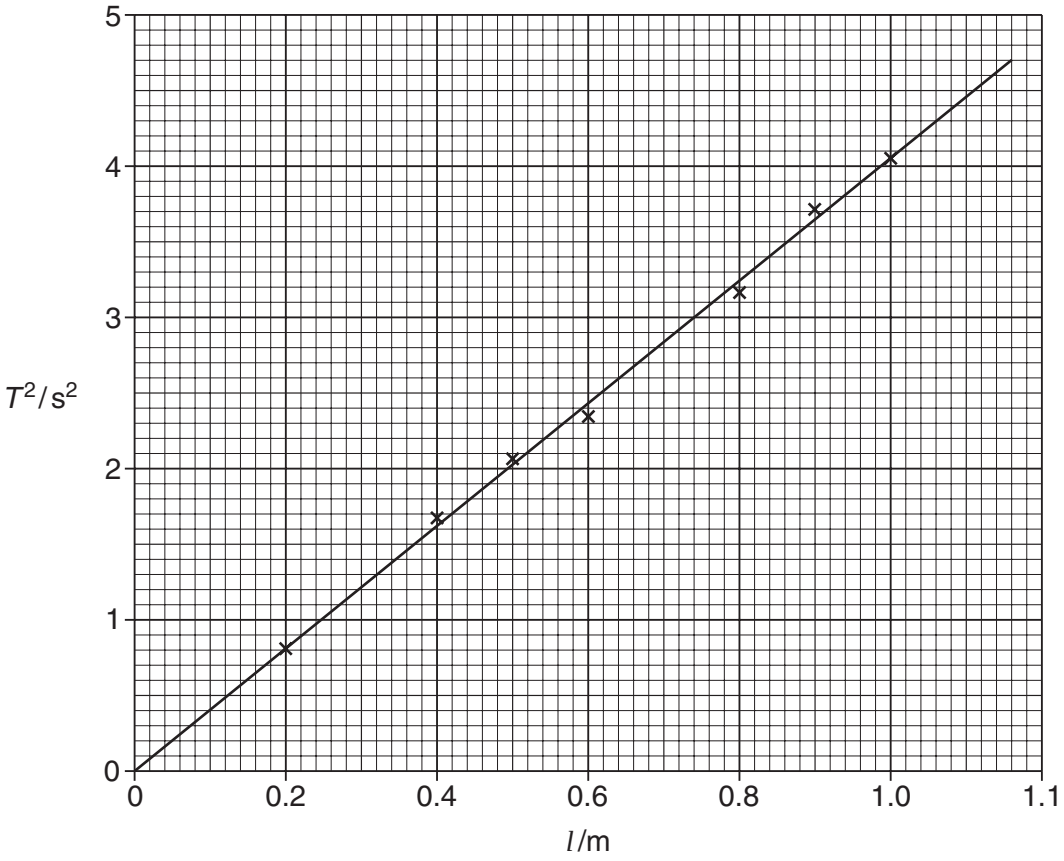
OSCILLATIONS-SIMPLE PENDULUM

1 An IGCSE student has carried out a timing experiment using a simple pendulum. She plotted a graph of T^2/s^2 against l/m. T is the time for one swing of the pendulum and l is the length of the pendulum. The graph is shown below.



(a) (i) Determine the gradient G of the graph. Show clearly on the graph how you obtained the necessary information.

G = ...

(ii) Calculate the acceleration g of free fall using the equation

$$g = \frac{4\pi^2}{G}.$$

g = ...m/s^2

(iii) The student could have calculated the acceleration of free fall g from just one set of readings. State the purpose of taking sufficient readings to plot a graph.

.....

..... [5]

(b) The student next studies the relationship between the mass *m* of the pendulum and the time for one swing *T*. The readings are shown in Table 5.1.

Table 5.1

***m*/g**	***T*/s**
50	1.58
100	1.60
150	1.61
200	1.57
250	1.59

(i) Suggest two variables that must be kept constant to make the experiment a fair test.

