

P3 GUIDEBOOK

(Applicable for As Levels Physics Practical 9702)

Made by

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Alpha Learning

General Guidelines:

Question 1:

- The distance between the rubber band and the end of the rule is x , as shown in Fig. 1.2.

Measure and record x .

$x = \dots\dots\dots$

- The angle indicated by the plumb-line on the protractor scale is θ , as shown in Fig. 1.2.

Measure and record θ .

$\theta = \dots\dots\dots^\circ$
[2]

Whenever you have to calculate length/measurements in Q1 part a remember these 2 points:

1) Give Value to the nearest decimal place that the instrument offers.

2) Take Average of multiple values.

Meter Rule:

- No Decimal Place. $\pm 1\text{mm}$ e.g. 78mm
- 1 Decimal Place. $\pm 0.1\text{ cm}$ e.g. 8.9cm
- 3 Decimal Place. $\pm 0.001\text{m}$ e.g. 0.254m

Stopwatch:

Human Reaction Time = $\pm 0.5\text{s}$

Protractor:

Error = $\pm 1^\circ$

Vernier Caliper:

- 2 Decimal Place e.g. 0.05 mm
- 3 Decimal Place e.g. 0.005 cm

Micrometer Screw Gauge:

- 2 Decimal Place e.g. 0.05 mm

Digital Multimeter (Voltmeter):

- Voltmeter set on 20 V. ± 0.01 V e.g. 30.11 V
- Voltmeter set on 2000 mV. ± 1 V e.g. 3032 V

Digital Multimeter (Ammeter):

- Ammeter set on 20 mA. ± 0.01 mA e.g. 20.56 mA
- Ammeter set on 200 mA. ± 0.1 mA e.g. 200.5 mA
- Ammeter set on 10 A. ± 0.01 A e.g. 15.05 A

Newton Meter (0–10N):

- ± 0.2 N

Thermometer:

- Least count ± 1 °C

Key Points:

1. All measured Quantities should be **averaged out** and is controlled by **decimal places of the instrument**.
2. All Calculated values are controlled by **significant figures**. If measured value is to **2 significant figures**, then **calculated values** should be to 2–3 significant values.
3. Uncertainty in time is equal to human reaction time. It can vary from **0.2s to 0.5s**.

Table Question:

- (b) Vary x by moving the rubber band along the metre rule. Adjust the position of W so that both springs are vertical. 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 $\cos \theta$ in your table.

Important Points:

6 readings collected with correct trend	5 marks
80% of the range of Independent variable should be covered	1 mark
Heading in correct Format (Symbol/unit)	1 mark
Decimal points of measured values are same and consistent with the instrument used	1 mark
Significant Figures of Calculated Values should be correct (same or +1 of the calculated values)	1 mark
All Calculations Correct	1 mark

For the Above Question a Table Like This will Guarantee **Highest Marks**:

x/cm	Q°	cosQ
5.0 cm	75°	0.259
15.0 cm	62°	0.469
25.0 cm	55°	0.574
35.0 cm	42°	0.743
40.0 cm	35°	0.819
55.0 cm	30°	0.866

Remember:

- Measurements of " x " are taken from meter rule. Hence 1 decimal place after cm.
- Measurements of " Q " are taken from protractor. Hence no decimal places
- x can be varied from 0-55cm.
- The values of "**CosQ**" can be to 2-3 significant figures because "**Q**" is to 2 significant figures.
- All Calculations should be correct

Graph Question:

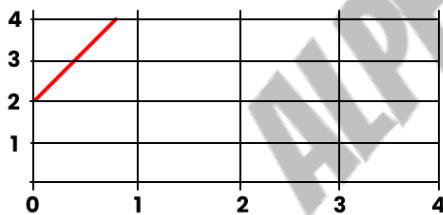
- (c) (i) Plot a graph of $\cos \theta$ on the y-axis against x on the x-axis. [3]
- (ii) Draw the straight line of best fit. [1]
- (iii) Determine the gradient and y-intercept of this line.

gradient = ...

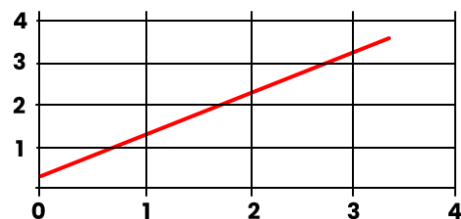
y-intercept = ... [2]

Important Points:

- 1) **Scale Chosen for the graph must be such that the plotted points cover at least 75 percent of the graph.**

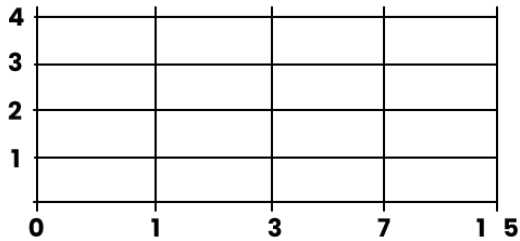


Not Acceptable

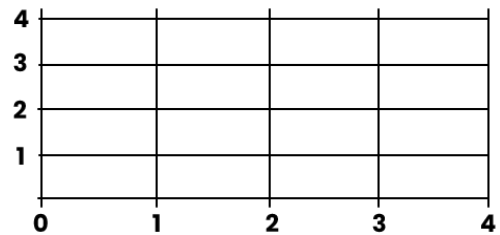


Acceptable

- 2) The axis should be linear i.e. the change in the magnitude of property per unit change in axis should remain the same. However, both the axis can have different distributions.

