



## Cambridge International AS & A Level

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## PHYSICS

9702/51

## Paper 5 Planning, Analysis and Evaluation

May/June 2026

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

## INSTRUCTIONS

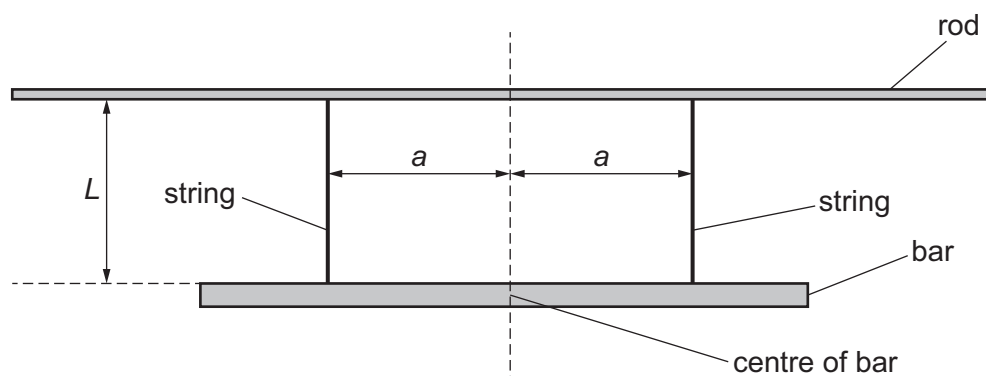
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- 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 rod is fixed horizontally. A solid bar of mass  $M$  is attached to the rod by two vertical strings so that the bar is horizontal, as shown in Figure 1.1.



**Figure 1.1**

The vertical strings are equal horizontal distances  $a$  from the centre of the bar.

The separation between the rod and the bar is  $L$ .

One end of the bar is displaced horizontally and then released. The bar rotates with oscillations about its centre. The period of the oscillations is  $T$ .

It is suggested that  $T$  is related to  $a$  by the relationship

$$T = \frac{2\pi P}{a^q} \sqrt{\frac{L}{M}}$$

where  $P$  and  $q$  are constants.

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

Draw a diagram showing the arrangement of your equipment.

Explain how the results could be used to determine values for  $P$  and  $q$ .

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]



- 2 A long tube contains a liquid of density  $\sigma$ . Two rubber bands are placed on the tube towards the bottom as shown in Figure 2.1.

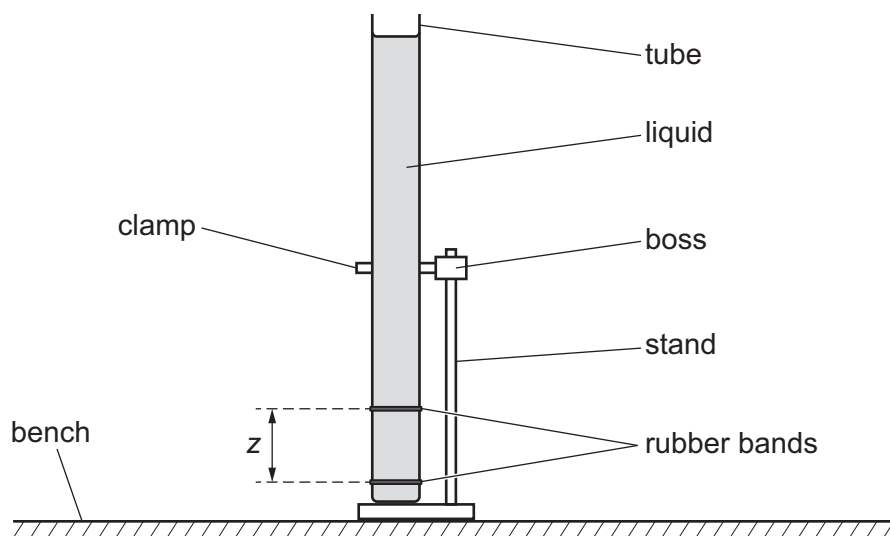


Figure 2.1

The distance between the two rubber bands is  $z$ .

A small steel ball of diameter  $d$  is dropped from the surface of the liquid. The time  $t$  for the ball to pass between the two rubber bands is measured.

The experiment is repeated with steel balls of different diameters.

It is suggested that  $t$  and  $d$  are related by the equation

$$\frac{z}{t} = \frac{gd^2(\rho - \sigma)}{18\beta}$$

where  $g$  is the acceleration of free fall,  $\rho$  is the density of steel and  $\beta$  is a constant.

- (a) A graph is plotted of  $t$  on the  $y$ -axis against  $\frac{1}{d^2}$  on the  $x$ -axis.

Determine an expression for the gradient.

gradient = ..... [1]

(b) Values of  $d$  and  $t$  are given in Table 2.1.

