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9702/33

February/March 2024

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential 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 will be allowed to work with the apparatus for a maximum of 1 hour for each question.
- You should record all your observations in the spaces provided in the question paper as soon as these observations are made.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [].

For Examiner's Use	
1	
2	
Total	

This document has **12** pages.

You may not need to use all of the materials provided.

1 In this experiment, you will investigate the properties of a pendulum.

- (a) (i)**
- Assemble the apparatus as shown in Fig. 1.1 and Fig. 1.2.
 - Push the nail through the central hole in the pendulum and then into the plastic tube.
 - Secure the tube and nail in the boss, as shown in Fig. 1.1.

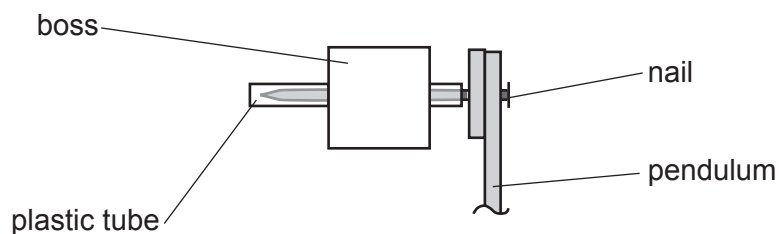


Fig. 1.1

- Ensure that the pendulum swings freely on the nail.

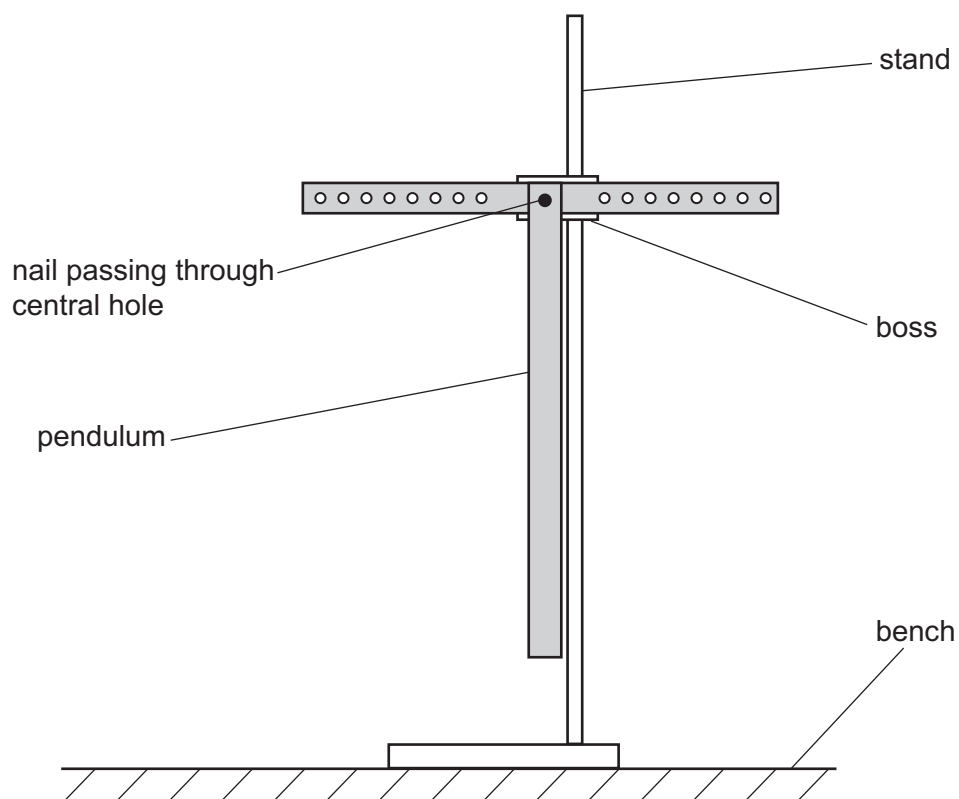


Fig. 1.2

- Attach two 50g slotted masses to the pendulum using the bolts and nuts. Use two holes which are the **same distance** x from the nail, as shown in Fig. 1.3.

