



CANDIDATE  
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CENTRE  
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## 9702/52

February/March 2023

**1 hour 15 minutes**

You must answer on the question paper.

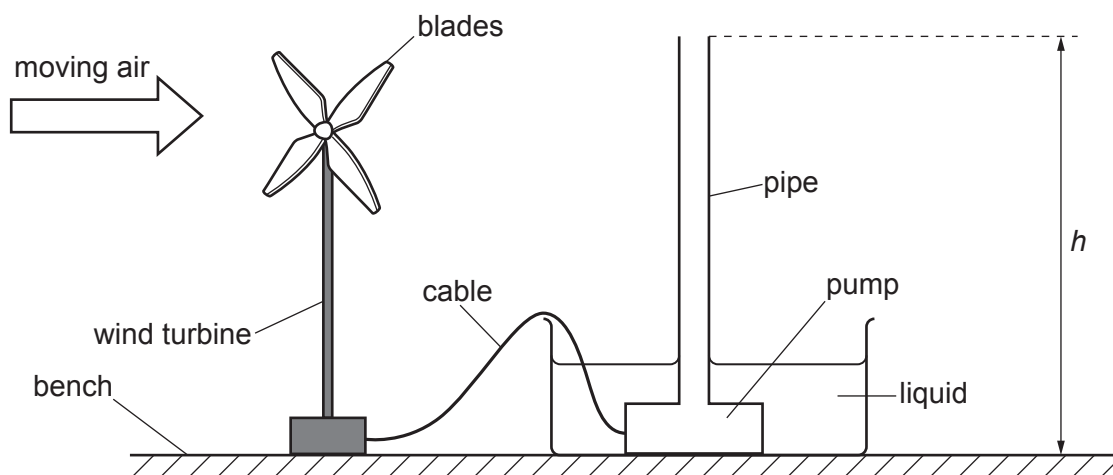
No additional materials are needed.

- 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.

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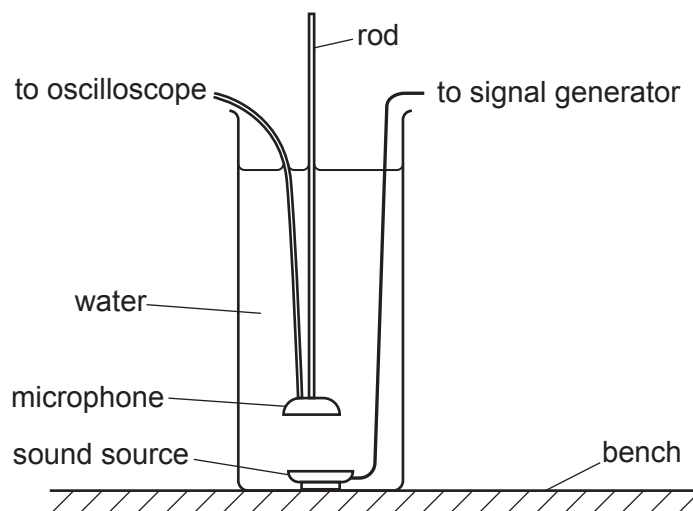
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- 2 A student investigates standing waves in water. A sound source is placed at the bottom of a cylinder containing water. A microphone, attached to a rod, is placed above the sound source, as shown in Fig. 2.1.



**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]

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

**Table 2.1**

| $f/10^3\text{ Hz}$ | $\frac{1}{f}/10^{-3}\text{ Hz}^{-1}$ | $d_1/\text{cm}$ | $d_2/\text{cm}$ | $d/\text{cm}$ |
|--------------------|--------------------------------------|-----------------|-----------------|---------------|
| 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  $d/\text{cm}$  in Table 2.1.