1. .....

2. .....

(ii) Study the readings in the table and complete the following sentence.

Within the limits of experimental accuracy, the readings show that the mass *m* of the pendulum ..... [3]

[Total: 8]

(a) (i) triangle method used
(whether or not shown on graph) [1]
Triangle using more than half line
and position indicated on graph [1]
Expect G = 4.00–4.35 (but allow correct working
from points read from beyond 1.0 on x axis) [1]
Expect g = 9.07–9.87 (ecf from G) [1]

(ii) greater accuracy/average value [1]

(b) (i) amplitude [1]
length [1]
(other possible correct responses shape/size of bob
and number of swings)

(ii) does not affect time [1]

[Total: 8]

2 The class is investigating the motion of a pendulum.

Fig. 4.1 shows the apparatus.

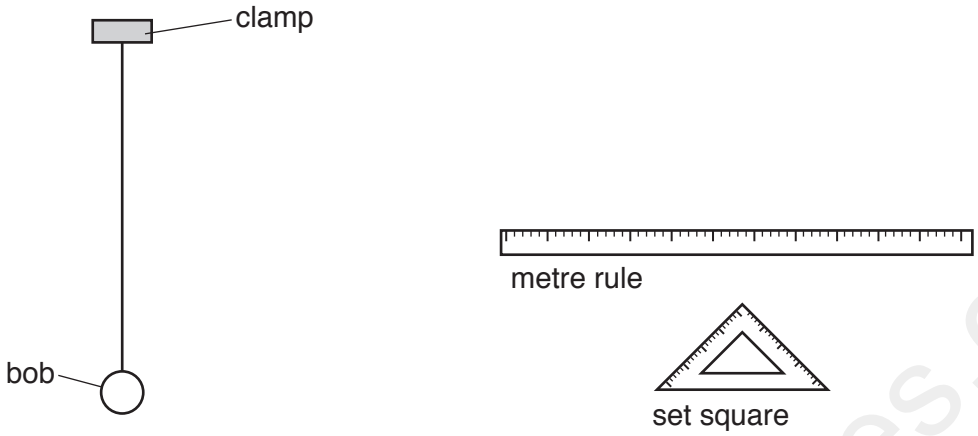


Fig. 4.1

(a) (i) On Fig. 4.1, show clearly the length l of the pendulum. [1]

(ii) Use Fig. 4.2 to explain how you would measure the length l accurately. You may draw on the diagram.

Fig. 4.2

.....

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.....

.....

.....[2]

(b) A student determines the period T of the pendulum. The period is the time taken for one complete oscillation. The student measures the time t for 20 oscillations.

Fig. 4.3 shows the time t.

Fig. 4.3

(i) Calculate the period T of the pendulum.

T = ...[1]

(ii) Explain how measuring the time for 20 oscillations rather than one oscillation helps the student to obtain a more reliable value for the period.

.....

.....

.....[2]

(c) The student wants to determine a value for the acceleration of free fall from his results. He needs the value of T^2 to do this.

Calculate T^2.

Give your answer to a suitable number of significant figures and include the unit.

T^2 = ... [2]

[Total: 8]

MARKING SCHEME:

1	(a)(i)	*l* shown clearly from bottom of clamp to centre of bob	**1**
	(a)(ii)	Any 2 from: Metre rule close to pendulum Measurement from bottom of clamp Set-square used as a horizontal reference	**2**
	(b)(i)	1.01(1)	**1**
	(b)(ii)	Any 2 from: Idea of averaging Reaction time / judgement of when to stop / start (owtte) Reduces effect of error / spreads error over 20 swings (owtte)	**2**
	(c)	1.02(212) with 2, 3 or 4 significant figures	**1**
		unit s^2	**1**
		Total:	**8**

3 A student is determining the acceleration of free fall g using a pendulum. Fig. 1.1 shows the pendulum. Fig. 1.2 shows one complete oscillation of the pendulum.