**Table 2.1**

| $d/\text{mm}$ | $\frac{1}{d^2}/\text{mm}^{-2}$ | $t/\text{s}$ |
|---------------|--------------------------------|--------------|
| $2.6 \pm 0.1$ |                                | 6.10         |
| $3.0 \pm 0.1$ |                                | 4.40         |
| $3.4 \pm 0.1$ |                                | 3.35         |
| $4.1 \pm 0.1$ |                                | 2.25         |
| $4.4 \pm 0.1$ |                                | 1.95         |
| $5.0 \pm 0.1$ |                                | 1.45         |

Calculate and record values of  $\frac{1}{d^2}/\text{mm}^{-2}$  in Table 2.1. Include the absolute uncertainties in  $\frac{1}{d^2}$ . [2]

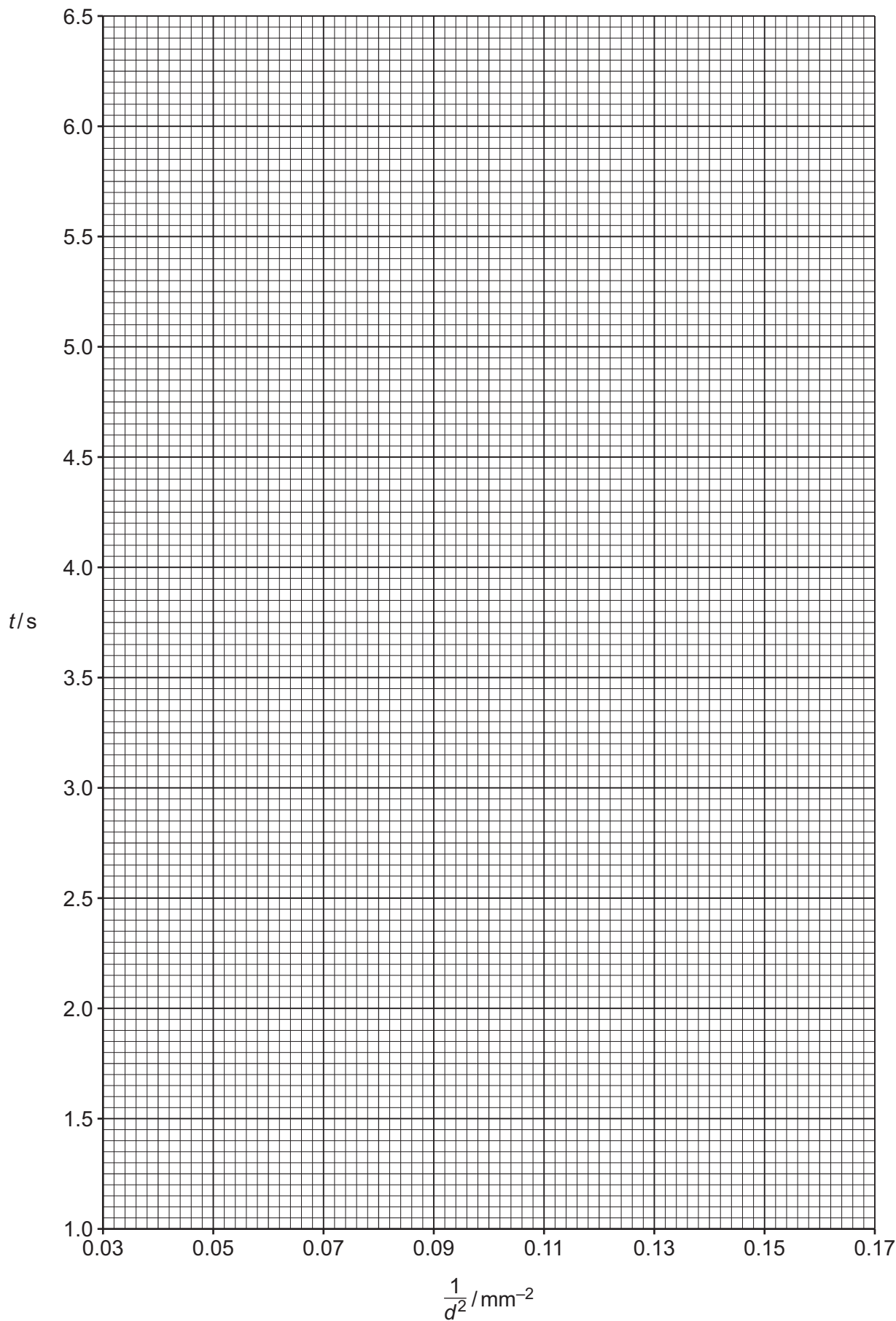
(c) (i) Plot a graph of  $t/\text{s}$  against  $\frac{1}{d^2}/\text{mm}^{-2}$ . Include error bars for  $\frac{1}{d^2}$ . [2]

(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]







- (d) The density  $\rho$  of steel is  $(7850 \pm 50) \text{ kg m}^{-3}$ .  
The density  $\sigma$  of the liquid is  $(1250 \pm 50) \text{ kg m}^{-3}$ .

Calculate  $(\rho - \sigma)$ . Include the absolute uncertainty.

$$(\rho - \sigma) = \dots\dots\dots \text{ kg m}^{-3} \quad [1]$$

- (e) (i) Using your answers to **2(a)**, **2(c)(iii)** and **2(d)**, determine the value of  $\beta$ . Include an appropriate unit.

Data:  $g = 9.81 \text{ m s}^{-2}$   
 $z = (97 \pm 2) \text{ mm}$

$$\beta = \dots\dots\dots [2]$$

- (ii) Determine the percentage uncertainty in  $\beta$ .

$$\text{percentage uncertainty in } \beta = \dots\dots\dots \% [1]$$

- (f) The experiment is repeated using a steel ball with a diameter of  $(1.20 \pm 0.01) \text{ cm}$ . Determine the time  $t$ . Include the absolute uncertainty.

$$t = \dots\dots\dots \text{ s} [2]$$

[Total: 15]

