



Cambridge International AS & A Level

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PHYSICS

9702/31

Paper 3 Advanced Practical Skills 1

October/November 2024

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

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.

INFORMATION

- 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 **16** pages. Any blank pages are indicated.



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

- 1** In this experiment, you will investigate the equilibrium position of a wooden strip.

Some of the apparatus has been set up for you.

- (a)** • Set up the apparatus as shown in Fig. 1.1.

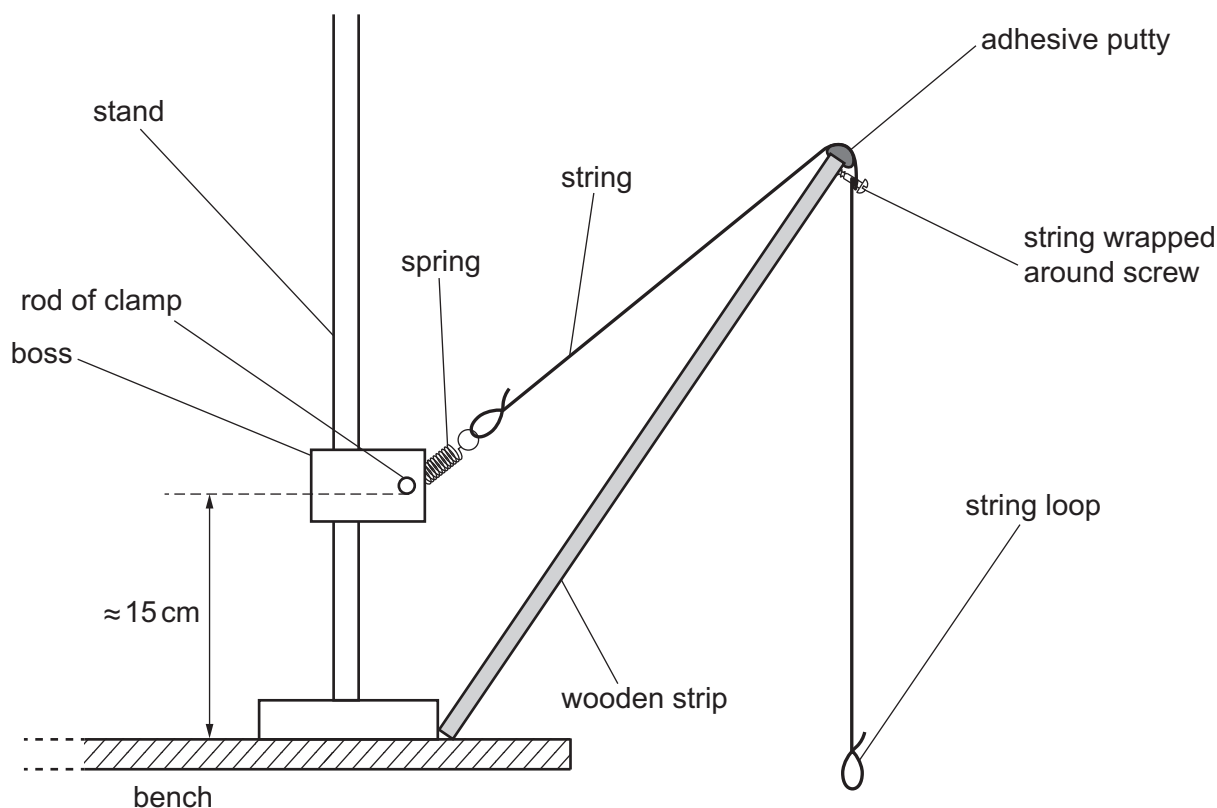


Fig. 1.1

- Ensure the rod of the clamp is approximately 15 cm above the bench.
- Arrange the wooden strip so that the bottom of the strip rests against the base of the stand.
- Use adhesive putty to fix the string centrally on the wooden strip in line with the spring.
- Wrap the string around the screw.



- Arrange the block and protractor as shown in Fig. 1.2.

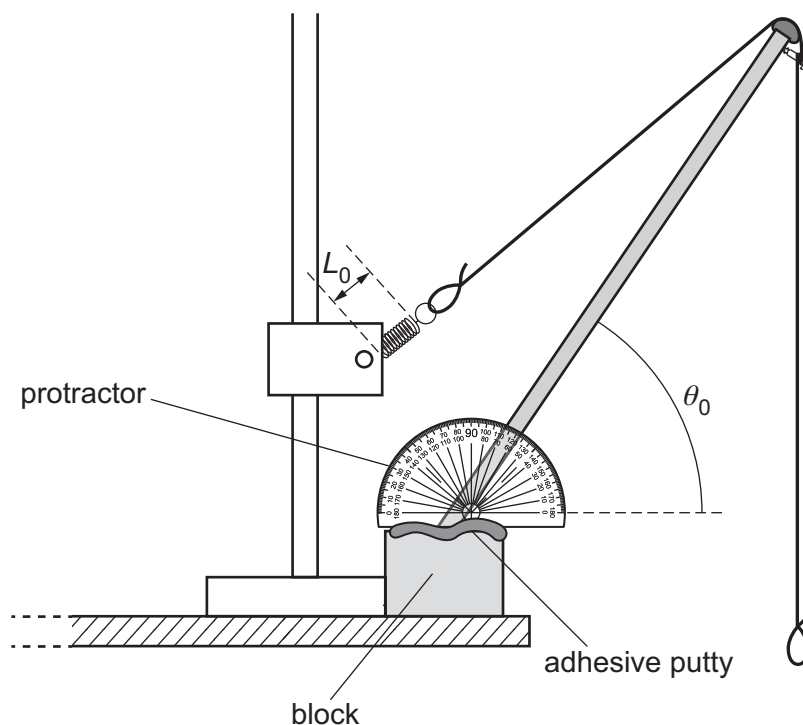


Fig. 1.2

- The length of the coiled section of the spring is L_0 , as shown in Fig. 1.2.

The angle between the lower edge of the wooden strip and the horizontal is θ_0 , as shown in Fig. 1.2.

Adjust the apparatus until θ_0 is between 75° and 85° . You may wish to move the protractor along the block.

- Measure and record L_0 and θ_0 .

$L_0 =$

$\theta_0 =$ $^\circ$

[1]





- (b) • Make a hook from one paper clip and hang nine paper clips from it as shown in Fig. 1.3.

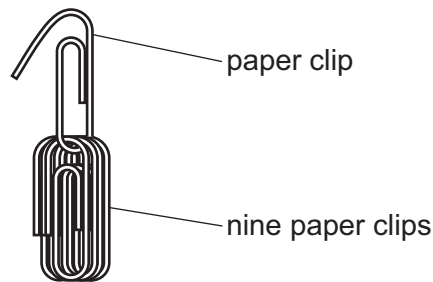


Fig. 1.3

- The mass of all ten paper clips is m .

Measure and record m .

$$m = \dots\dots\dots [1]$$

- (c) • Using the mass hanger and slotted masses, hang a mass of 40g from the string loop.
- Hang the paper clips from the string loop as shown in Fig. 1.4.