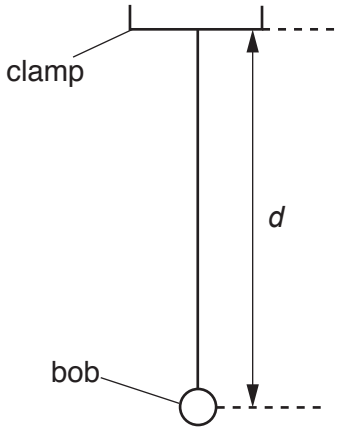

Fig. 1.1

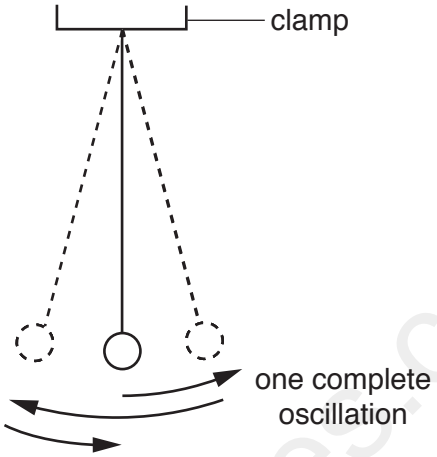

Fig. 1.2

(a) On Fig. 1.1, measure the distance d.

d = ... cm [1]

(b) Fig. 1.1 is drawn 1/10th actual size.

(i) Calculate the actual distance D from the bottom of the clamp to the centre of the bob.

D = ... cm [1]

The student displaces the bob slightly and releases it so that it swings. He measures the time t for 10 complete oscillations. The time t is shown on the stopwatch in Fig. 1.3.

Fig. 1.3

(ii) Write down the time t shown in Fig. 1.3.

t = ... [1]

(iii) Calculate the period T of the pendulum. The period is the time for one complete oscillation.

T = ... [1]

(iv) Calculate T^2.

T^2 = ... [1]

(v) Calculate the acceleration of free fall g using the equation $g = \frac{20}{T^2}$.

g = ... [1]

(c) The student adjusts the pendulum until the distance D measured to the centre of the bob is 100.0 cm.

He repeats the procedure and obtains another value of T^2.

T^2 = 3.94

(i) On the dotted line above, write the unit for T^2. [1]

(ii) Calculate the acceleration of free fall g using the equation $g = \frac{40}{T^2}$ and the value of T^2 from **(c)**. Give your answer to a suitable number of significant figures for this experiment.

g = ... [1]

(d) Another student states that repeating the experiment improves the reliability of the value obtained for g.

Suggest **two** changes that you would make to improve the reliability. The stopwatch cannot be changed.

1. .....

.....

2. .....

.....

[2]

(e) State **one** precaution that you would take in this experiment in order to obtain accurate readings.

.....

..... [1]

[Total: 11]

MARKING SCHEME:

2

(a)	d = 5(.0) (cm)	**1**
(b)(i)	D = 50 (cm)	**1**
(b)(ii)	t = 14.06	**1**
(b)(iii)	T = 1.406 (allow ecf from 1(b)(ii): t/10 (s))	**1**
(b)(iv)	T^2 = 1.98 or 1.99 (allow ecf from 1(b)(iii))	**1**
(b)(v)	g = 10.1 (allow ecf from 1(b)(iv))	**1**
(c)(i)	Unit s^2	**1**
(c)(ii)	g given to 2 or 3 significant figures	**1**
(d)	Use of additional d values **OR** use a larger d value	**1**
	Count more swings	**1**
(e)	Any **one** from: Perpendicular viewing of rule Counting beginning with zero (owtte) Use of fiducial mark (owtte) Use of set-square or horizontal rule to aid measurement of d Use rule close to/touching the bob Time taken from centre of swing, (not extremities) Measure length to top and bottom of bob and average Measure string length and add radius of bob measured with callipers or micrometer	**1**

4 A student uses a pendulum to determine a value for the acceleration of free fall

g. Figs. 1.1 and 1.2 show the apparatus.