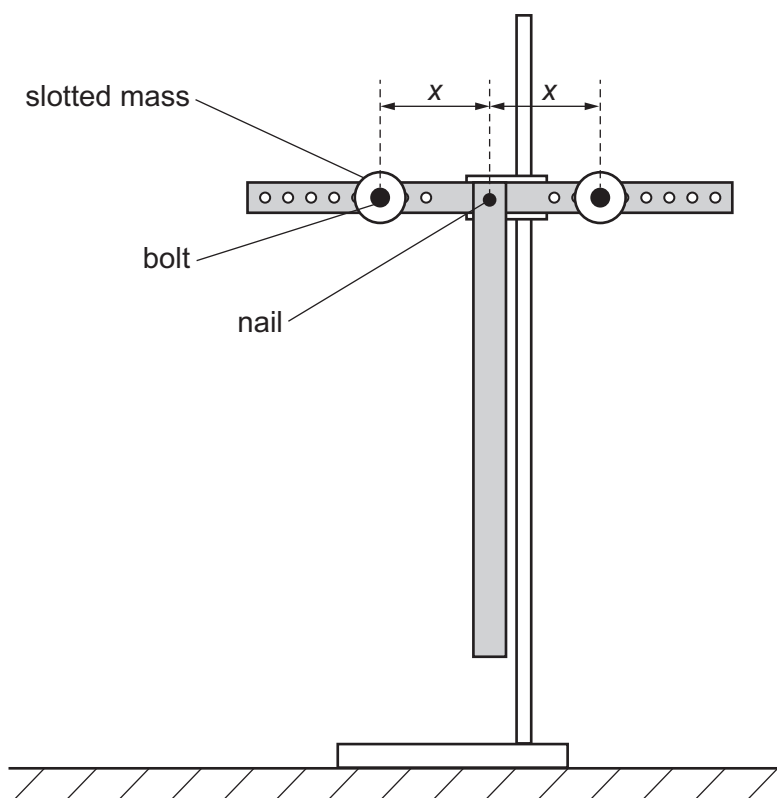


Fig. 1.3

- The distance from the centre of each bolt to the nail is x .
- Measure and record x .

$x =$ [1]

- (ii) Push the bottom of the pendulum a short distance to one side and then release it.

Take measurements to determine the period T of the oscillations.

$T =$ [2]

- (b) Vary x by using different holes and measure T .

Repeat until you have six sets of values of x and T .

Record your results in a table. Include values of $\sqrt{x^3}$ in your table.

[9]

- (c) (i) Plot a graph of T on the y -axis against $\sqrt{x^3}$ on the x -axis.

[3]

- (ii) Draw the straight line of best fit.