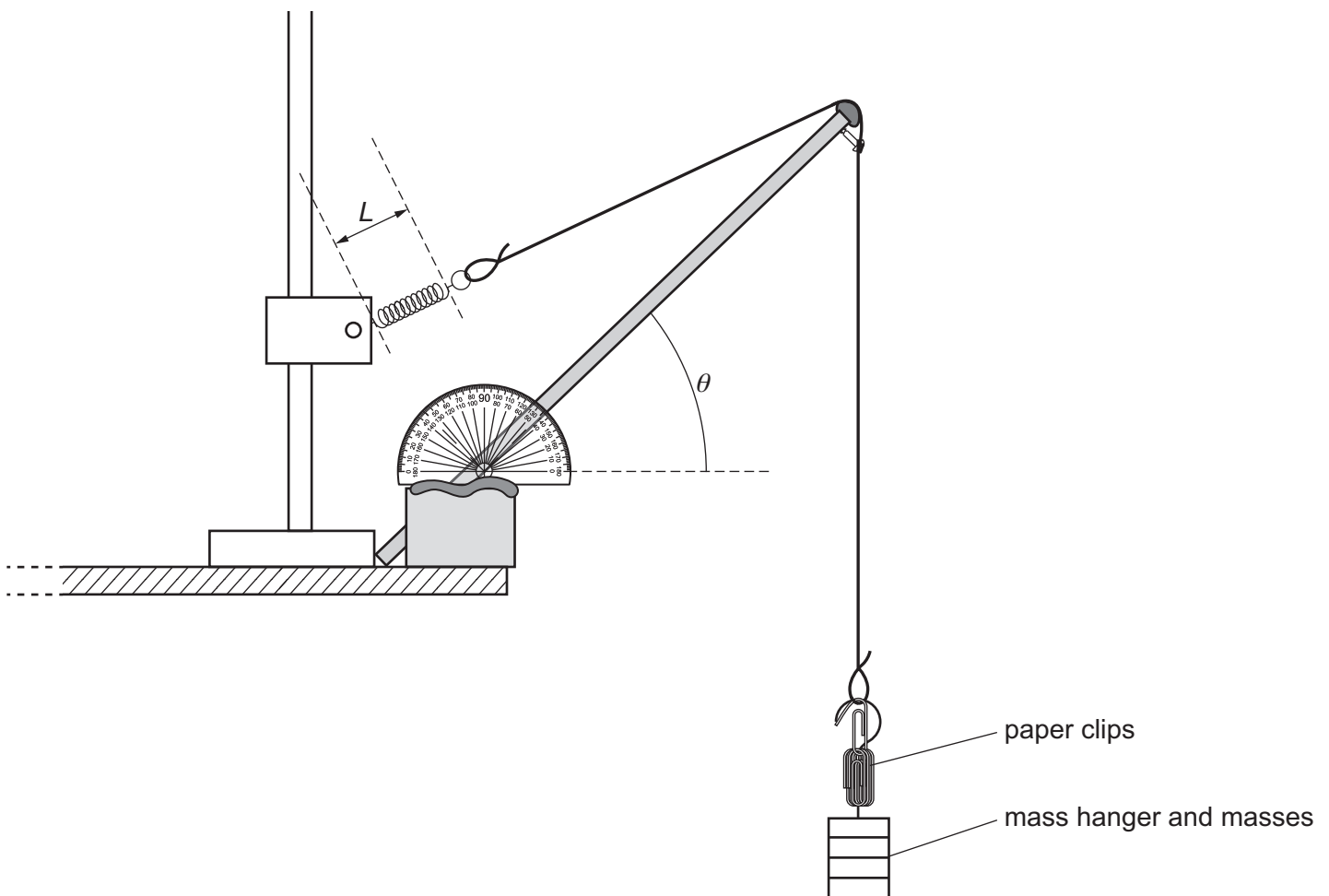


Fig. 1.4





- The total mass hanging from the string loop is M .

The angle between the wooden strip and the horizontal is θ , as shown in Fig. 1.4.

The length of the coiled section of the spring is L , as shown in Fig. 1.4.

Determine and record M .

$$M = \dots\dots\dots$$

- Measure and record θ and L .

$$\theta = \dots\dots\dots^\circ$$

$$L = \dots\dots\dots$$

- Calculate e where

$$e = (L - L_0).$$

$$e = \dots\dots\dots$$

[1]





- (d) Vary M . The total mass M may be made from slotted masses only or from m and slotted masses. For each value of M , measure and record M , θ and L . Repeat until you have six sets of values.

Record your results in a table. Include values of e and $\sin \theta$ in your table.

[9]

- (e) (i) Plot a graph of e on the y -axis against $\sin \theta$ 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]



A full-page sheet of white graph paper featuring a uniform grid of thin black lines. The grid consists of small squares covering the entire area, with no margins or additional markings.



(f) It is suggested that the quantities e and θ are related by the equation

$$e = P \sin \theta + Q$$

where P and Q are constants.

Using your answers in (e)(iii), determine the values of P and Q .

Give appropriate units.

$P =$

$Q =$

[2]

[Total: 20]

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

2 In this experiment, you will investigate oscillations.

(a) You have been provided with a board of width w and thickness x , as shown in Fig. 2.1.

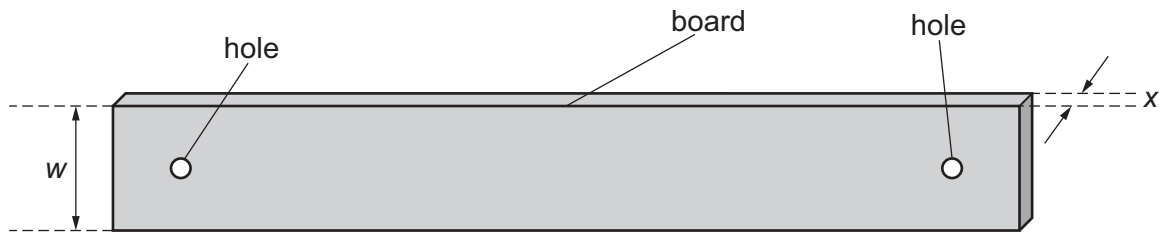


Fig. 2.1 (not to scale)

Measure and record w and x .

$w =$

$x =$

[1]

(b) (i) • Set up the apparatus as shown in Fig. 2.2.

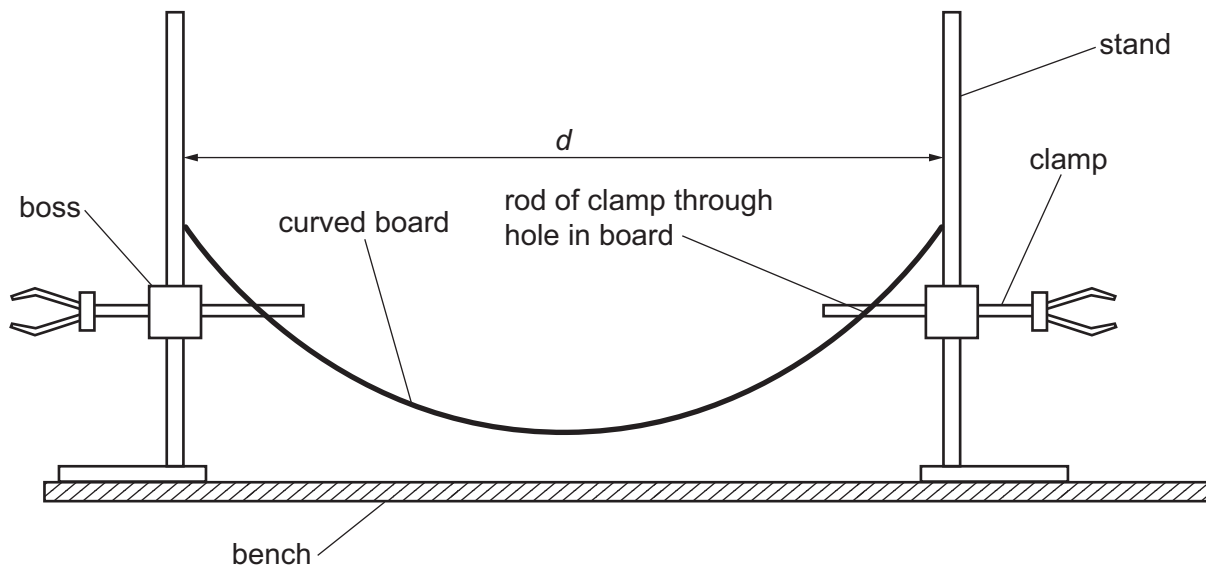


Fig. 2.2

- Ensure the rods of the clamps are the same height above the bench.
- Slide the rods of the clamps through the holes in the board as shown in Fig. 2.2. Ensure that each end of the board touches a stand.



- The distance between the inside edges of the stands is d , as shown in Fig. 2.2.
- Adjust the apparatus until d is in the range 92 cm to 99 cm.
- Measure and record d .

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

- (ii) Estimate the percentage uncertainty in your value of d . Show your working.

percentage uncertainty = $\dots\dots\dots$ % [1]

- (c)
- Place the spring in the middle of the curved board.
 - Displace the spring a short distance to one side, as shown in Fig. 2.3.

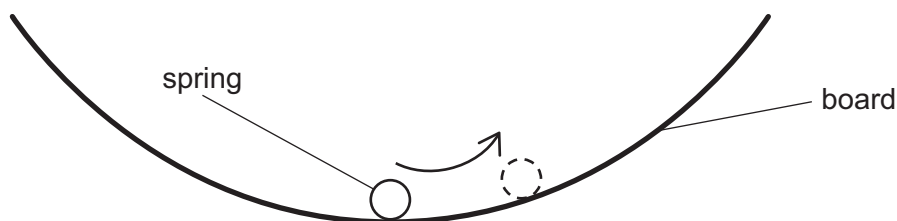


Fig. 2.3

- Release the spring. The spring will roll from side to side on the board.
- Take measurements to determine the period T of these oscillations.