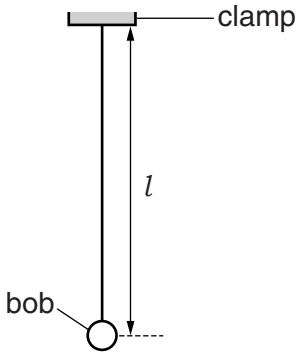

Fig. 1.1

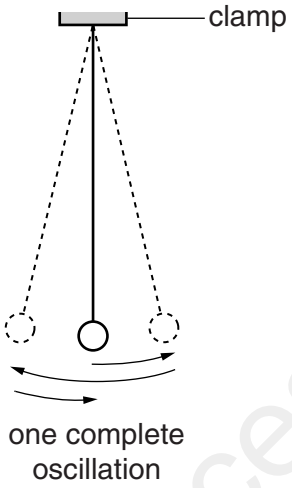

Fig. 1.2

(a) On Fig. 1.1, measure the length l of the pendulum.

l = ... cm [1]

(b) The student adjusts the pendulum until its length l = 50.0 cm. The length l is measured to the centre of the bob.

Explain briefly how the student avoids a parallax (line of sight) error when measuring length l.

.....

.....

.....[1]

(c) The student displaces the pendulum bob slightly and releases it so that it swings.

He measures the time t for 20 complete oscillations of the pendulum.

$t =$ 27.8 s

(i) Calculate the period T of the pendulum. The period is the time for one complete oscillation.

$T =$ .....[1]

(ii) Measuring the time for a large number of oscillations, rather than for one oscillation, gives a more accurate value for T.

Suggest one practical reason why measuring the time for 200 oscillations, rather than 20 oscillations, may **not** be suitable.

.....

.....[1]

(iii) Calculate T^2.

$T^2 =$ .....[1]

(iv) Calculate the acceleration of free fall g using the equation $g = \frac{4\pi^2 l}{T^2}$. Give your answer to a suitable number of significant figures for this experiment.

$g =$ ..... m/s^2 [2]

(d) The student checks the value of the acceleration of free fall g in a text book. The value in the book is $9.8\,m/s^2$.

(i) Suggest a practical reason why the result obtained from the experiment may be different.

.....

.....

.....[1]

(ii) Suggest **two** improvements to the experiment.

1. .....

.....

2. .....

.....

[2]

[Total: 10]

MARKING SCHEME:

3	(a)	l = 4.1 – 4.2 (cm)	**1**
	(b)	Either suitable use of a horizontal straight edge, explained briefly Or holding rule close to pendulum Or line of sight perpendicular (to rule)	**1**
	(c)(i)	T = 1.39 (s) OR 1.4	**1**
	(c)(ii)	Pendulum may stop OR student may lose count	**1**
	(c)(iii)	1.93 s^2 (ecf allowed)	**1**
	(c)(iv)	10.2(2) 2 or 3 significant figures	**1** **1**
	(d)(i)	Explanation of cause of inaccuracy in measurement of t or l. e.g. student did not react quickly enough when starting/stopping stopwatch OR difficulty in measuring accurately to centre of bob	**1**
	(d)(ii)	Any two from: Use different length(s) Repeat timing Use of a fiducial mark Increased number of oscillations Plot a graph using length and time or time^2	**2**
		Total:	**10**

5 **(a)** A student hangs a mass on a spring and observes it as it oscillates up and down.

The student wants to find the factors that affect the time taken for one complete oscillation. She finds that increasing the mass increases the time.

Suggest two other variables that the student could investigate.

1. .....

2. .....
[2]

(b) Another student is investigating the oscillations of the pendulum shown in Fig. 3.1.