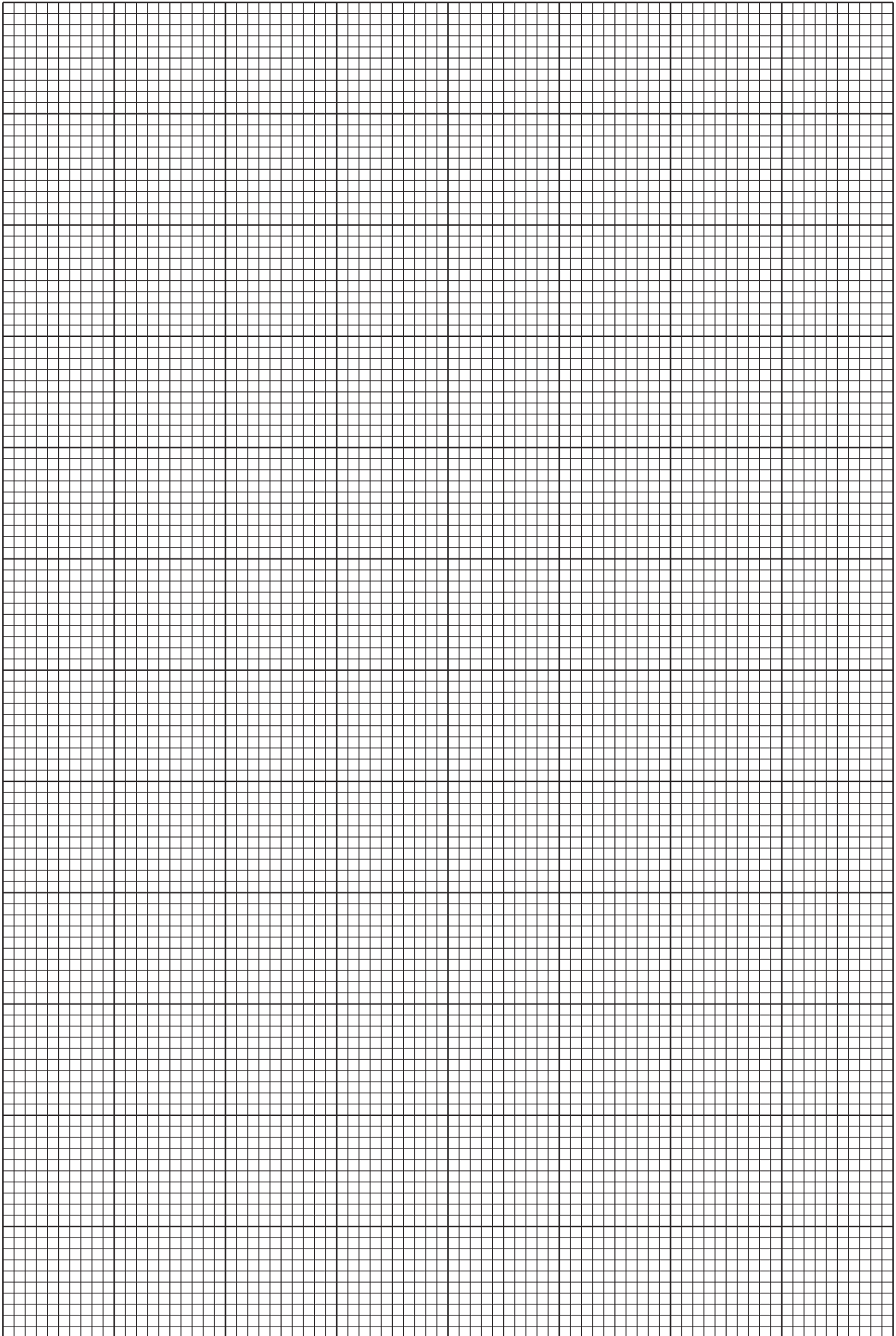
[1]

- (iii) Determine the gradient and y -intercept of this line.

gradient =

y -intercept =

[2]



(d) It is suggested that the quantities T and x are related by the equation

$$T = a\sqrt{x^3} + b$$

where a and b are constants.

Using your answers in (c)(iii), determine the values of a and b .
Give appropriate units.

$a =$

$b =$

[2]

[Total: 20]

You may not need to use all of the materials provided.

2 In this experiment, you will investigate the frictional forces on a wooden strip.

- (a) (i) • You have been provided with two wooden strips. Select the **thicker** strip.

Measure and record its length L .

$L = \dots\dots\dots$ cm

- Attach the slotted mass to one of the wider faces of the strip approximately 10 cm from one end using a small piece of adhesive putty, as shown in Fig. 2.1.

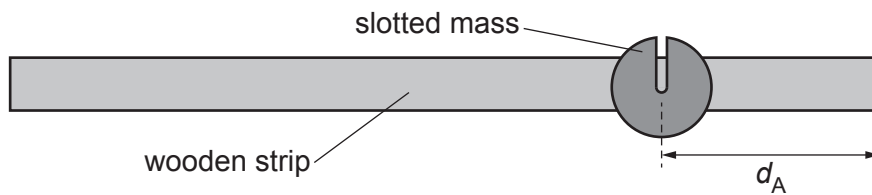


Fig. 2.1

- The distance from the centre of the slotted mass to the nearest end of the strip is d_A , as shown in Fig. 2.1.

Measure and record d_A .

$d_A = \dots\dots\dots$ cm
[2]

- (ii) You have been provided with a smooth board. Support the board vertically on the bench using the stand, boss and clamp, as shown in Fig. 2.2.