$T = \dots\dots\dots$ s [2]





- (d) • Adjust the apparatus until d is in the range 66 cm to 74 cm. Ensure that the board does not touch the bench.
- Measure and record d .

$d = \dots\dots\dots$ cm

- Repeat (c).

$T = \dots\dots\dots$ s
[3]

- (e) It is suggested that the relationship between T and d is

$$(T - a) = kd$$

where a is 0.70 s and k is a constant.

- (i) Using your data, calculate two values of k .

first value of $k = \dots\dots\dots$

second value of $k = \dots\dots\dots$
[1]

- (ii) Justify the number of significant figures that you have given for your values of k .

.....
.....
..... [1]





(f) It is suggested that the percentage uncertainty in the values of k is 10%.

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

.....

.....

.....

..... [1]





- (g) (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.

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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.

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[4]

[Total: 20]





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1 In this experiment, you will determine the resistivity of a metal.

(a) • Set up the circuit shown in Fig. 1.1.

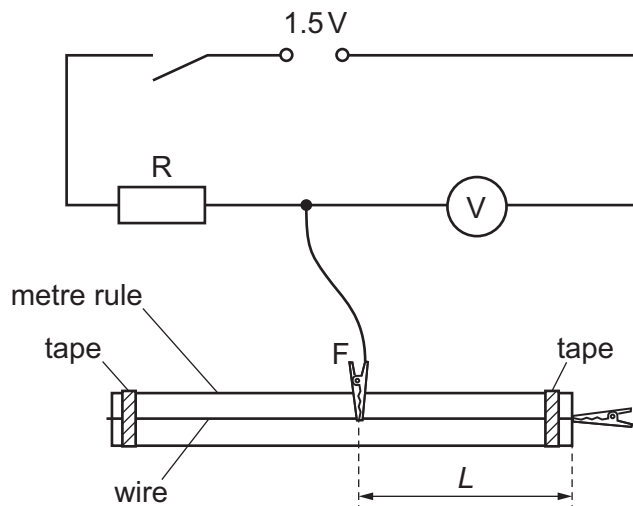


Fig. 1.1 (not to scale)

- The distance between the two crocodile clips is L . The reading on the voltmeter is V .
Adjust the position of crocodile clip F so that L is approximately 45 cm.
- Close the switch.
- Record the value of L and the voltmeter reading V .

$L =$ cm

$V =$ V

- Open the switch.

[1]





- (b) Vary L in the range $15.0\text{ cm} \leq L \leq 95.0\text{ cm}$ by adjusting the position of F. For each position of F, measure L and V . Repeat until you have six sets of values of L and V .

Record your results in a table. Include values of $\frac{1}{L}$ and $\frac{1}{V}$ in your table.

[8]

- (c) (i) Plot a graph of $\frac{1}{V}$ on the y -axis against $\frac{1}{L}$ 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]



A full-page sheet of white graph paper featuring a uniform grid of thin black lines. The grid consists of small squares covering the entire area, with no margins or additional markings.



(d) It is suggested that the quantities V and L are related by the equation

$$\frac{1}{V} = \frac{J}{L} + W$$

where J and W are constants.

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

$$J = \dots\dots\dots$$

$$W = \dots\dots\dots [2]$$

(e) (i) Use a micrometer to measure the diameter d of the wire.

$$d = \dots\dots\dots [2]$$

(ii) Theory suggests that

$$J = \frac{\pi d^2 W R}{4 \rho}$$

where R is 33Ω and ρ is the resistivity of the metal of the wire.

Using your answers in (d) and (e)(i), determine a value for ρ .

$$\rho = \dots\dots\dots \Omega \text{ m } [1]$$

[Total: 20]



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

2 In this experiment, you will investigate the movement of a ball.

(a) You are provided with two table tennis balls A and B, each attached to a string.

The mass of A and its string is m .

Use the balance to measure m .

$m = \dots\dots\dots$ g [1]

- (b) (i)
- Attach the clamp to the stand using the boss.
 - Place both strings between the two wooden strips and secure the wooden strips in the clamp, as shown in Fig. 2.1.

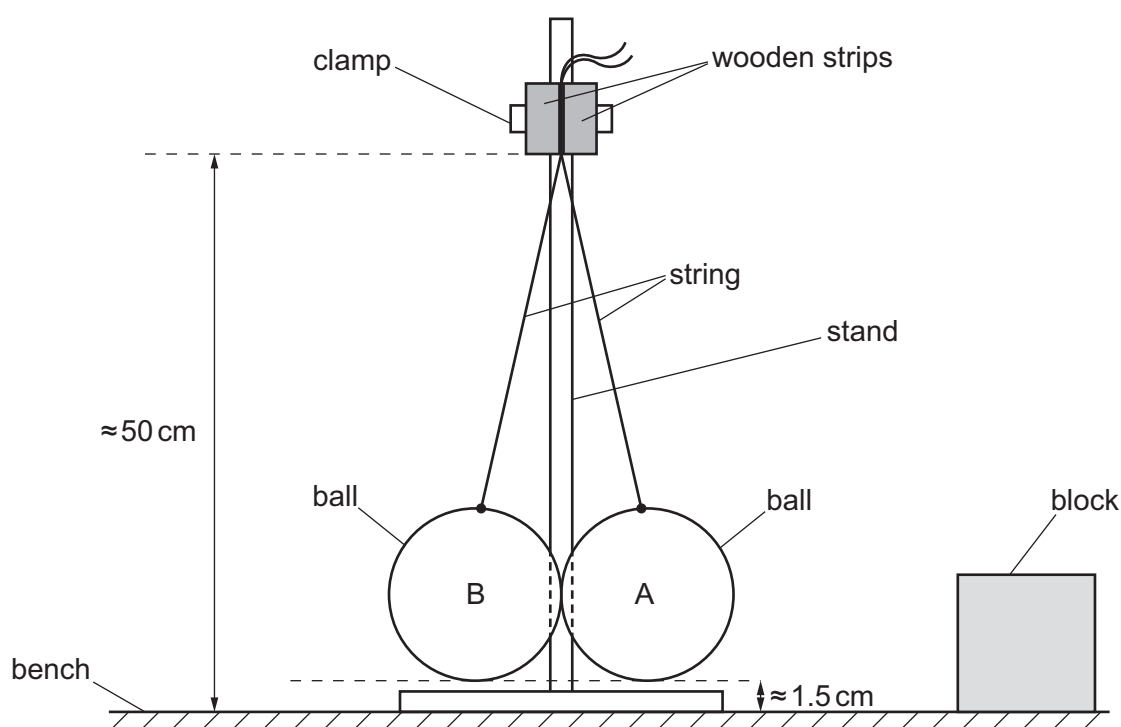


Fig. 2.1 (not to scale)

- Adjust the apparatus so that the bottoms of the two wooden strips are approximately 50 cm above the bench and the bottoms of the two balls are approximately 1.5 cm above the bench.



- Displace A and adjust the position of the block so that, when they are touching, the centre of A is level with the top of the block, as shown in Fig 2.2.

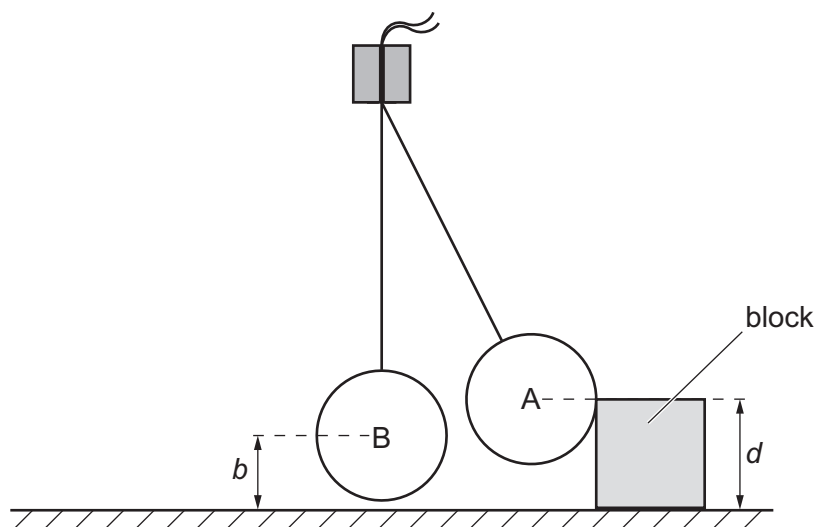


Fig. 2.2 (not to scale)

- When A is in this position, the distance between the centre of B and the bench is b , as shown in Fig. 2.2.

