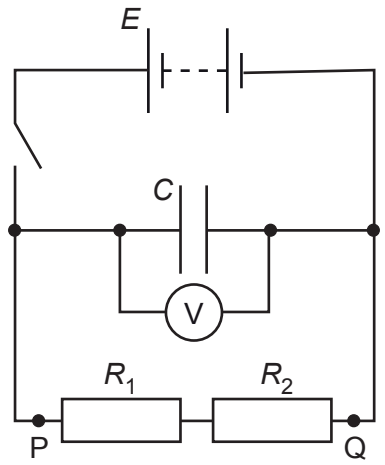


Fig. 2.1

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 ±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	$\ln(V/\text{V})$
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]

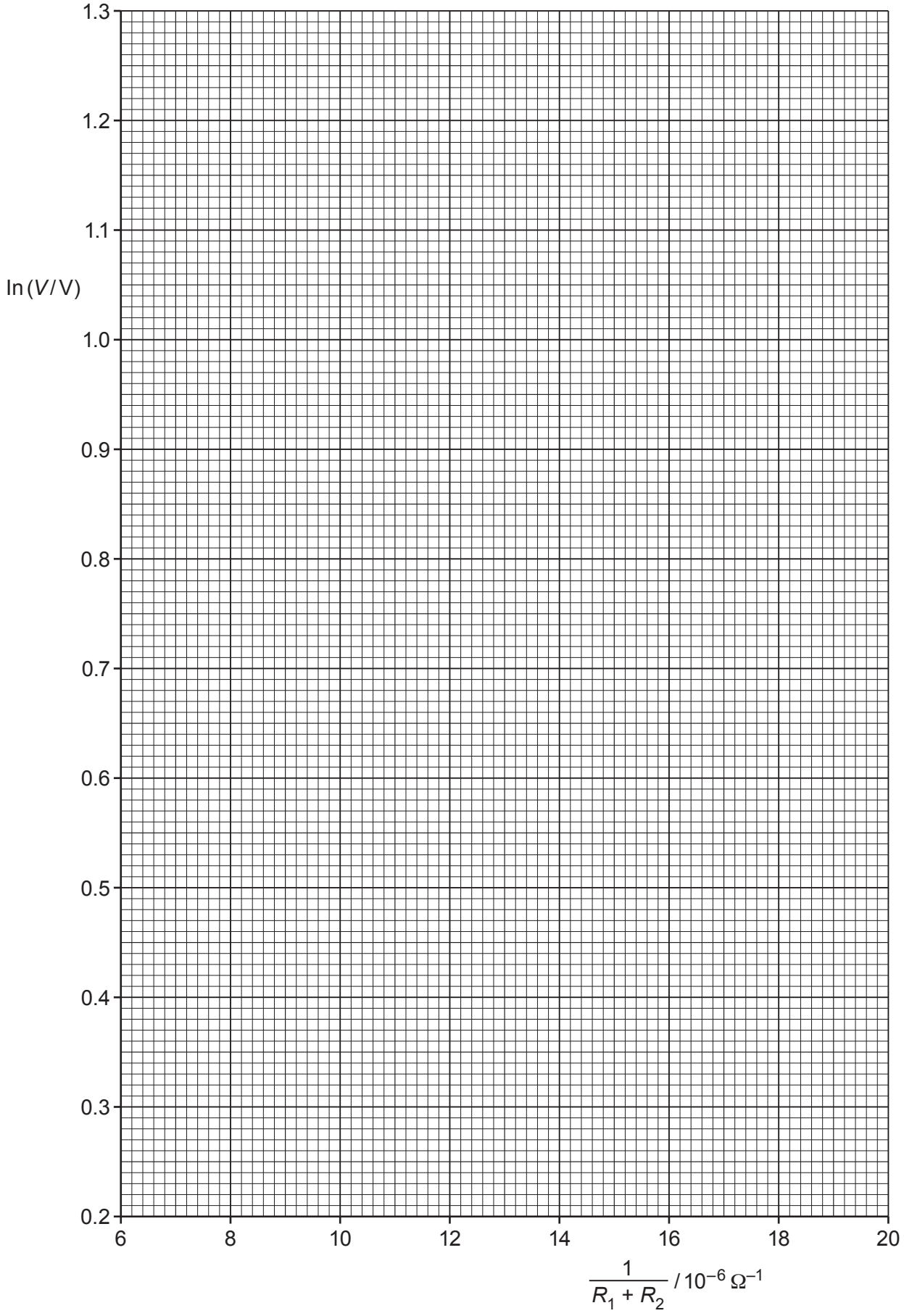
(c) **(i)** Plot a graph of $\ln(V/\text{V})$ against $\frac{1}{R_1 + R_2}/10^{-6}\,\Omega^{-1}$.

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]


1.3
1.2
1.1
ln (V / V)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
6
8
10
12
14
16
18
20
1 / R1 + R2 / 10−6 Ω−1

(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: $t = (60 \pm 1)\,s$

C = ...

E = ...
[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 $t = 60\,s$.

$(R_1 + R_2)$ = ... Ω [1]

[Total: 15]