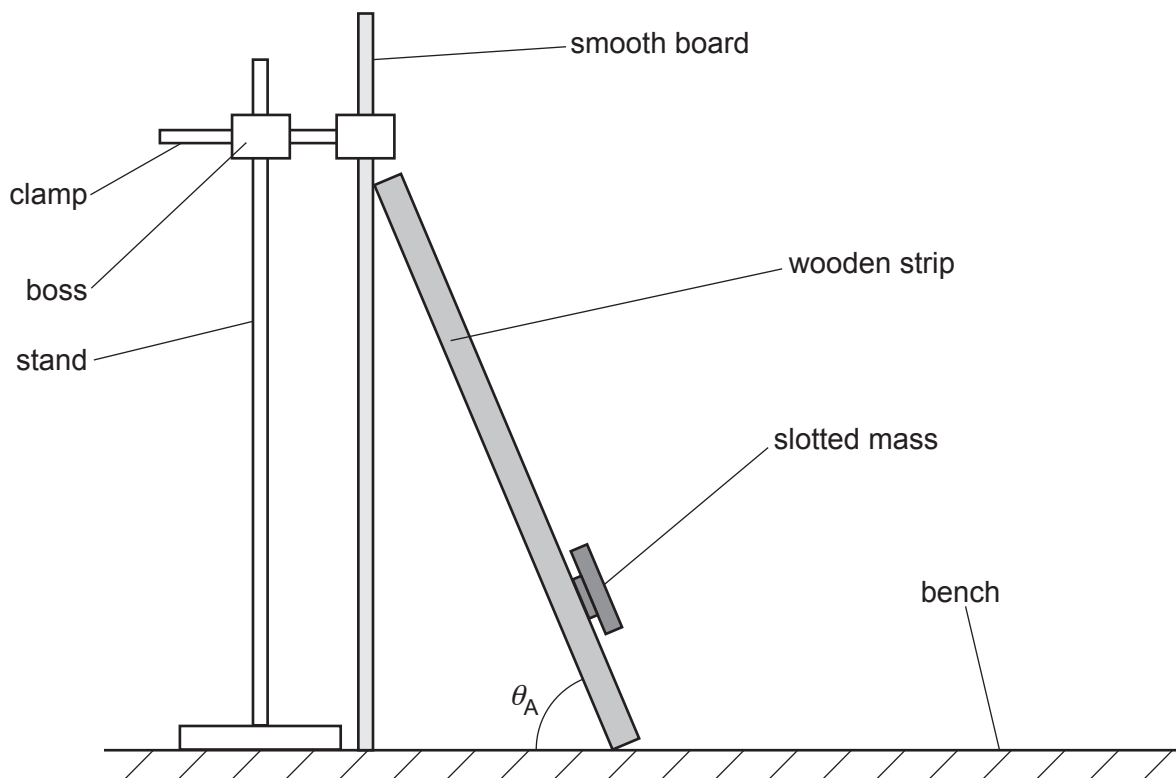


Fig. 2.2

- Lean the strip against the smooth board with the slotted mass nearer the lower end, as shown in Fig. 2.2.
- Move the bottom of the strip away from the smooth board until the strip starts to slip. Gradually push the bottom of the strip back towards the board until it **just** stays in position by itself.
- The angle between the strip and the bench is θ_A , as shown in Fig. 2.2.

Measure and record θ_A .

$$\theta_A = \dots\dots\dots^\circ \quad [2]$$

- (iii) Estimate the percentage uncertainty in your value of θ_A .
Show your working.

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

- (iv) The mass of the thicker strip is M . The value of M is written on the strip.

- Record M .

$$M = \dots\dots\dots \text{ g}$$

- Calculate F_A using

$$F_A = \frac{\frac{M}{2} + \frac{Sd_A}{L}}{(M + S)\tan \theta_A}$$

where S is 100 g.

$$F_A = \dots\dots\dots \quad [1]$$

- (v) • Invert the thicker strip and lean it against the smooth board so that the slotted mass is nearer the upper end as shown in Fig. 2.3.