The distance between the top of the block and the bench is d .

Measure and record b and d .

$b =$ cm

$d =$ cm

- Calculate $\sqrt{d-b}$.
Give an appropriate unit.

$\sqrt{d-b} =$ [2]

- (ii) Justify the number of significant figures that you have given for your value of $\sqrt{d-b}$.

.....

 [1]



- (iii)
- Release A so that it moves towards B.
 - When A hits B, it causes B to move.

At the maximum height of ball B, the vertical distance between the centre of B and the bench is H , as shown in Fig. 2.3.

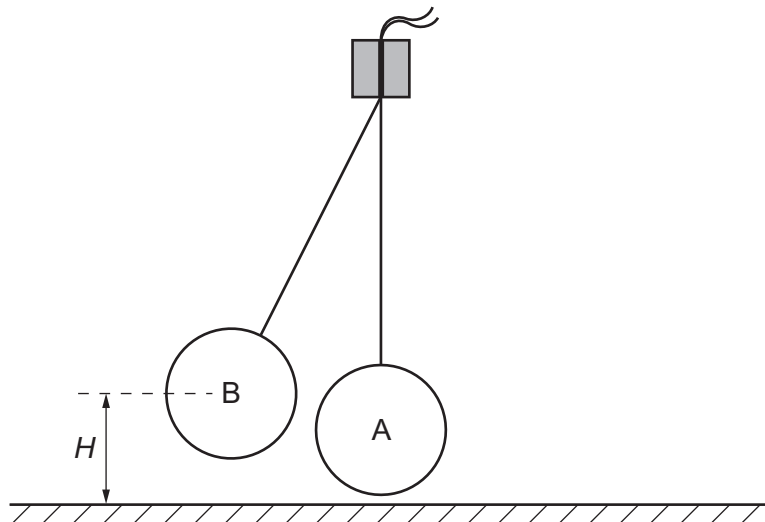


Fig. 2.3 (not to scale)

Determine H .

$$H = \dots\dots\dots \text{ cm } [2]$$

- (iv) Estimate the percentage uncertainty in your value of H . Show your working.

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

- (v) With this arrangement of the apparatus, the total mass of A is equal to m measured in (a).

- Record the total mass M of A.

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

- Calculate $\sqrt{H - b}$.

$$\sqrt{H - b} = \dots\dots\dots$$





- (c) • Use the adhesive putty to attach the 10.0 g slotted mass to A.

The total mass M of A is now equal to the sum of m and the mass of the slotted mass.

- Displace A and adjust the position of the block so that, when they are touching, the centre of A is level with the top of the block, as shown in Fig. 2.2.
- Repeat (b)(iii) and (b)(v).

$H =$ cm

$M =$ g

$\sqrt{H-b} =$ [2]

- (d) It is suggested that the relationship between H , b , m , M and d is

$$\frac{1}{\sqrt{H-b}} = k + \frac{m}{2M\sqrt{d-b}}$$

where k is a constant.

Using your data, calculate two values of k .

first value of $k =$

second value of $k =$ [1]





(e) 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 (d).

.....

.....

.....

..... [1]





- (f) (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.

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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.

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[4]

[Total: 20]

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PHYSICS**9702/34**

Paper 3 Advanced Practical Skills 2

October/November 2024**2 hours**

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
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- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

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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 flow of water through a nozzle.

- (a) (i)
- Remove the plunger from the syringe body.
 - Assemble the apparatus as shown in Fig. 1.1 with the bottom of the syringe nozzle approximately 15 cm above the bench.

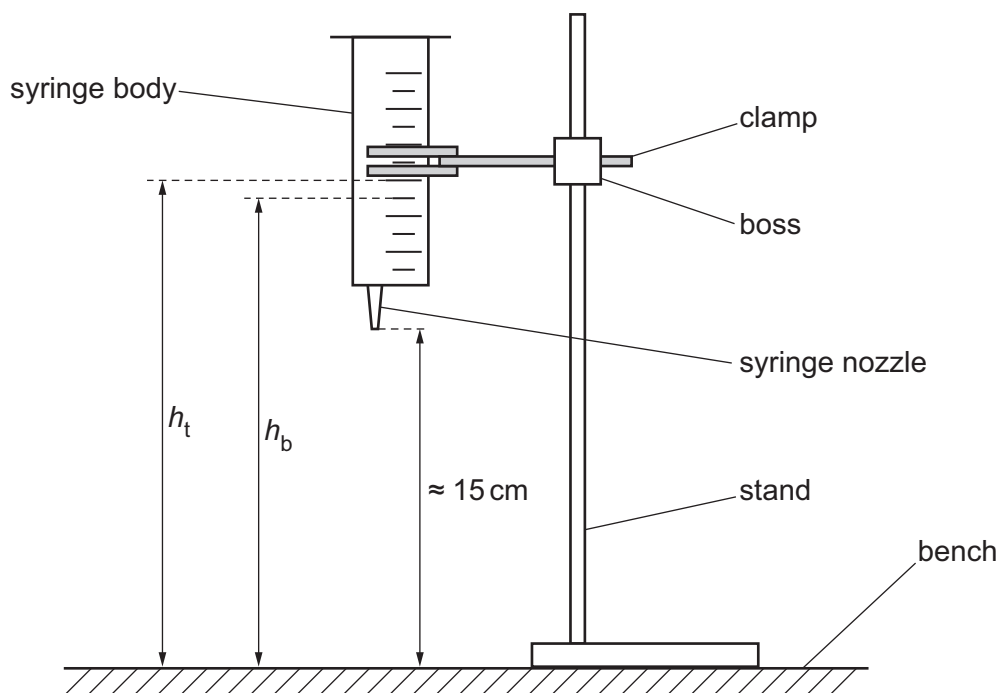


Fig. 1.1 (not to scale)

- Measure and record the height h_t of the 30 cm³ graduation above the bench, as shown in Fig. 1.1.

$$h_t = \dots\dots\dots$$

- Measure and record the height h_b of the 25 cm³ graduation above the bench, as shown in Fig. 1.1.

$$h_b = \dots\dots\dots$$

- Calculate the mean h_m of the two values h_t and h_b .

$$h_m = \dots\dots\dots [1]$$





- (ii)
- Place the empty beaker below the syringe nozzle.
 - Pour water from the other beaker into the syringe body so that the water level is near the top, then watch the water level fall.
 - Start the stop-watch as the water level passes the 30 cm^3 graduation, then stop the stop-watch as the water level passes the 25 cm^3 graduation.
 - Record the stop-watch reading T .

$T =$ [2]





(b) Choose two different graduations that are 5 cm^3 apart and measure h_t , h_b and T .

Repeat until you have six sets of values of h_t , h_b and T .

Record your results in a table. Include values of h_m and $\frac{1}{T}$ in your table.

[9]

(c) (i) Plot a graph of $\frac{1}{T}$ on the y-axis against h_m on the x-axis.

[3]

(ii) Draw the straight line of best fit.

[1]