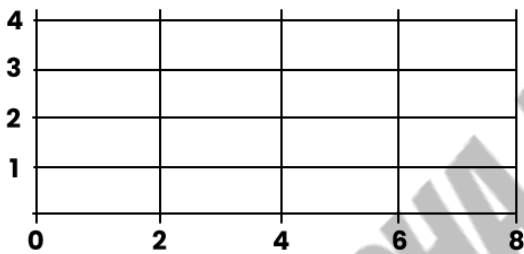


Non-Uniform plotting

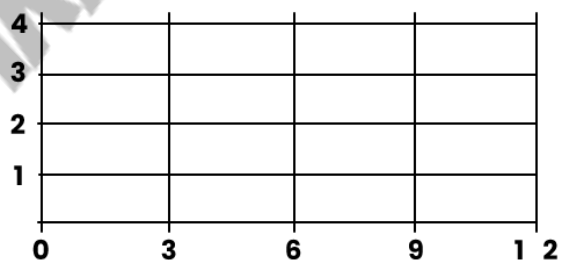


Uniform Plotting

- 3) An easy scale/readable scale should be used. Multiples of 2 and 5 are preferred. Avoid multiples of 3.



Middle values are easily readable



Middle values are not easily readable

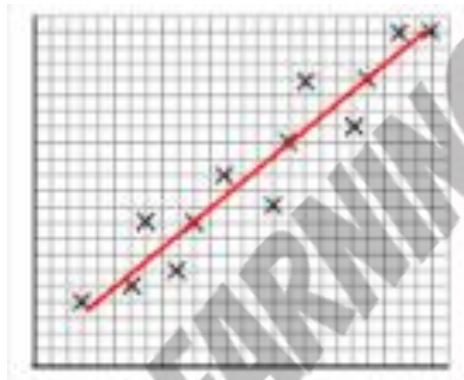
- 4) Axis should be labelled in this format:

"Symbol/unit"

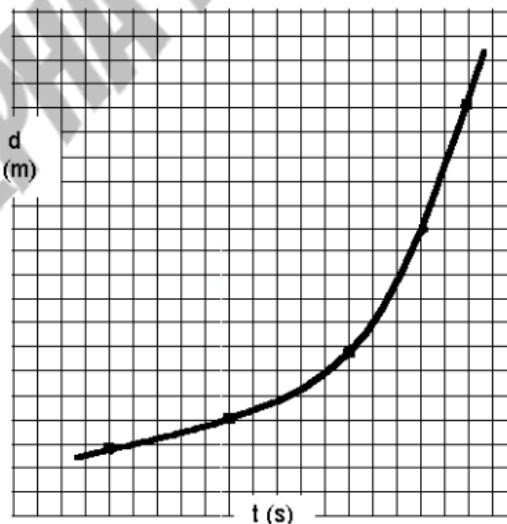
e.g

L/cm

- 5) While plotting points either use a "x" or "."
- 6) Start the graph from the values instructed by the examiner. It is not necessary to always initiate the graph from the origin i.e. (0,0). Generally, the examiner marks the initial points on the graph himself.
- 7) Examiner will always instruct you to either draw "line of best fit" or "curve of best fit"



A best fit line is a balanced line that has equal number of points above and below it.



Curve of Best fit

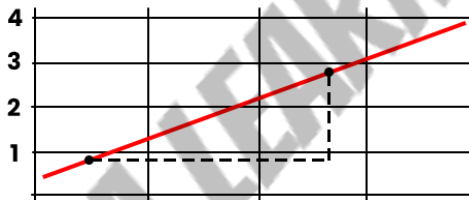
If there is an Anomalous point mark it with a circle and label it on the graph.

8) While plotting the points remember these three things:

- Make sure all observations are plotted
- Plotted points must be accurate to better than one half of a small square of the graph grid.
- Draw the graph with a thin and light pencil. (But not too light)

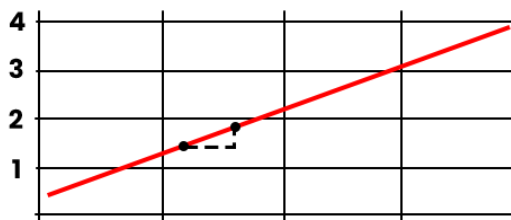
9) While calculating gradient of a best fit line do remember these things:

- Select two points that lie on the line
- 2 points taken should be far away that is they must cover at least half of the graph
- Draw a dotted triangle to show which points you have taken.



Gradient Acceptable:

- Points marked
- Dotted triangle made
- Points cover 50% of graph
- It is preferred to label the points as (x_1, y_1) and (x_2, y_2)



Gradient not Acceptable:

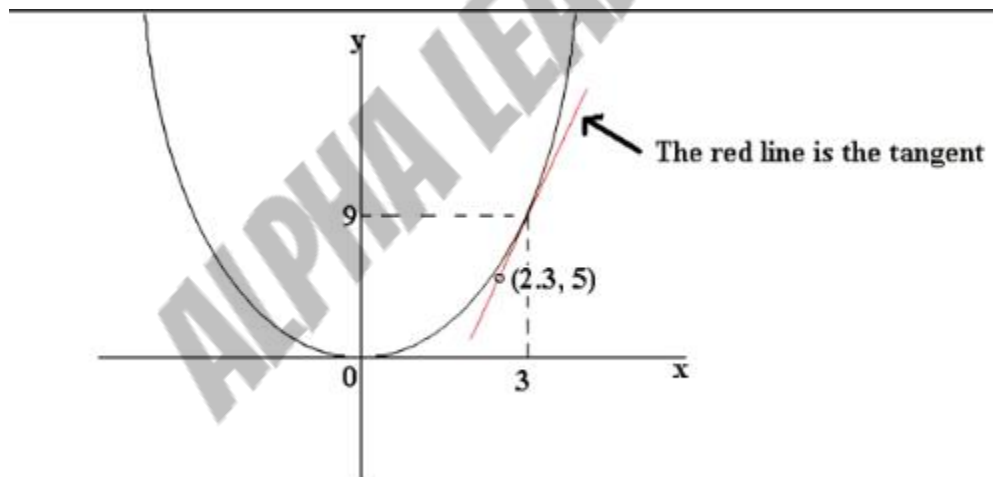
- Points don't cover half of the graph.

Apply Gradient's formula:

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

10) To calculate the gradient of a curve:

- Draw a tangent at the specific point where you want the gradient
- Take 2 points on the tangent that are far away
- Apply gradient formula.



11) Dependent variable comes on the y axis whereas independent variable comes on the x-axis.

12) The Quality of data is also checked and it is confirmed by a consistent trend.

13) Calculating Y -intercept

Method 1: If X-axis starts from zero

- Extend the line
- The point where the line cuts the y-axis that is $x=0$ is your y-intercept.

Method 2: If X-axis starts from non-zero

- Use the equation $y = mx + c$
- Choose any point and gradient and plug in the values
- The only unknown variable will be the y-intercept.

ALPHA LEARNING

“Comparing with Equation of Line” Question:

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

$$\cos \theta = ax + b$$

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]

Important Points:

- Compare the Given Equation with the equation of the line ($y=mx+c$) and give the answer of the constants.
- For this case after comparing:
 - a = gradient
 - b – y intercept
- Do remember to put in the units as well.

Question 2:

General Rules:

If you have to **measure** anything in Q2 remember the same 2 rules:

- 1) Give Value to the nearest decimal place that the instrument offers.
- 2) Take Average of multiple values.

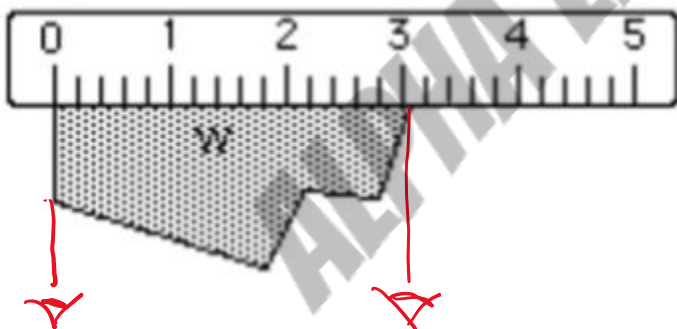
To Calculate Absolute Uncertainty:

There are 3 ways to calculate Absolute Uncertainty:

1) For Analog Instruments:

- The absolute uncertainty is **half** the smallest division.
- Analog instruments include Rulers, Vernier Calipers, Micrometer Screw Gauges, Thermometers etc.

In **Exams** we take a **complete small division** as the absolute uncertainty.
Why?



Because in exams we are usually taking 2 measurements for each reading.
This increases the uncertainty.

For this case its ± 0.2 cm

Actual Length = 3.1 cm

Final answer = 3.1 ± 0.2 cm

2) Stopwatches usually have an uncertainty of 0.2–0.5s due to human Reaction time.

3) Digital Instruments:

- The absolute uncertainty is equal to the smallest division.
- Digital instruments include multimeter, top pan balance, CRO.



Smallest division = 0.1 mV

Hypothetical reading = 29.2 mV

Final Reading = 29.2 ± 0.1 mV

To Calculate Percentage Uncertainty:

$$\frac{\text{Absolute Uncertainty}}{\text{Actual Value}} \times 100$$

Direct and Inverse Proportionality:

Direct Proportionality:

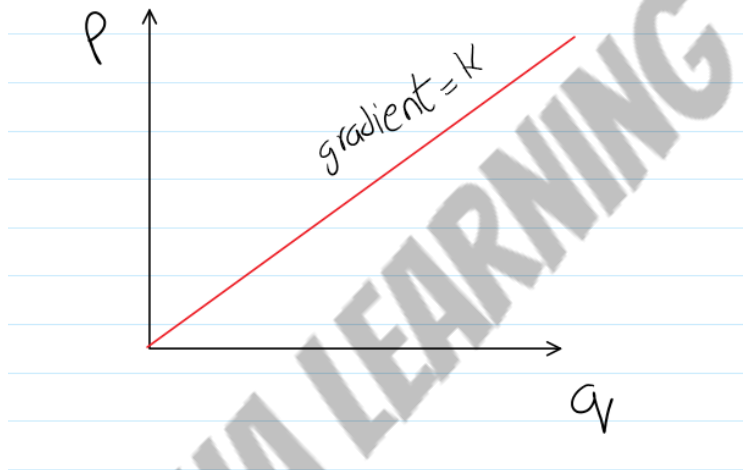
If “**p**” is directly proportional to “**q**”.

$$p \propto q$$

You can remove the proportionality sign and form an equation like:

$$p = kq$$

where “**k**” is a constant.