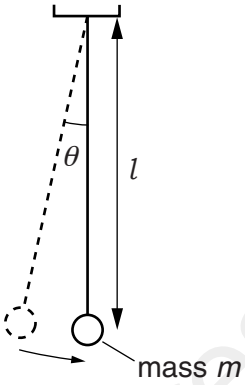

Fig. 3.1

The variables are

- the length l of the pendulum
- the mass m of the pendulum bob
- the amplitude θ of the swing.

The time taken for one complete oscillation is called the period T.

She carries out three experiments. Each experiment investigates the effect on the period T of changing one variable.

Her results are shown in Tables 3.1, 3.2 and 3.3.

Table 3.1

l/m	T/s
0.200	0.89
0.400	1.25
0.600	1.54
0.800	1.78
1.000	1.99

Table 3.2

m/g	T/s
50	1.40
60	1.42
70	1.39
80	1.41
90	1.38

Table 3.3

θ/°	T/s
4	2.00
6	1.98
8	2.06
10	2.02
12	1.97

(i) Study the results tables and use words from this list to complete the sentences.

increases

decreases

has no effect on

is proportional to

- An increase in length l ..... the period T.
- An increase in mass m ..... the period T.
- An increase in amplitude θ ..... the period T.

[3]

(ii) Suggest a precaution you would take in this pendulum experiment to obtain T values that are as reliable as possible.

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.....[1]

[Total: 6]

MARKING SCHEME:

4	(a)	any two from: length of spring / number of coils diameter / thickness of spring material / type / stiffness / elasticity / spring constant of spring how far spring is displaced / amplitude (of oscillations)	**2**
	(b)(i)	increases has no effect on has no effect on	**1** **1** **1**
	(b)(ii)	one from: repeats large number of oscillations and divide timing sensor / light gate use a fiducial mark (however expressed) counting down to zero (before starting the timer)	**1**
		Total:	**6**

6 A student is investigating whether the diameter of a pendulum bob affects the period of a pendulum. The period is the time taken for one complete oscillation of the pendulum. Fig. 3.1 shows a pendulum.

Fig. 3.2 shows one complete oscillation.

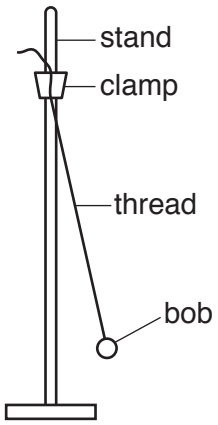

Fig. 3.1

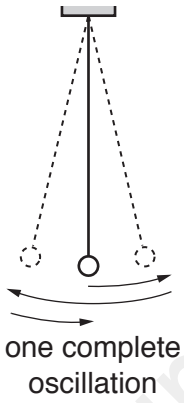

Fig. 3.2

The student has the following apparatus:

pendulum bobs made of polystyrene with diameters 1 cm, 2 cm, 3 cm, 4 cm and 5 cm
a supply of thread and a pair of scissors
clamp and stand.

Plan an experiment to investigate whether the diameter of a pendulum bob affects the period of a pendulum.

You should:

- list additional apparatus that you would require
- explain briefly how you would carry out the investigation
- state the key variables that you would control
- draw a table with column headings, to show how you would display your readings (You are **not** required to enter any readings in the table.)
- explain briefly how you would use your readings to reach a conclusion.

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.....[7]

[Total: 7]

MARKING SCHEME:

5	**MP1**	Stopwatch (or equivalent) AND (metre) rule / ruler	**1**
	MP2	Measure time for 5 (□) oscillations	**1**
	MP3	Divide by number of oscillations to find period (T)	**1**
	MP4	Repeat for each bob	**1**
	MP5	Variable; one from: Initial amplitude / starting position Length of pendulum / thread Number of oscillations	**1**
	MP6	Table with column headings for t, or period (T), or both AND d, with correct units	**1**
	MP7	Conclusion: Plot graph(s) of d against period (T) or t (or vice versa) OR compare period (T) or t values for different diameters	**1**