



# Cambridge International AS & A Level

CANDIDATE  
NAME

CENTRE  
NUMBER

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## PHYSICS

9702/51

Paper 5 Planning, Analysis and Evaluation

May/June 2024

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.

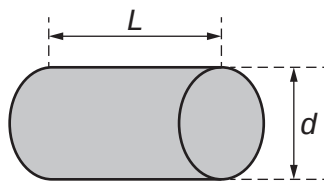
## INFORMATION

- 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.

## 2

- 1 Fig. 1.1 shows a small solid metal cylinder of mass  $m$ , length  $L$  and diameter  $d$ .



**Fig. 1.1**

The cylinder is heated to a uniform temperature. The cylinder is then removed from the heat source and the cylinder is wrapped in an insulating material.

The temperature of the room is  $T_R$ . At time  $t$  after the cylinder starts to cool, the surface temperature of the cylinder is  $T_C$ .

It is suggested that  $T_C$  is related to  $t$  by the relationship

$$(T_C - T_R) = Ze^{-\frac{UAt}{mc}}$$

where  $A$  is the total surface area of the cylinder,  $c$  is the specific heat capacity of the metal, and  $U$  and  $Z$  are constants.

Plan a laboratory experiment to test the relationship between  $T_C$  and  $t$ .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for  $U$  and  $Z$ .

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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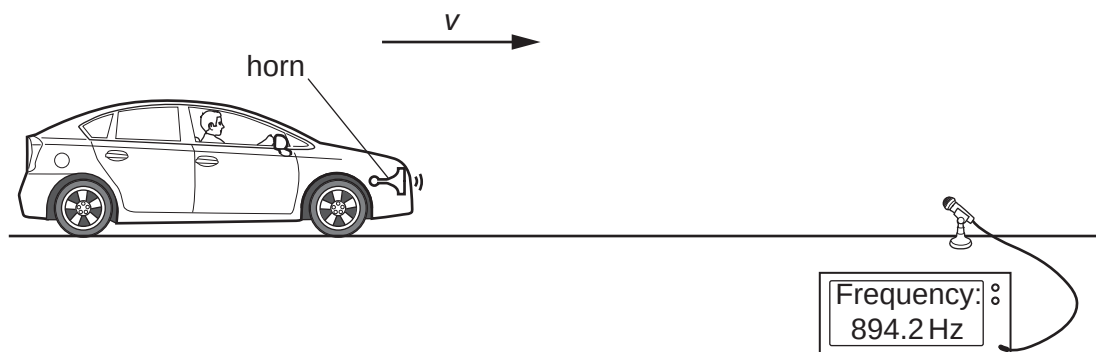
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- 2 A student investigates the sound from a horn attached to a car, as shown in Fig. 2.1.



**Fig. 2.1** (not to scale)

A microphone is placed at the side of the road and connected to a frequency meter. The car travels towards the microphone. The frequency  $f$  of the sound detected by the microphone is read from the frequency meter.

The speed of the car is measured by two speed detectors. The two measurements of speed are  $v_1$  and  $v_2$ . The average speed  $v$  of the car is determined from  $v_1$  and  $v_2$ .

The experiment is repeated for different speeds of the car.

It is suggested that  $f$  and  $v$  are related by the equation

$$f = \frac{f_s k}{k - v}$$

where  $f_s$  is the frequency of the sound emitted by the horn and  $k$  is a constant.

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

Determine expressions for the gradient and  $y$ -intercept.

gradient = .....

$y$ -intercept = .....

[1]

(b) Values of  $v_1$ ,  $v_2$  and  $f$  are given in Table 2.1.

**Table 2.1**

| $v_1/\text{ms}^{-1}$ | $v_2/\text{ms}^{-1}$ | $v/\text{ms}^{-1}$ | $f/\text{Hz}$ | $\frac{1}{f}/10^{-3}\text{Hz}^{-1}$ |
|----------------------|----------------------|--------------------|---------------|-------------------------------------|
| 3.1                  | 3.9                  |                    | 894.2         |                                     |
| 6.7                  | 5.9                  |                    | 901.2         |                                     |
| 9.2                  | 8.2                  |                    | 908.0         |                                     |
| 11.9                 | 10.9                 |                    | 915.8         |                                     |
| 13.3                 | 14.5                 |                    | 923.6         |                                     |
| 15.6                 | 16.8                 |                    | 931.2         |                                     |

Calculate and record values of  $v/\text{ms}^{-1}$  and  $\frac{1}{f}/10^{-3}\text{Hz}^{-1}$  in Table 2.1.