Inverse Proportionality:

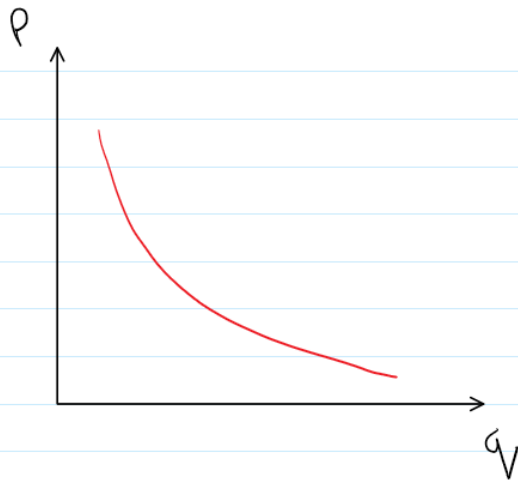
If “**p**” is inversely proportional to “**q**”.

$$p \propto \frac{1}{q}$$

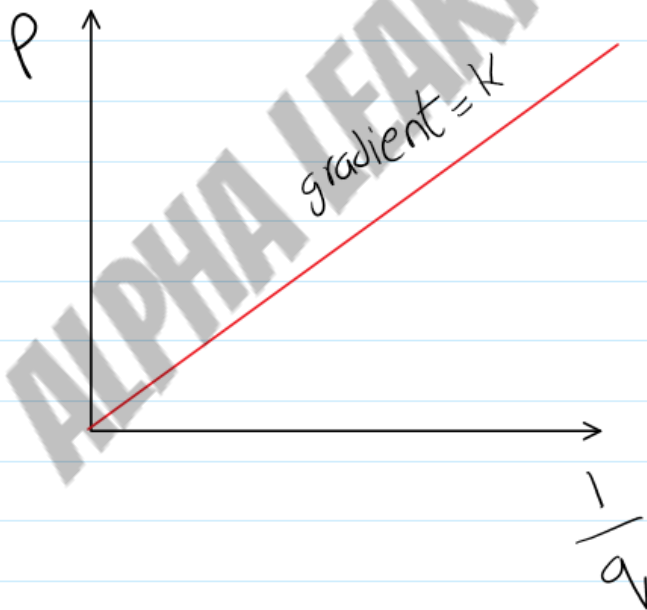
You can remove the proportionality sign and form an equation like:

$$p = \frac{k}{q}$$

where “**k**” is a constant.



However, if you plot a graph of p vs $\frac{1}{q}$ It will be a straight line.



Justifying/Supporting the relationship Question:

- (c) It is suggested that the relationship between T and C is

$$T^2 = kC$$

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]

Important Points:

- Calculate the two values of K
- We calculate the percentage difference using the formula:

$$\frac{k_1 - k_2}{k_{avg}} \times 100$$

- If percentage difference is greater than 15 reject the hypothesis and if it is less than 15 accept it.

Error Sources & Improvements:

- (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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[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]

Here is a List of some General Sources of Error and their improvements.

1) Equipment:

Limitations and Sources of Error	Improvements
Only 2-3 sets of data recorded – not enough to draw a valid conclusion.	Take more reading and plot a graph or calculate ratios of k.
Difficult to check whether a meter rule is vertical .	Hold a set square on the bench against the ruler.
Difficult to check whether a wooden strip is horizontal .	Measure the height of the wooden strip above the bench at both ends and check they are same.
Difficult to hold a Ruler or protractor steady when making a measurement.	Clamp the ruler or protractor using a clamp and stand.
Friction at pulley not negligible.	Apply oil to lubricate the pulley.

Resistance of Contacts (Electrical components)	Clean the contacts to get rid of dust.
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2) Length

Limitations and Sources of Error	Improvements
Large % uncertainty to measure small quantity (such as the diameter of a wire or coin thickness)	Use more precise instrument (e.g. Vernier Calipers or a micrometer) instead of ruler.
Difficult to measure small change in length (e.g. when stretching a metal wire)	Use a travelling microscope
Hard to see where moving object passes a marker .	Use sensor to stop timer once marker is passed. Or use an assistant.
Difficult to measure volume of liquid as liquid is clear/transparent	Add Colored dye to the liquid.

3) Time Related

Limitations and Sources of Error	Improvements
Difficult to time an event because the event is short or there is a large human error in timing.	Video the experiment, then play back frame-by-frame and see clock in the video/ use light gate.
Difficult to release an object without exerting some external force.	Hold the object against a stop (e.g. piece of card) and release.
Difficult to judge the start or end of an oscillation because it moves too fast.	Place marker at end or center of oscillation. Start/Stop stopwatch when oscillator passes the marker.
Object movement affected by wind or draught.	Turn off fans/air conditioning or make a wind shield.

