



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/51

May/June 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 [].

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[Turn over

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

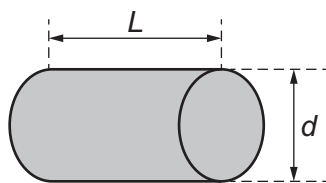


Fig. 1.1

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

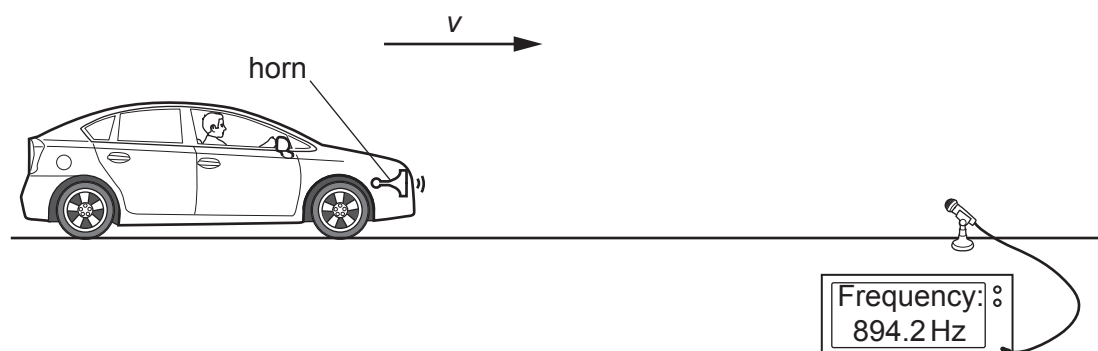


Fig. 2.1 (not to scale)

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/ms^{-1}	v_2/ms^{-1}	v/ms^{-1}	f/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/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/ms^{-1} . Include error bars for v .

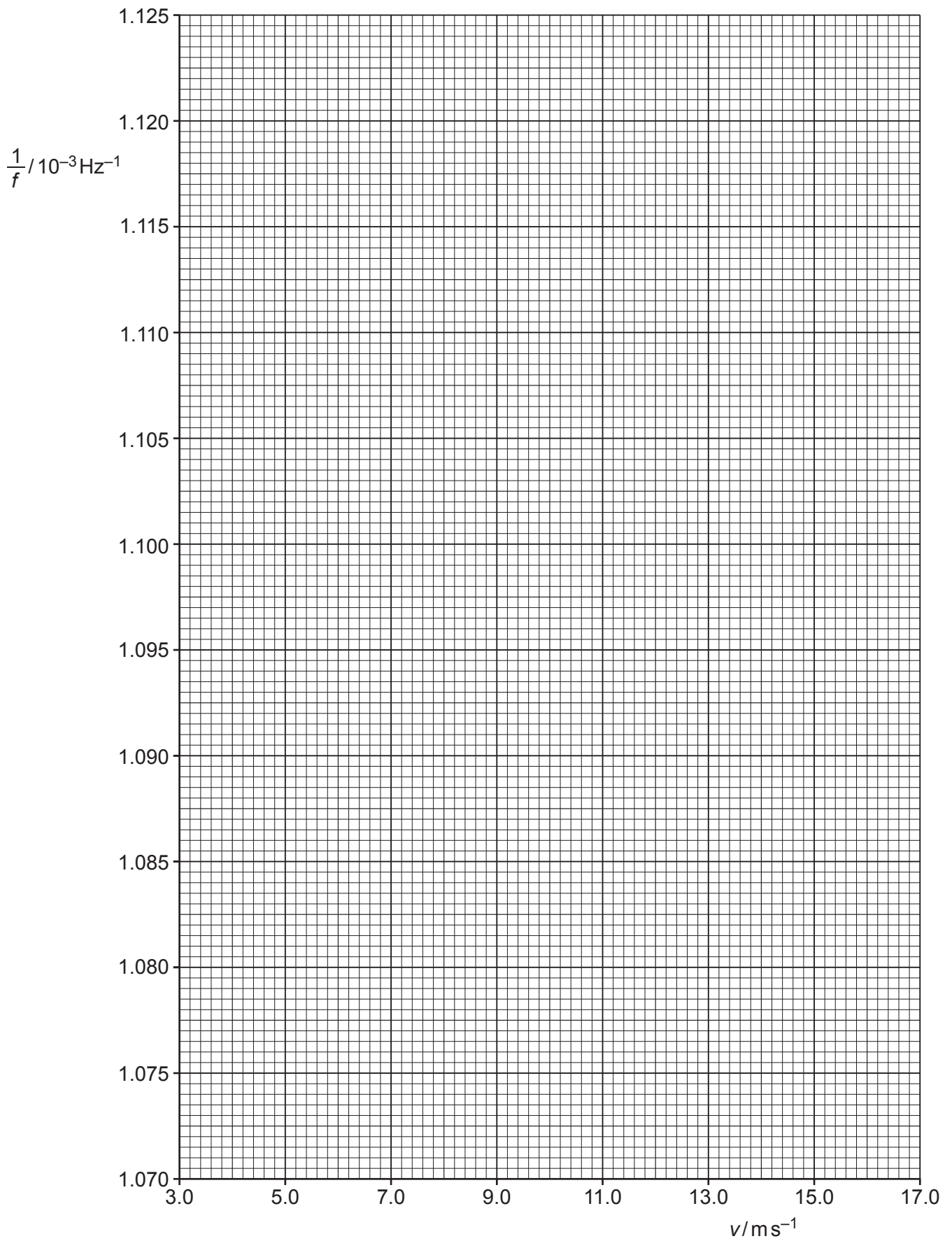
[2]

(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 = ms^{-1} [1]

[Total: 15]