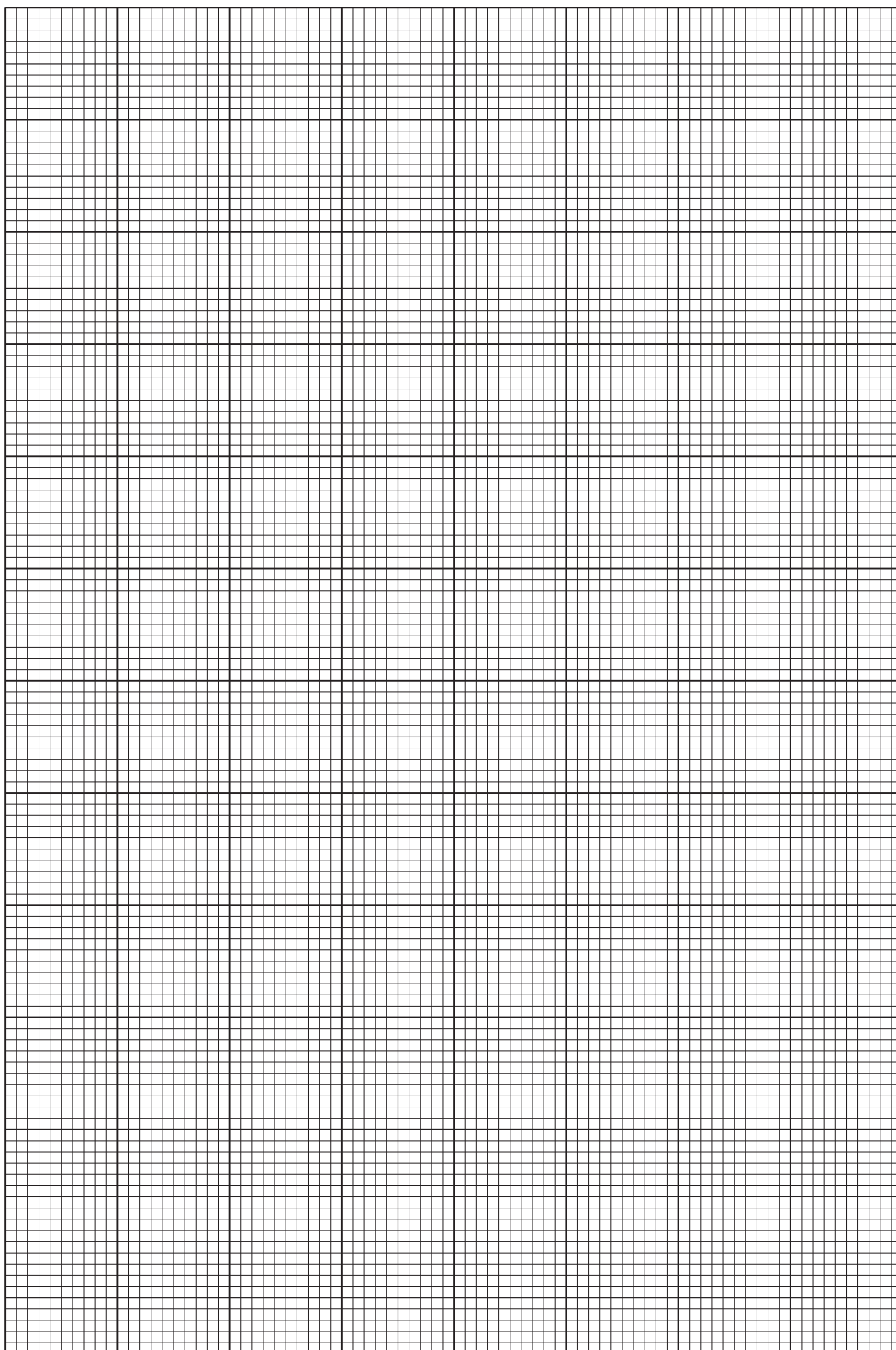
(iii) Determine the gradient and y-intercept of this line.

gradient = ...

y-intercept = ...

[2]







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

$$\frac{1}{T} = ph_m + q$$

where p and q are constants.

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

$p =$

$q =$

[2]

[Total: 20]



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

2 In this experiment, you will investigate the conservation of momentum.

(a) (i) The apparatus has been partly set up as shown in Fig. 2.1.

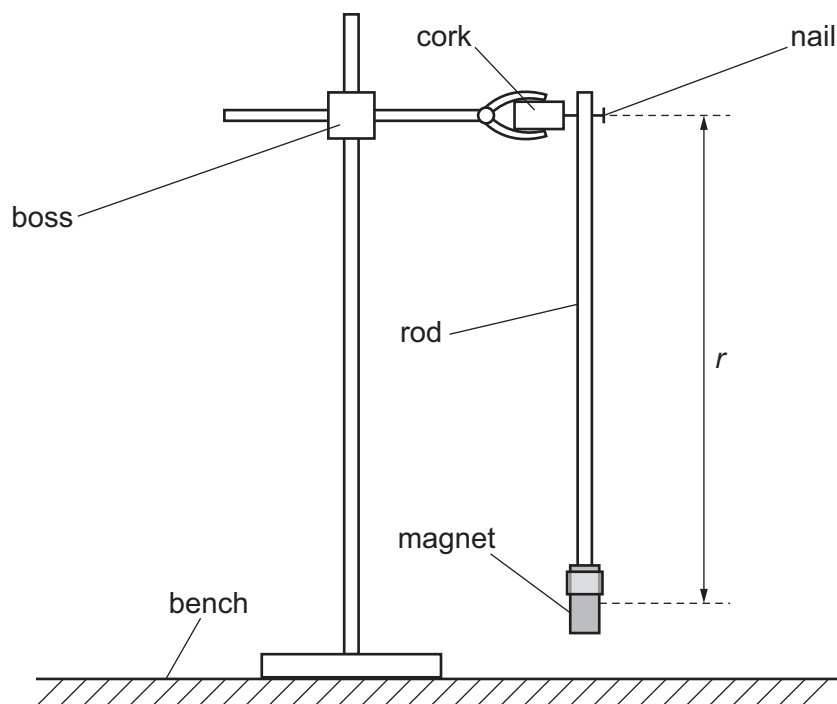


Fig. 2.1

- Check that the rod can swing freely on the nail.
- The distance between the nail and the centre of the magnet is r .

Measure and record r .

$r = \dots\dots\dots$ cm

- Record the mass M of the magnet written on the card.

$M = \dots\dots\dots$ g
[2]





- (ii)
- Use small pieces of adhesive putty to fix the 30 cm ruler to the bench with the zero of its scale directly below the centre of the magnet, as shown in Fig. 2.2.
 - Attach nut A to the bottom of the magnet. Adjust the position of the boss on the stand until the bottom of the nut is approximately 3 mm above the ruler, as shown in Fig. 2.2.

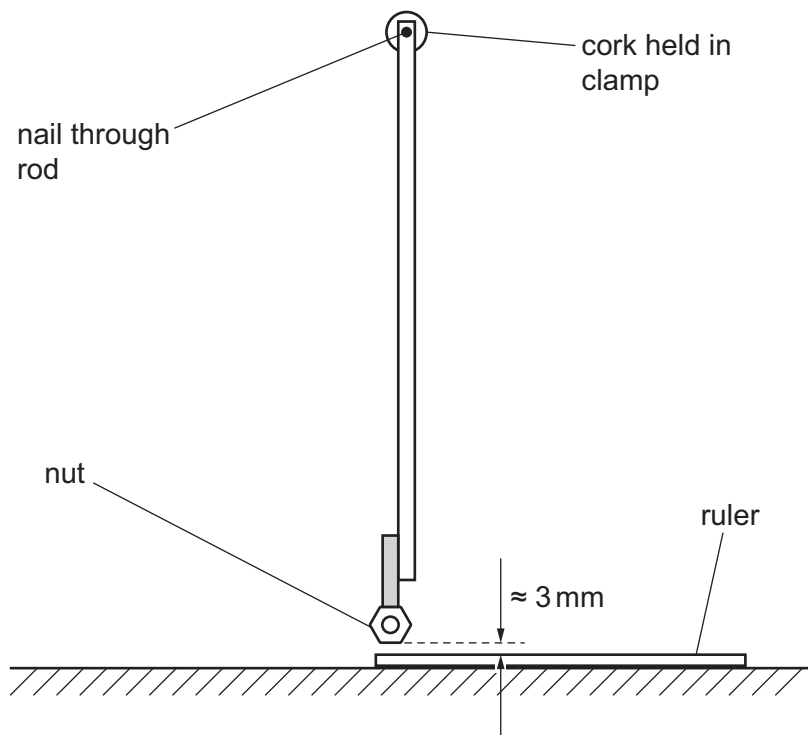


Fig. 2.2

- Record the mass m of nut A written on the card.

$m = \dots\dots\dots$ g



- Detach the nut from the magnet.
- Move the rod and hold it so that the bottom of the magnet is directly above the 15.0 cm mark on the ruler scale.
- Place the nut on the ruler so that its centre is above the zero on the ruler scale, as shown in Fig. 2.3.

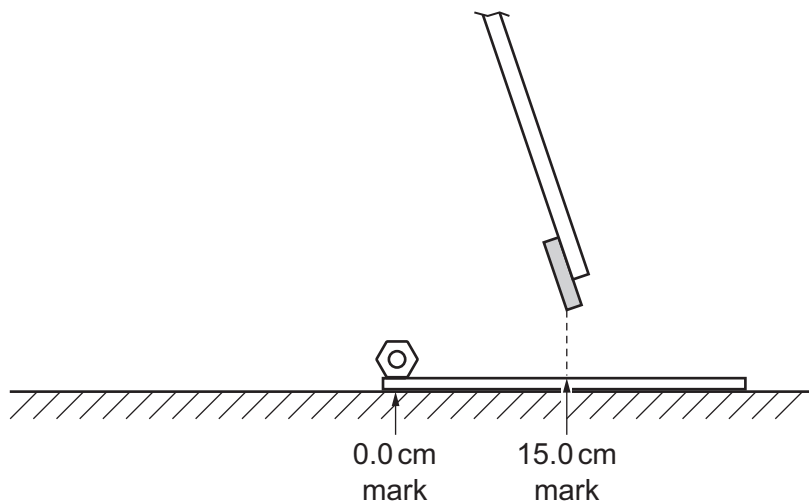


Fig. 2.3

- Release the rod so that the magnet picks up the nut as it passes and then swings back to a position x on the ruler scale, as shown in Fig. 2.4.