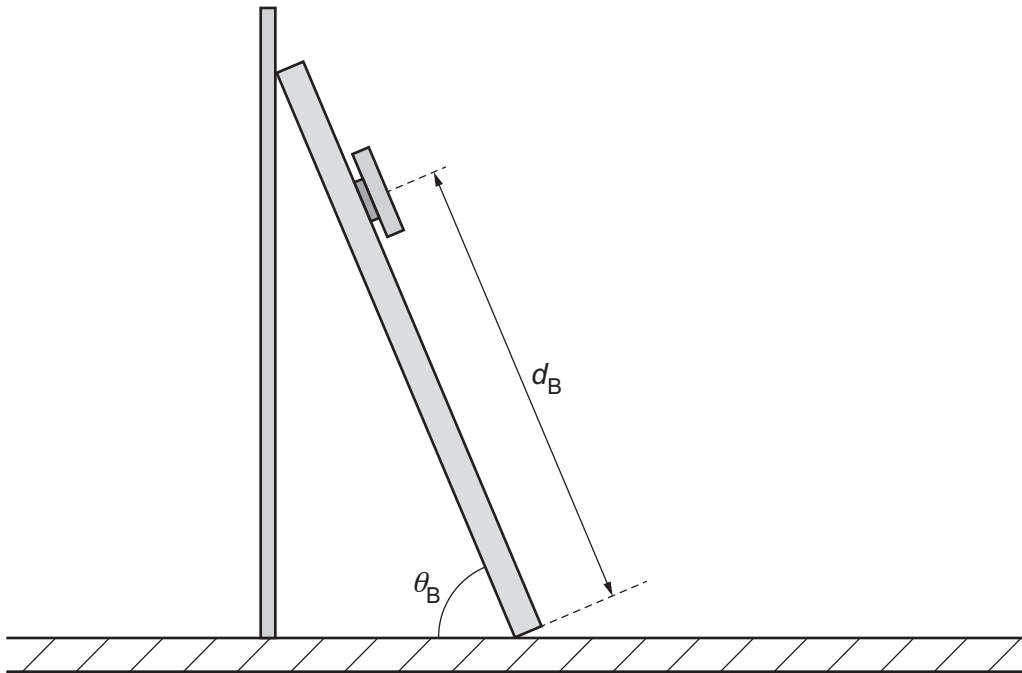


Fig. 2.3

- The distance from the centre of the slotted mass to the lower end of the strip is d_B .

Measure and record d_B .

$d_B = \dots\dots\dots$ cm

- Move the bottom of the strip away from the smooth board until the strip starts to slip. Gradually push the bottom of the strip back towards the board until it **just** stays in position by itself.
- The angle between the strip and the bench is θ_B , as shown in Fig. 2.3.

Measure and record θ_B .

$\theta_B = \dots\dots\dots^\circ$

- Calculate F_B , using

$$F_B = \frac{\frac{M}{2} + \frac{Sd_B}{L}}{(M + S) \tan \theta_B}.$$

$F_B = \dots\dots\dots$

[1]

(b) Repeat (a)(i), (a)(ii), (a)(iv) and (a)(v) using the **thinner** wooden strip.

$$L = \dots\dots\dots \text{cm}$$

$$d_A = \dots\dots\dots \text{cm}$$

$$\theta_A = \dots\dots\dots^\circ$$

$$M = \dots\dots\dots \text{g}$$

$$F_A = \dots\dots\dots$$

$$d_B = \dots\dots\dots \text{cm}$$

$$\theta_B = \dots\dots\dots^\circ$$

$$F_B = \dots\dots\dots$$

[3]

- (c) It is suggested that the relationship between F_A and F_B is

$$k = \frac{F_A}{F_B}$$

where k is a constant.

Using your data, calculate two values of k .

first value of k =

second value of k = [1]

- (d) It is suggested that the percentage uncertainty in the values of k is 15%.

Using this uncertainty, explain whether your results support the relationship in (c).

.....

 [1]

- (e) (i) Describe **four** sources of uncertainty or limitations of the procedure for this experiment.

For any uncertainties in measurement that you describe, you should state the quantity being measured and a reason for the uncertainty.

1

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2

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3

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4

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[4]

- (ii) Describe **four** improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1

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2

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3

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4

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[4]

[Total: 20]

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