



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/52

February/March 2023

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.

2

- 1 An electric pump is placed in a container of liquid. A model wind turbine is connected to the pump by a cable, as shown in Fig. 1.1.

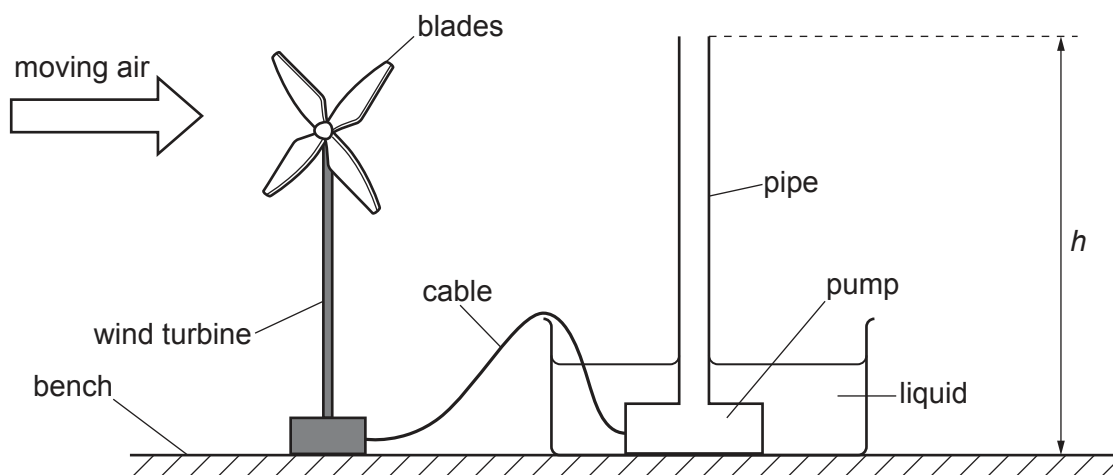


Fig. 1.1 (not to scale)

The turbine is placed in moving air. As the turbine blades turn, electricity is generated and the pump pushes liquid through a vertical pipe.

The frequency of rotation of the turbine blades is f . The height the liquid moves is h . The mass per unit time of the liquid leaving the top of the pipe is Q .

It is suggested that Q is related to f by the relationship

$$Qgh = C + Df^3$$

where g is the acceleration of free fall, and C and D are constants.

Plan a laboratory experiment to test the relationship between Q and f .

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for C and D .

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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[15]

5

- 2 A student investigates standing waves in water. A sound source is placed at the bottom of a cylinder containing water. A microphone, attached to a rod, is placed above the sound source, as shown in Fig. 2.1.

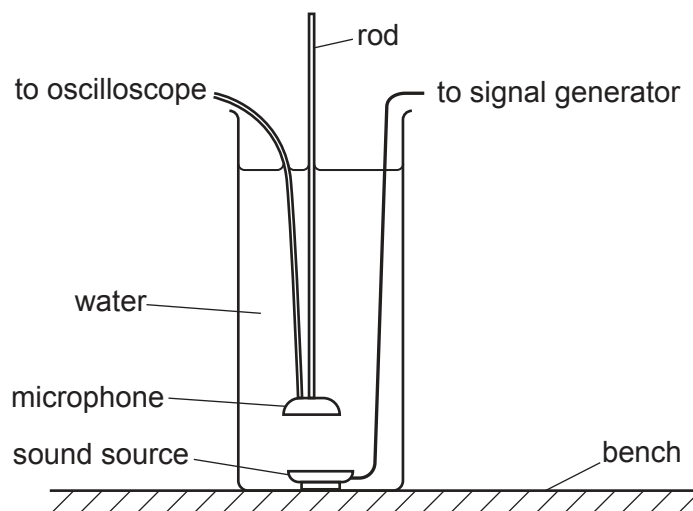


Fig. 2.1

The sound source is connected to a signal generator. The microphone is connected to an oscilloscope.

The signal generator is set to a frequency f . The microphone is moved up away from the sound source until the maximum amplitude is observed on the oscilloscope screen. The distance d_1 between the microphone and sound source is measured.

The microphone is moved up a further 2.0 cm. The microphone is then moved down until the maximum amplitude is observed on the oscilloscope screen. A second value d_2 is measured. The average value of d is calculated.

The experiment is repeated for different values of f .

It is suggested that f and d are related by the equation

$$\frac{v}{f} = 4(d + k)$$

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

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

Determine expressions for the gradient and the y -intercept.

gradient =

y -intercept =

[1]

6

(b) Values of f , d_1 and d_2 are given in Table 2.1.