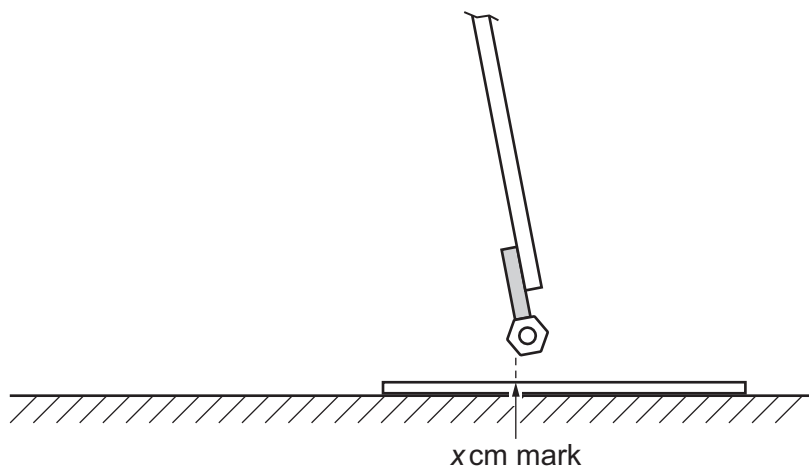


Fig. 2.4

- Read and record x .

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



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

percentage uncertainty = ...% [1]

(iv) Calculate h using

$$h = r - \sqrt{(r^2 - x^2)}.$$

$h =$ cm [1]

(b) Repeat (a)(ii) and (a)(iv) using nut B.

$m =$ g

$x =$ cm

$h =$ cm
[3]





- (c) It is suggested that the relationship between M , m and h is

$$h = \frac{k}{(M + m)^2}$$

where k is a constant.

- (i) Using your data, calculate two values of k .

first value of k = ...

second value of k = ...

[1]

- (ii) Justify the number of significant figures that you have given for your values 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).

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- (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.

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PHYSICS

9702/35

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

1 In this experiment, you will investigate the balancing of a metre rule.

(a) • Set up the apparatus as shown in Fig. 1.1.

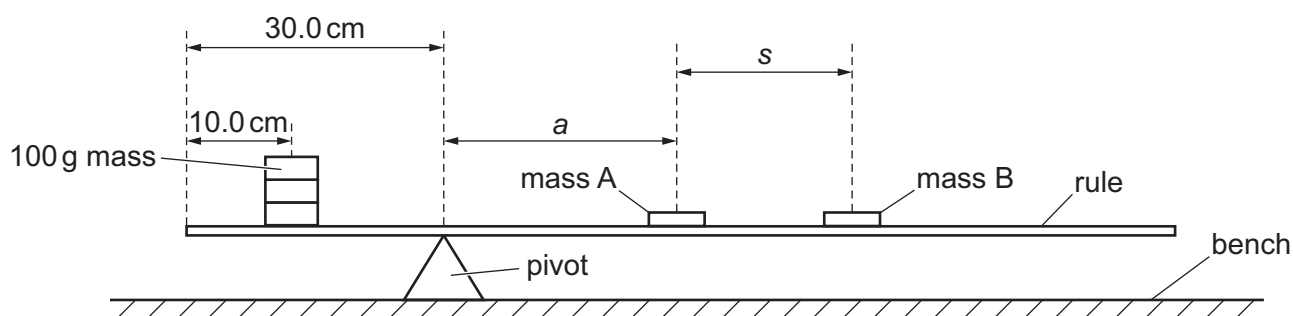


Fig. 1.1

- Use the adhesive putty to fix three 100 g slotted masses with their centres above the 10.0 cm mark on the rule, as shown in Fig. 1.1.
- Place the rule on the pivot at the 30.0 cm mark.

The 100 g masses and the pivot must remain at these positions throughout the experiment.

- Place masses A and B on the rule.
- The distance between the centre of A and the pivot is a .
The distance between the centre of B and the centre of A is s .

Adjust the position of A until a is approximately 20 cm.

- Adjust the position of B until the rule is balanced.
- Determine a and s .

$a =$ cm

$s =$ cm
[1]





- (b) Change the position of A. Adjust the position of B until the rule is balanced. Determine a and s . Repeat until you have six sets of values of a and s . Do **not** use values of a less than 10.0 cm.

Record your results in a table. Include values of $\frac{1}{a}$ and $\frac{s}{a}$ in your table.

[10]

- (c) (i) Plot a graph of $\frac{s}{a}$ on the y -axis against $\frac{1}{a}$ 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]



A full page of blank graph paper. The grid consists of small squares formed by thin black lines. There are no margins, text, or other markings on the page.



(d) (i) It is suggested that the quantities a and s are related by the equation

$$\frac{s}{a} = \frac{P}{a} + Q$$

where P and Q are constants.

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

$P =$

$Q =$ [2]

(ii) Theory suggests that

$$P = \frac{(Z - R)d}{m}$$

where $Z = 300 \text{ g}$,
 $d = 20.0 \text{ cm}$,
 $m = 50 \text{ g}$ and
 R is a constant.

Using your value of P , determine a value for R .
Give an appropriate unit.

$R =$ [1]

[Total: 20]



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

2 In this experiment, you will investigate the oscillations of a wooden rod.

- (a) (i) You are provided with two identical wooden rods. The length of one rod is L and the diameter of the rod is d , as shown in Fig. 2.1.

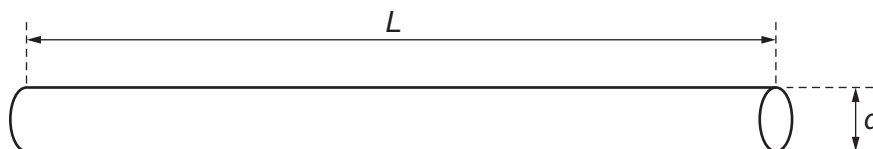


Fig. 2.1 (not to scale)

- Measure and record L .

$L =$

- Using the micrometer, measure and record d .

$d =$

- The volume V of the rod is given by

$$V = \frac{\pi d^2 L}{4}.$$

Calculate V .

$V =$ [2]

- (ii) Justify the number of significant figures that you have given for your value of V .

.....

 [1]





- (b) (i) • Set up the apparatus as shown in Fig. 2.2.

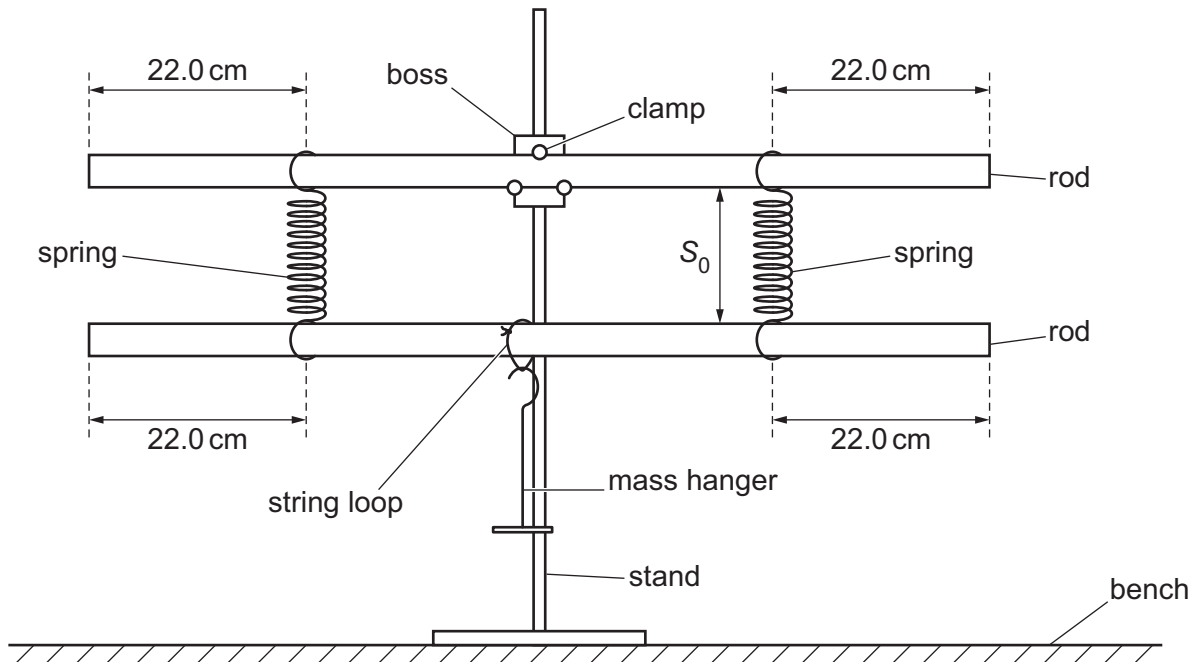


Fig. 2.2 (not to scale)