****You can also include other Errors and Improvements****

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

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

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

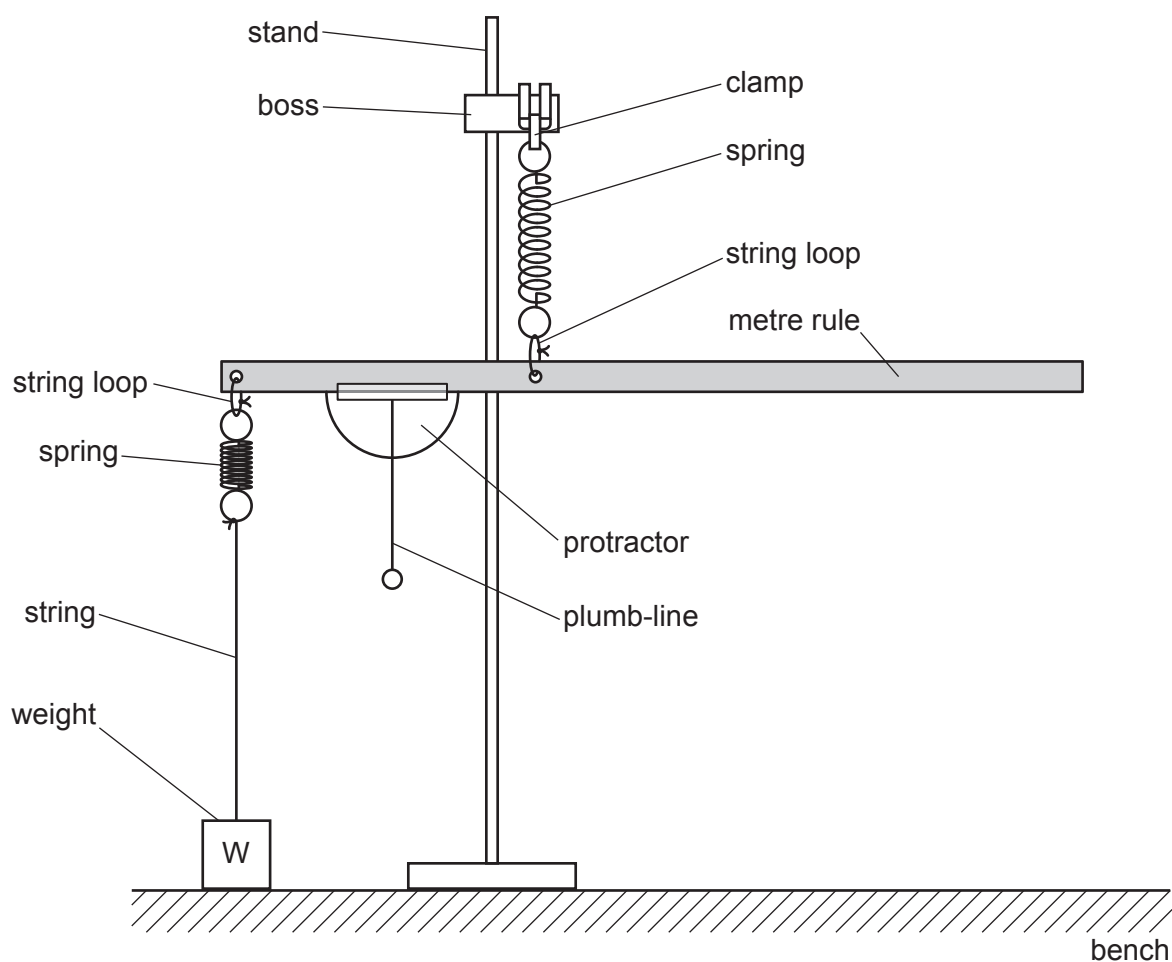


Fig. 1.1

- Adjust the height of the boss and the position of the weight W on the bench so that the metre rule is parallel to the bench and both springs are vertical.

- Slide the rubber band and slotted mass onto the rule so that the rubber band is approximately 30 cm from the end of the rule. The rule will tilt down, as shown in Fig. 1.2.
- Adjust the position of W so that both springs are vertical.