Table 2.1

$f/10^3\text{ Hz}$	$\frac{1}{f}/10^{-3}\text{ Hz}^{-1}$	d_1/cm	d_2/cm	d/cm
1.5		24.9	24.5	
2.1		17.2	17.6	
2.8		12.4	13.0	
4.1		8.1	8.7	
5.2		6.2	7.0	
7.6		5.0	4.2	

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

Include the absolute uncertainties in d . [2]

(c) (i) Plot a graph of d/cm against $\frac{1}{f}/10^{-3}\text{ Hz}^{-1}$.

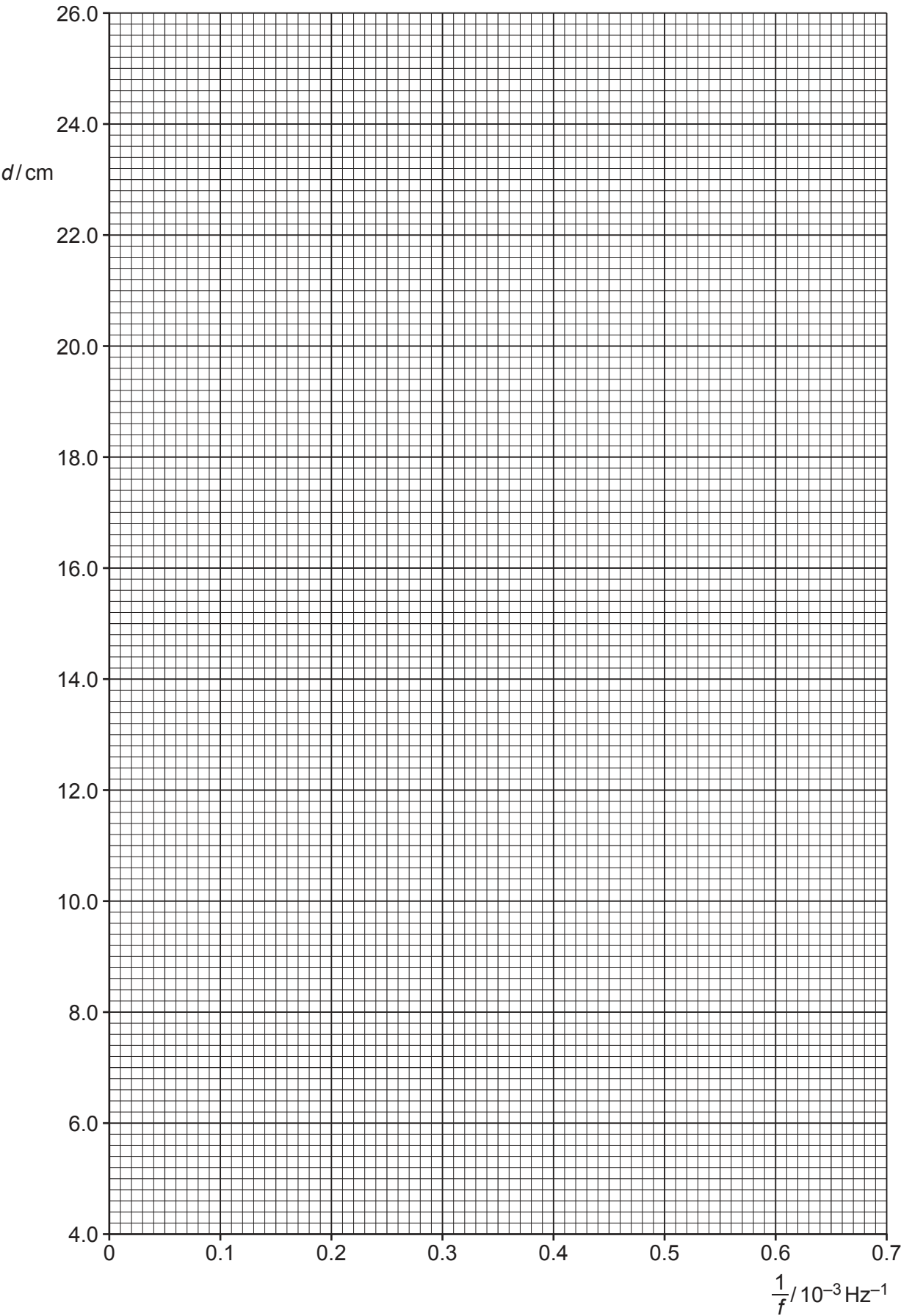
Include error bars for d . [2]

(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]

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- (iv) Determine the y -intercept of the line of best fit. Include the absolute uncertainty in your answer.

y -intercept = [2]

- (d) Using your answers to (a), (c)(iii) and (c)(iv), determine the values of v and k . Include appropriate units and include the absolute uncertainties in your answers.

v =

k = [3]

- (e) The experiment is repeated. Determine the frequency f that gives a value of d of 30.0 cm.

f = Hz [1]

[Total: 15]