- Clamp one rod at its midpoint so that it is parallel to the bench.
- Slide the string loop onto the other rod.
- Slide the springs onto the rods and adjust the positions of the springs so that each spring is 22.0 cm from the nearest end of the rod, as shown in Fig. 2.2.
- Hang the mass hanger from the string loop. Adjust the position of the string loop so that it is at the midpoint of the lower rod.
- The distance between the two rods is S_0 .

Measure and record S_0 .

$$S_0 = \dots\dots\dots \text{ m [1]}$$

- (ii) Estimate the percentage uncertainty in your value of S_0 . Show your working.

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





- (iii) • Add a 100 g slotted mass to the mass hanger.
- The distance between the two rods is now S_1 .

Measure and record S_1 .

$$S_1 = \dots\dots\dots \text{ m}$$

- The spring constant k of the arrangement is given by

$$k = \frac{W}{S_1 - S_0}$$

where W has the value 0.98 N.

Calculate k .

$$k = \dots\dots\dots \text{ Nm}^{-1}$$

[1]

- (c) • The total mass hanging from the string loop is M .

Record M .

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

- Move the lower rod a small distance downwards. Release the rod. The rod oscillates in a vertical plane.
- Take measurements to determine the period T of the oscillations.

$$T = \dots\dots\dots \text{ s}$$

[2]





- (d) • Add an additional mass of 200g to the mass hanger.
- Repeat (c).

$M =$ kg

$T =$ s
[2]

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- (e) It is suggested that the relationship between T , M , V and k is

$$\rho V = \frac{kT^2}{4\pi^2} - M$$

where ρ is a constant.

Using your data, calculate two values of ρ .

first value of $\rho =$

second value of $\rho =$

[1]

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

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

.....

.....

.....

..... [1]





- (g) (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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[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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[4]

[Total: 20]

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PHYSICS

9702/36

Paper 3 Advanced Practical Skills 2

October/November 2024

2 hours

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

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.

INFORMATION

- The total mark for this paper is 40.
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You may not need to use all of the materials provided.

- 1** In this experiment, you will investigate the equilibrium position of a suspended cardboard sheet.
- (a)** You are provided with a flat sheet of cardboard with a hole through it and two lines drawn near two of the edges.
- Assemble the apparatus as shown in Fig. 1.1 with the bottom edge of the cardboard approximately 5 cm above the bench. Check that the cardboard swings freely on the knitting needle.

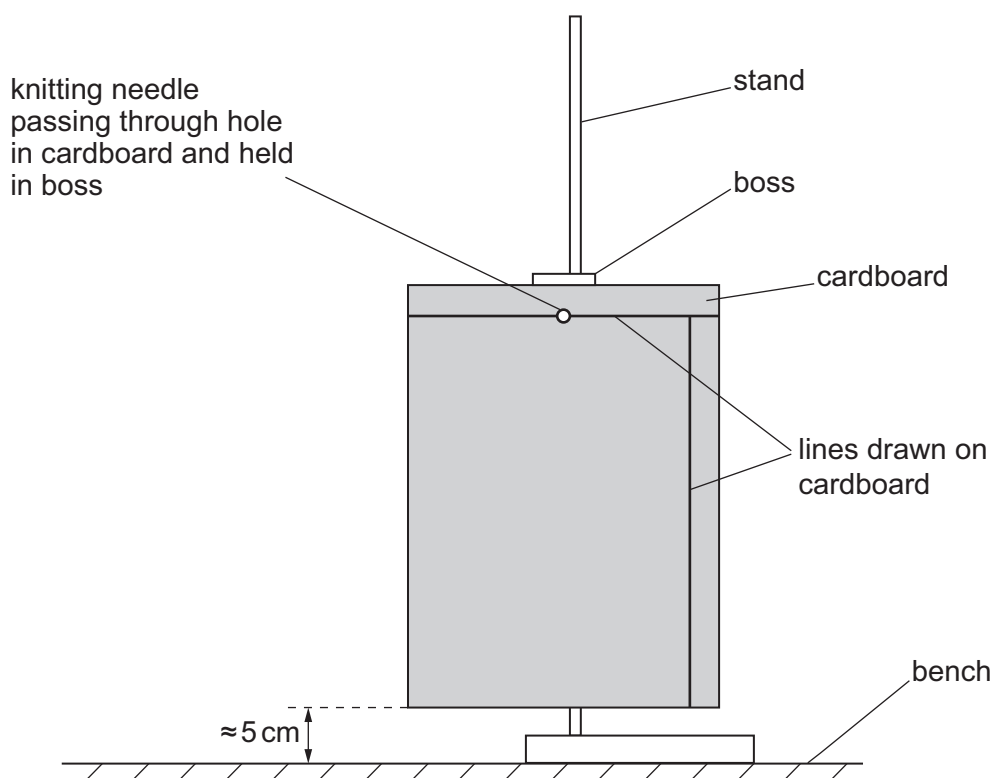


Fig. 1.1



- Use the sharp pencil to make a hole through the cardboard approximately half-way along the longer line.
- Pass the bolt through the slotted mass and then through the hole in the cardboard, as shown in Fig. 1.2.
- Secure the bolt using the nut.

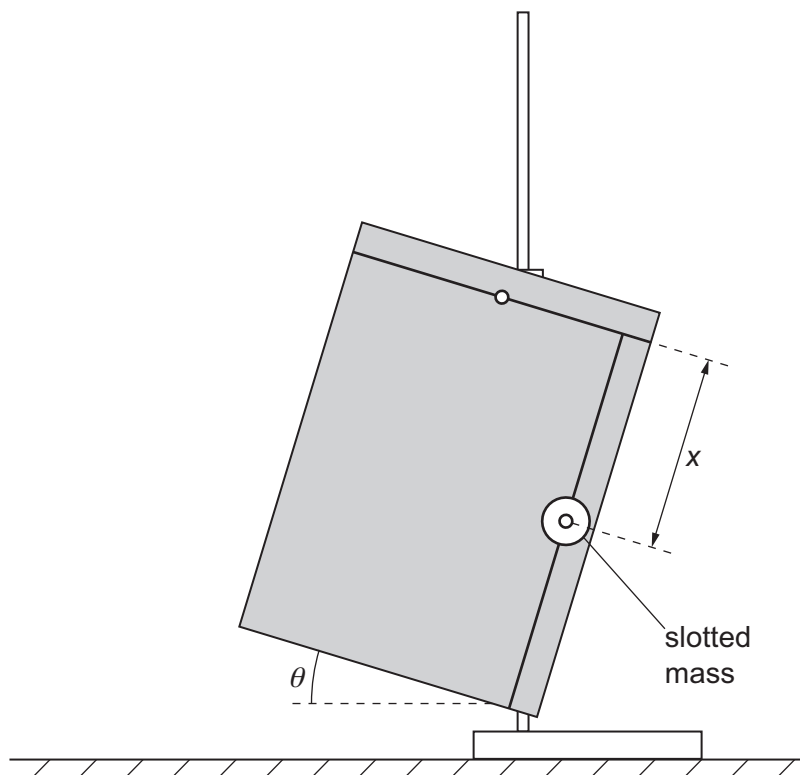


Fig. 1.2

- The distance between the centre of the slotted mass and the intersection of the two lines is x , as shown in Fig. 1.2.

Measure and record x .

$x =$

- The angle between the bottom edge of the cardboard and the horizontal is θ , as shown in Fig. 1.2.

Use the wooden block and the protractor to measure θ .