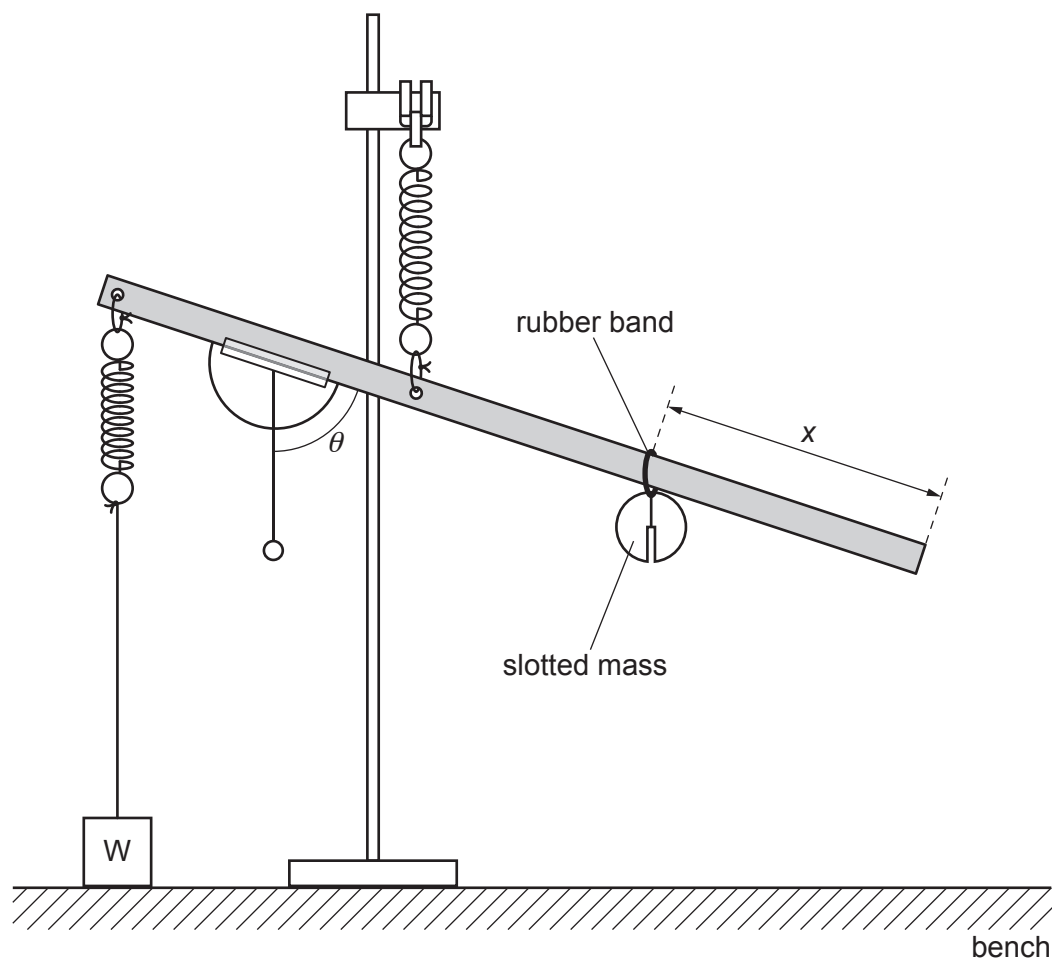


Fig. 1.2

- The distance between the rubber band and the end of the rule is x , as shown in Fig. 1.2.
Measure and record x .

$x = \dots\dots\dots$

- The angle indicated by the plumb-line on the protractor scale is θ , as shown in Fig. 1.2.
Measure and record θ .

$\theta = \dots\dots\dots^\circ$
[2]

- (b) Vary x by moving the rubber band along the metre rule. Adjust the position of W so that both springs are vertical. 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 $\cos \theta$ in your table.

[9]

- (c) (i) Plot a graph of $\cos \theta$ on the y -axis against x on the x -axis.

[3]

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

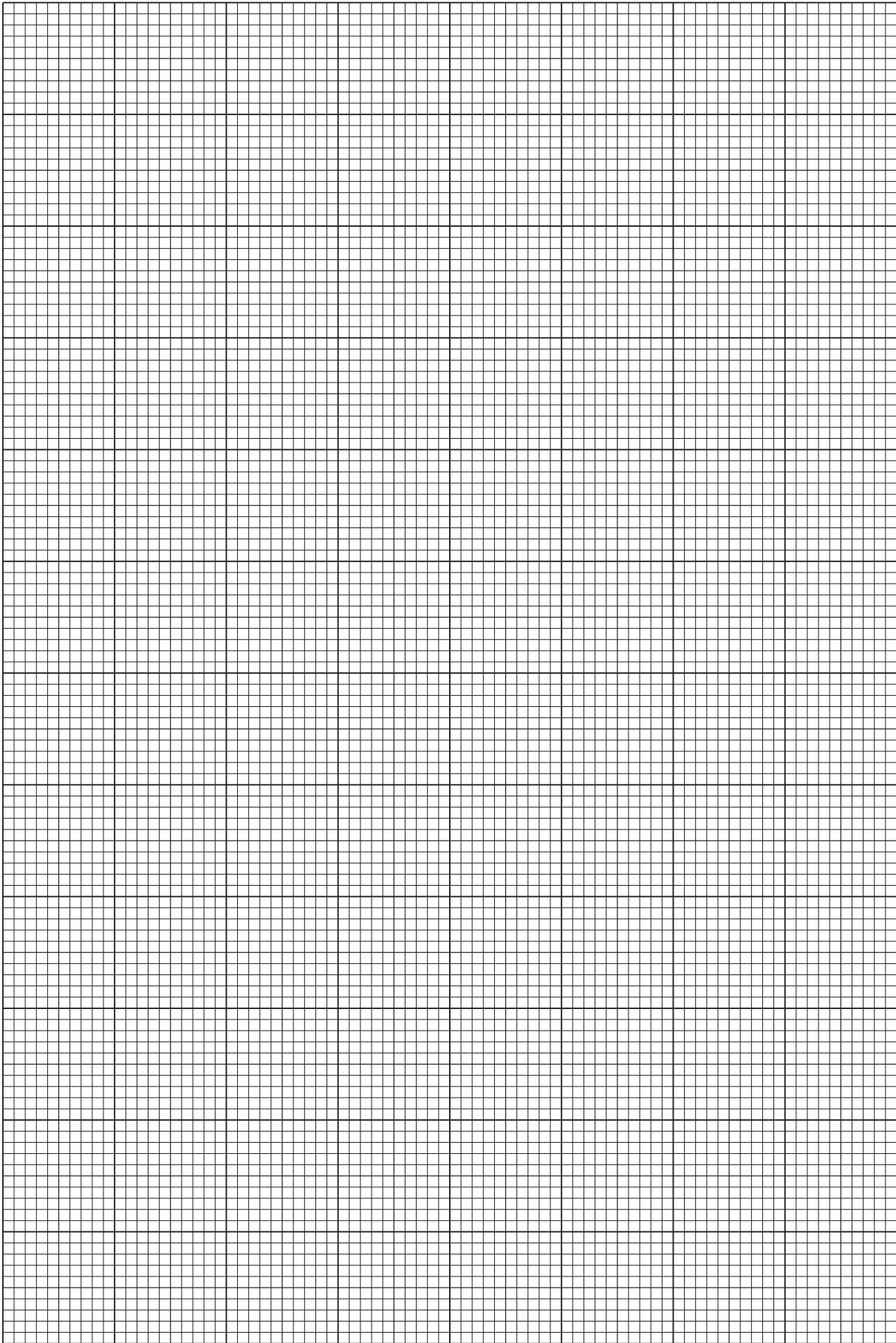
[1]

- (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

$$\cos \theta = ax + b$$

where a and b are constants.