Include the absolute uncertainties in  $d$ . [2]

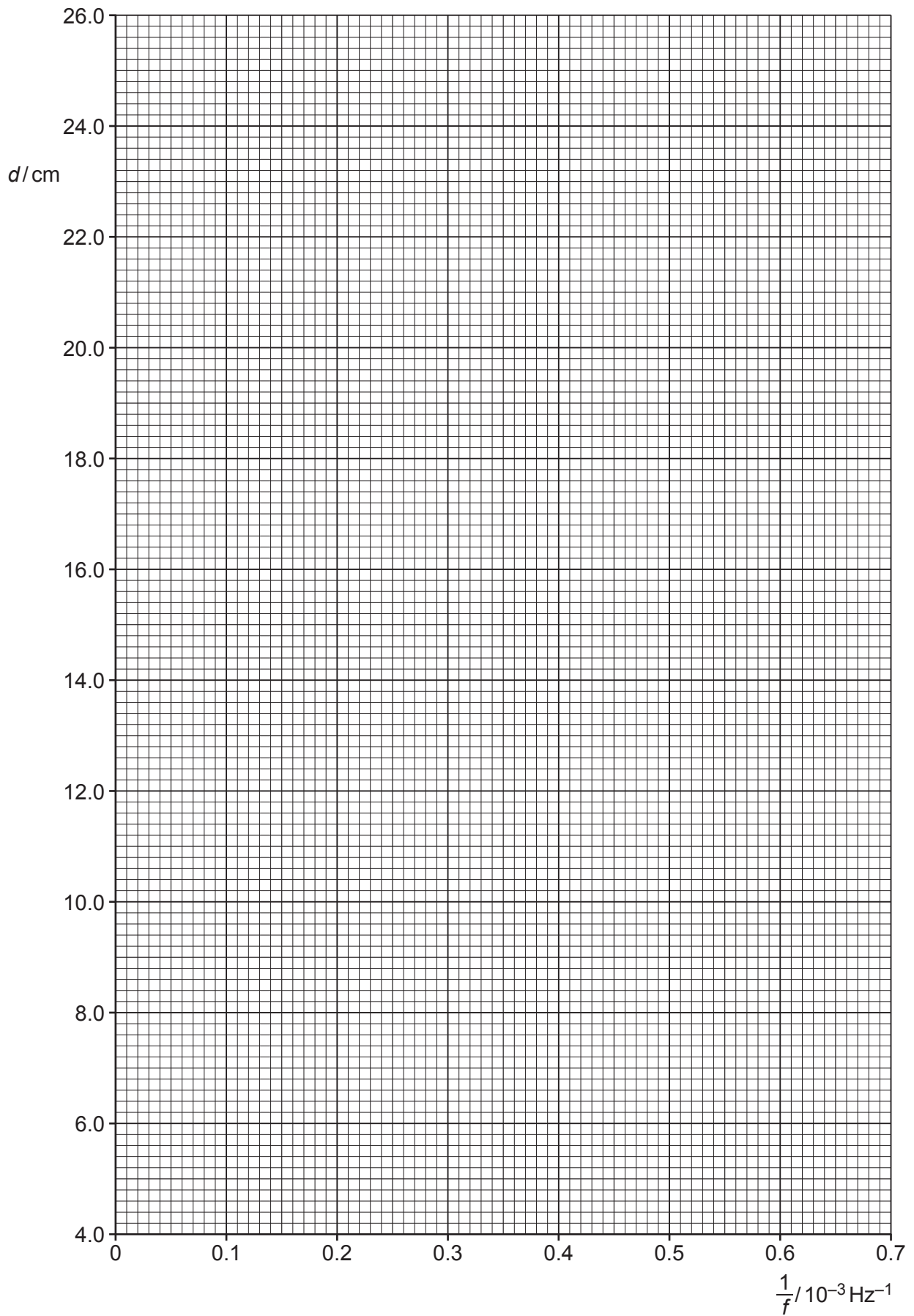
(c) (i) Plot a graph of  $d/\text{cm}$  against  $\frac{1}{f}/10^{-3}\text{ Hz}^{-1}$ .

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]



- (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]