Include the absolute uncertainties in  $v$ .

[2]

(c) (i) Plot a graph of  $\frac{1}{f}/10^{-3}\text{Hz}^{-1}$  against  $v/\text{ms}^{-1}$ . Include error bars for  $v$ .

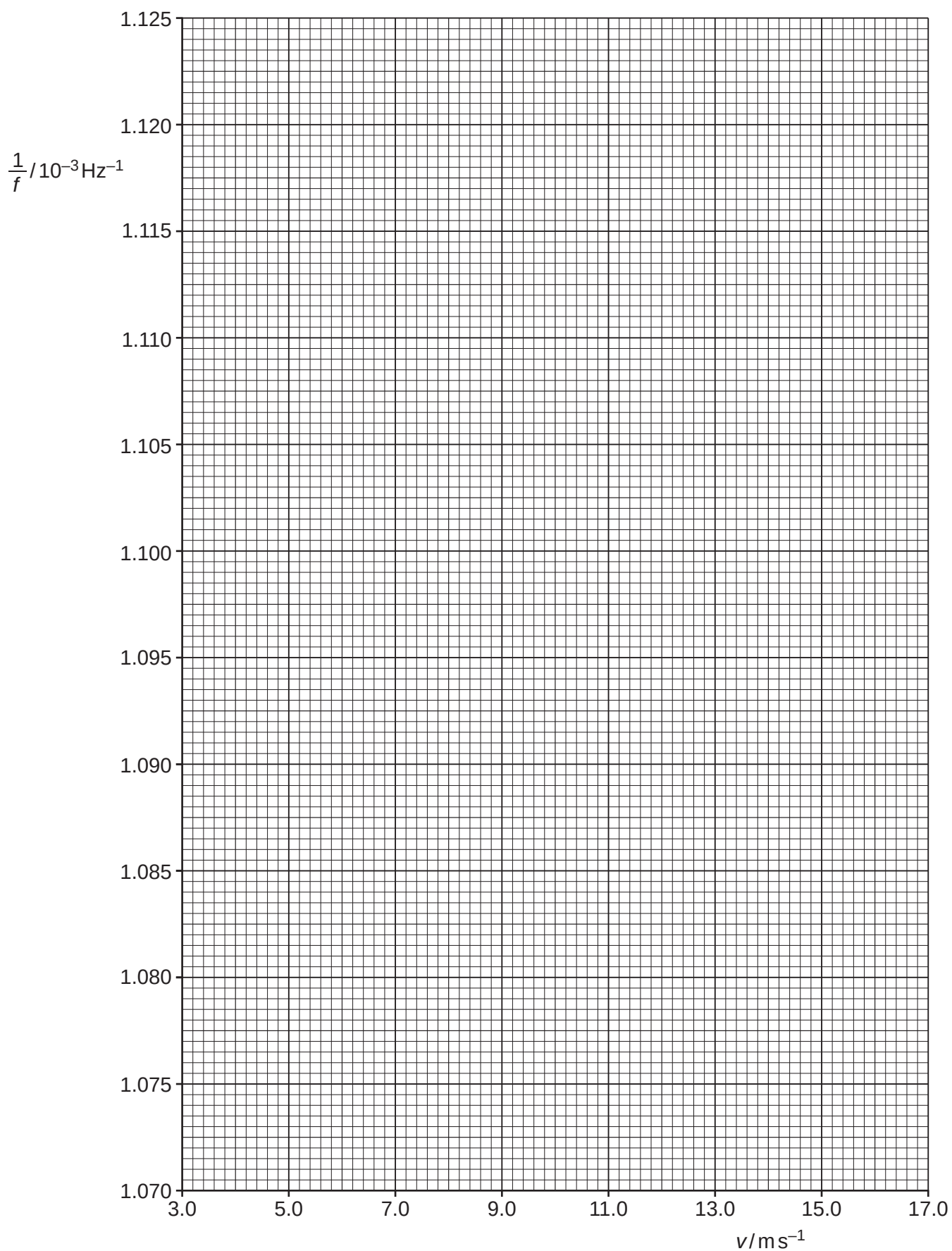
[2]

(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  $f_s$  and  $k$ . Include appropriate units.

$f_s$  = .....

$k$  = ..... [2]

- (ii) Determine the percentage uncertainty in  $k$ .

percentage uncertainty in  $k$  = ..... % [1]

- (e) The experiment is repeated. Determine the speed  $v$  that gives a value of  $f$  of 987.8 Hz.

$v$  = .....  $\text{ms}^{-1}$  [1]

[Total: 15]