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

$$a = \dots\dots\dots$$

$$b = \dots\dots\dots [2]$$

- (e) For this experiment, the constant a is related to the spring constant S of each spring by

$$a = -\frac{p}{S}$$

where $p = 13.15 \text{ Nm}^{-2}$.

Determine the value of S . Give an appropriate unit.

$$S = \dots\dots\dots [1]$$

[Total: 20]

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

2 In this experiment, you will investigate the properties of a flywheel.

(a) (i) You are provided with a slotted mass fixed to a length of plastic tube, as shown in Fig. 2.1.

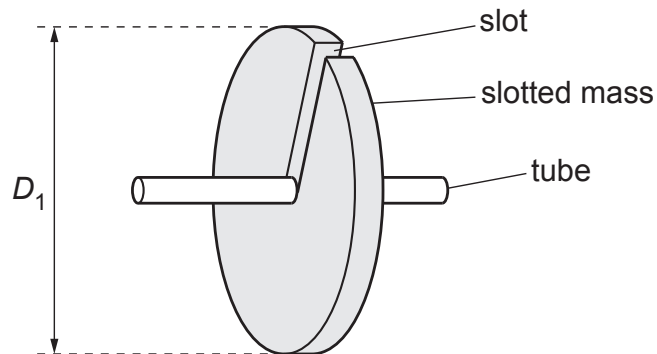


Fig. 2.1

- Measure and record the diameter D_1 of the slotted mass.

$D_1 = \dots\dots\dots$ cm

- Calculate C using

$$C = M_1 D_1^2$$

where $M_1 = 0.100$ kg.

$C = \dots\dots\dots$ [2]

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

.....

 [1]

- (iii) • Assemble the apparatus as shown in Fig. 2.2.

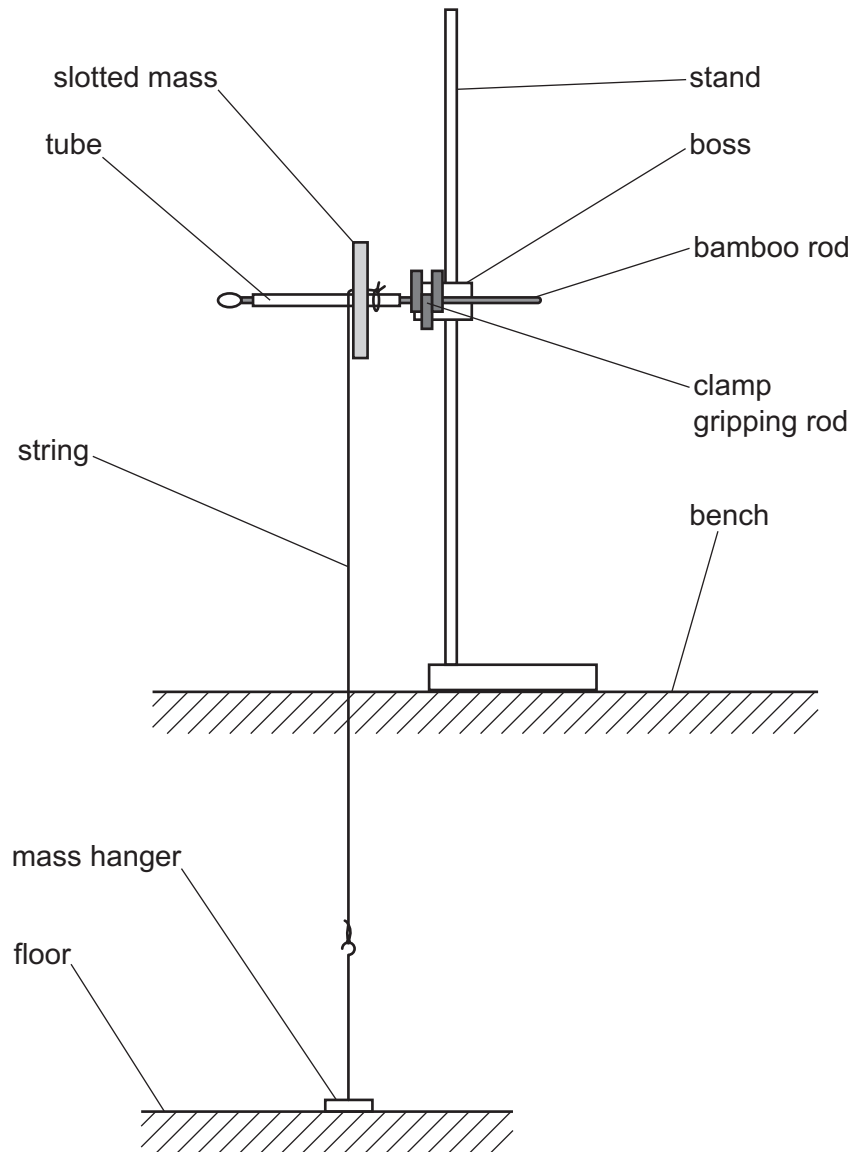


Fig. 2.2

- Pass the string through the slot of the slotted mass and tie it to the tube, as shown in Fig. 2.2.
- Hook the mass hanger onto the other end of the string and then adjust the height of the boss until the mass hanger is just touching the floor.