$\theta =$ [°]
[2]





- (b) Use the pencil to make another hole through the longer line and move the slotted mass and bolt to the new hole. Measure x and θ .

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

Record your results in a table. Include values of $\frac{1}{\tan \theta}$ in your table.

[10]

- (c) (i) Plot a graph of $\frac{1}{\tan \theta}$ on the y -axis against x on the x -axis.

[3]

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

[1]

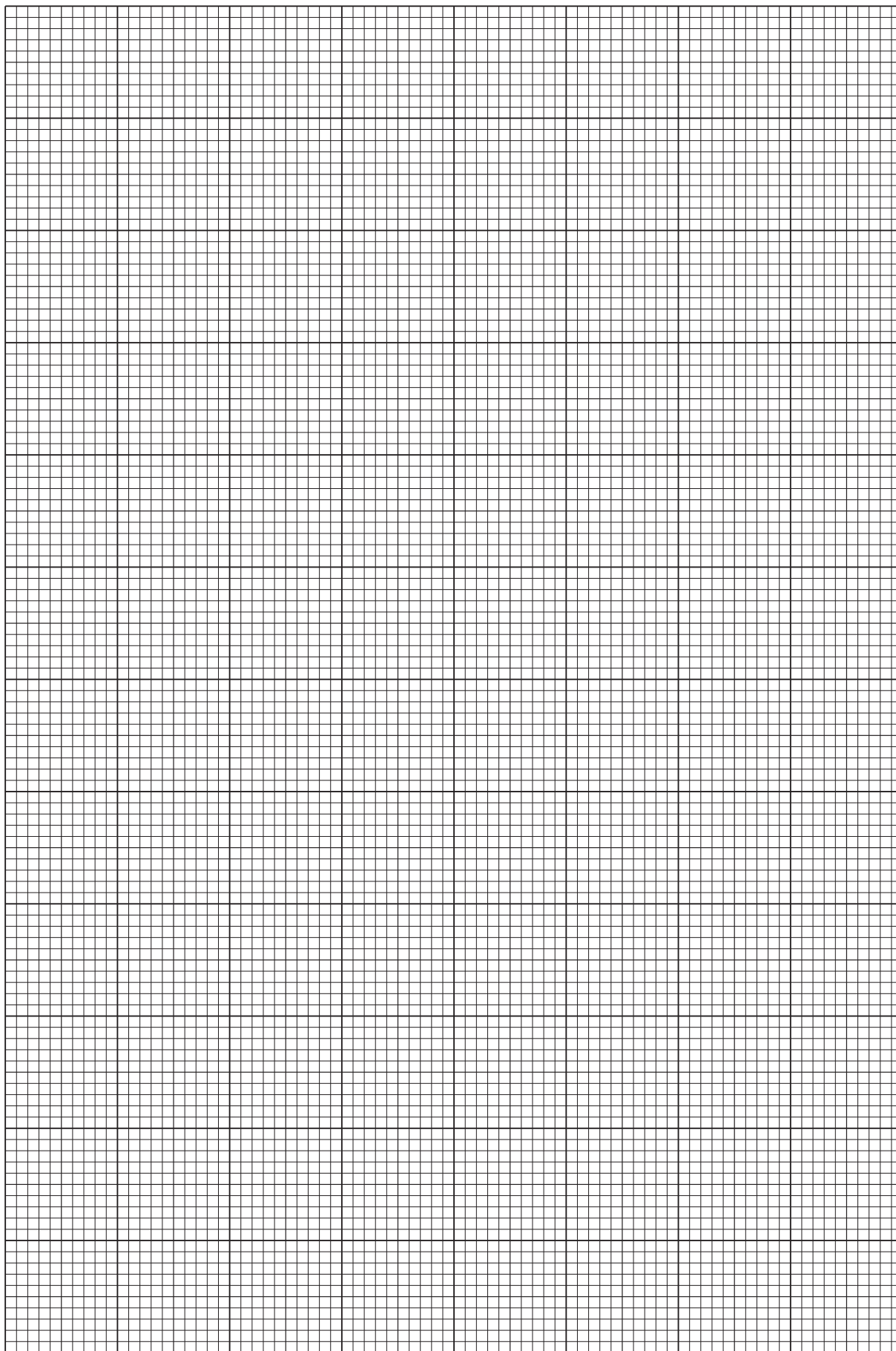
- (iii) Determine the gradient and y -intercept of this line.

gradient = ...

y -intercept = ...

[2]







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

$$\frac{1}{\tan \theta} = ax + b$$

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 motion of a conical pendulum.

- (a)
- Set the compasses to a radius of approximately 9 cm and then use them to draw a circle on the sheet of paper.
 - Mark the centre of the circle with a cross.
 - Measure and record the diameter D of the circle.

$D = \dots\dots\dots$ cm [1]

(b) (i) You are provided with a pendulum bob with a length of string attached.

- Tie a knot in the string approximately 19 cm from the top of the bob.
- Measure and record the distance p from the knot to the **centre** of the bob.

$p = \dots\dots\dots$ cm [1]

(ii) Estimate the percentage uncertainty in your value of p . Show your working.

percentage uncertainty = $\dots\dots\dots$ % [1]





- (c) (i) • Place the paper with the circle on the bench.
- Holding the knot, suspend the bob approximately 5 mm above the cross at the centre of the circle, as shown in Fig. 2.1.

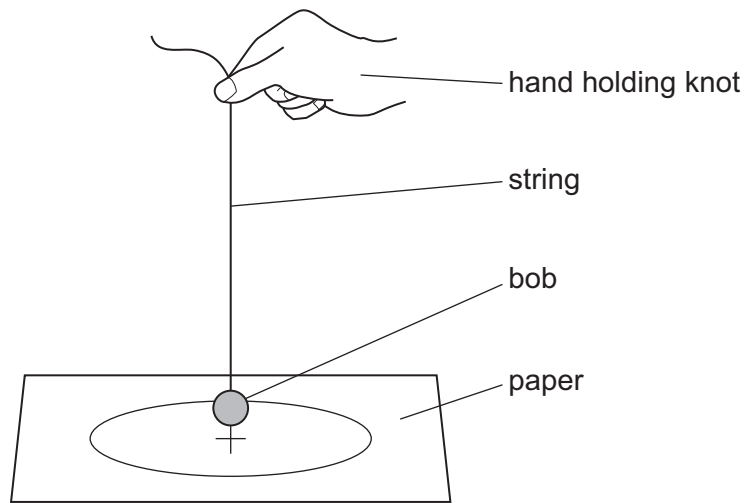


Fig. 2.1

- Move the knot in small, slow circles so that the bob starts to move in a circle.
- Adjust the movement of the knot until the bob moves just above the circle on the paper, as shown in Fig. 2.2.

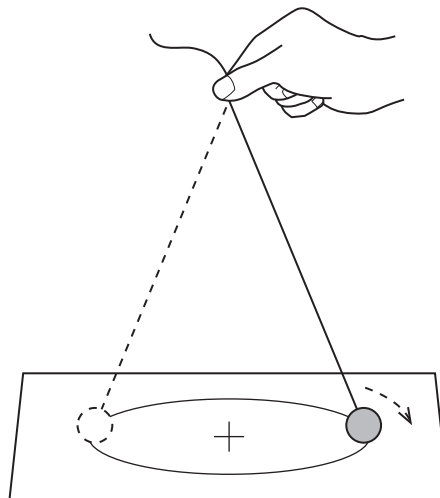


Fig. 2.2

- The period T of the rotation of the bob is the time the bob takes to travel through one complete circle.

When this motion is steady, take measurements to determine T .

$T = \dots\dots\dots$ [2]





- (ii) The angle between the string and the vertical when the bob follows this circular path is ϕ , where ϕ is given by

$$\sin \phi = \frac{D}{2p}.$$

Calculate ϕ .

$$\phi = \dots\dots\dots^\circ \quad [1]$$

- (d) • Tie a knot in the string approximately 13 cm from the top of the bob.
- Using this knot, measure and record p .

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

- Using this knot, repeat (c).

$$T = \dots\dots\dots$$

$$\phi = \dots\dots\dots^\circ \quad [3]$$





- (e) It is suggested that the relationship between T , p and Φ is

$$T^2 = k p \cos \Phi$$

where k is a constant.

- (i) Using your data, calculate two values of k .

first value of k = ...

second value of k = ...

[1]

- (ii) Justify the number of significant figures that you have given for your values of k .

.....

.....

..... [1]

- (f) 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 (e).

.....

.....

.....

..... [1]





(g) (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.

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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.

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[Total: 20]





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