- Rotate the slotted mass and tube 16 times so that the string is wound around the tube, as shown in Fig. 2.3.

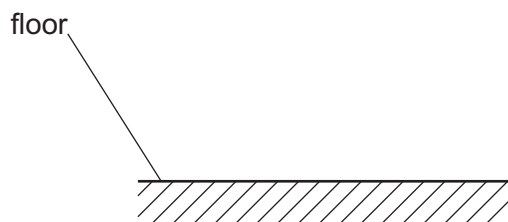
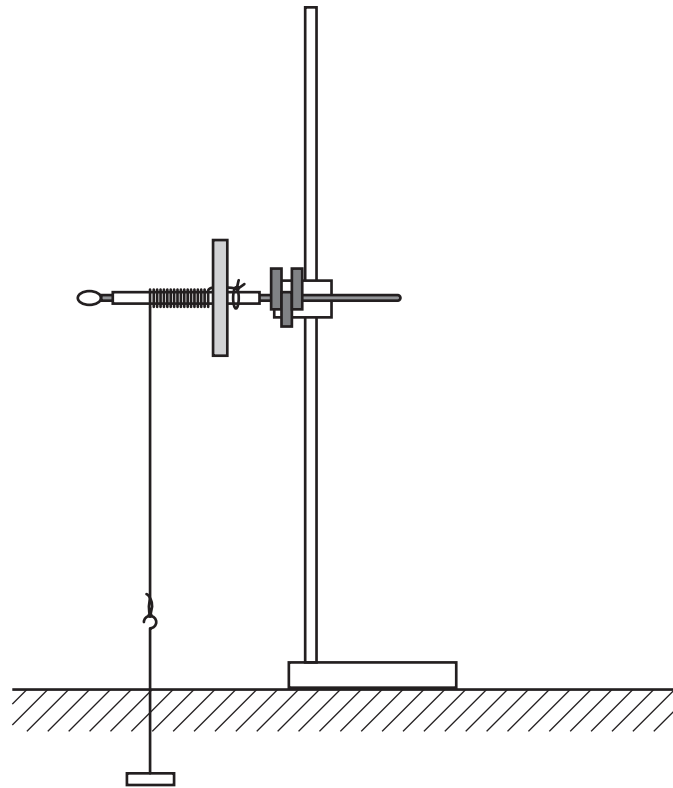


Fig. 2.3

- Release the slotted mass and take measurements to determine the time T for the mass hanger to reach the floor.

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

- (b) (i) • You are provided with modelling clay.

Using **all** the modelling clay, roll the modelling clay into a long cylinder and bend it to form a ring around the outside of the slotted mass, as shown in Fig. 2.4. Ensure it is securely attached to the slotted mass.

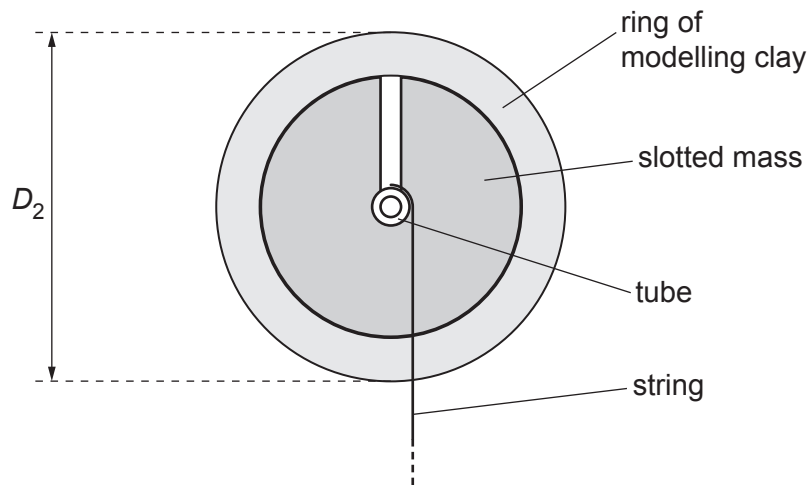


Fig. 2.4

- Measure and record the outside diameter D_2 of the ring of modelling clay, as shown in Fig. 2.4.

$D_2 = \dots\dots\dots$ cm [1]

- (ii) Estimate the percentage uncertainty in your value of D_2 . Show your working.

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

(iii) Calculate C using

$$C = M_1 D_1^2 + \frac{M_2 (D_2 + D_1)^2}{2}$$

where $M_2 = 0.070 \text{ kg}$.

$C = \dots\dots\dots$ [1]

- (iv) • Rotate the slotted mass and tube 16 times so that the string is wound around the tube, as shown in Fig. 2.3.
- Release the slotted mass and take measurements to determine the time T for the mass hanger to reach the floor.

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

- (c) It is suggested that the relationship between T and C is

$$T^2 = kC$$

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).

.....

.....

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..... [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.

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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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