INVESTIGATING OSCILLATIONS OF A SIMPLE PENDULUM

1 A student investigates the oscillations of a pendulum.

The student sets up the pendulum in a clamp as shown in Fig. 5.1.

Fig. 5.1 is drawn one-fifth full size.

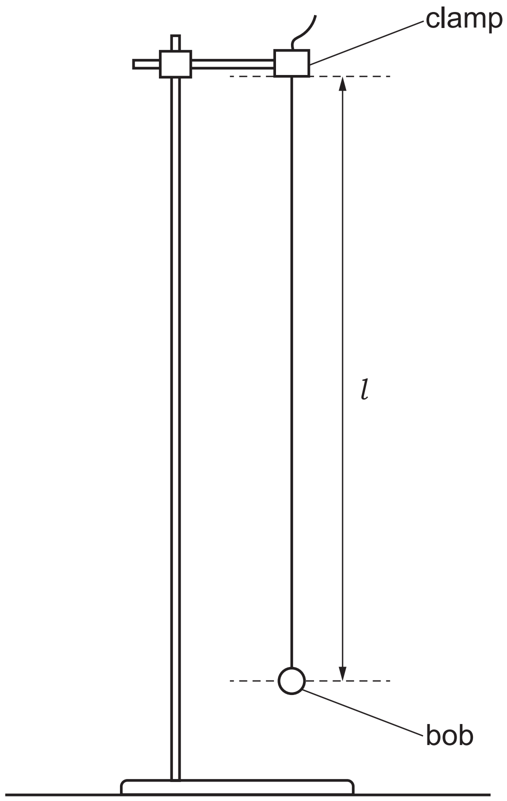


Fig. 5.1

The length l of the pendulum is the distance from the bottom of the clamp to the centre of the pendulum bob.

(a) **(i)** Measure the length l of the pendulum in centimetres to the nearest 0.1 centimetre.

l = ... cm [1]

(ii) Calculate the actual length L of the pendulum.

L = ... cm [1]

(b) Procedure

The student:

- gives the bob a small sideways displacement and releases it so that it swings to and fro
- measures the time for 20 complete oscillations
- repeats the timing for 20 oscillations two more times.

The student's results are shown.

25.4 s 25.6 s 25.3 s

(i) Calculate the average time t for 20 oscillations of the pendulum.

Give your answer to **three** significant figures.

t = ... s [2]

(ii) Calculate the time T for **one** complete oscillation of the pendulum.

Use the equation shown.

$$T = \frac{t}{20}$$

T = ... s [1]

(iii) Calculate T^2.

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

(c) (i) The length L in centimetres of a pendulum which has a time T for one oscillation is calculated using the equation shown.

$$L = 25.0T^2$$

Use this equation and your value of T^2 from **(b)(iii)** to calculate a value for L.

L = ... cm [1]

(ii) Two values are considered to be equal within the limits of experimental error if they are within 10% of each other.

Compare your value of *L* from part **(a)(ii)** with the calculated value of *L* from **(c)(i)**.

State if your values agree within the limits of experimental error.

Justify your answer with reference to your values.

....

.... [1]

(d) Procedure

The student:

- adjusts the string until the length *L* of the pendulum is double the length of *L* in **(a)(ii)**
- repeats **(b)(i)** and **(b)(ii)**.

The student's results are shown.

t = ...35.9............... s

T = ...1.80............... s

The student states that the time *T* for one oscillation of a pendulum is proportional to the length of the pendulum.

Compare the values of *T* in **(b)(ii)** and **(d)** to state if you agree with the student.

Give a reason for your answer.

statement ....

reason ....

....
[1]

(e) The student holds the rule close to the pendulum to measure its length.

Explain why this gives a more accurate value for the length of the pendulum.

....

.... [1]

[Total: 10]

MARKSCHEME:

(a)(i)	8.<u>0</u> ;	**1**
(a)(ii)	40(.0) / (a)(i) × 5 ;	**1**
(b)(i)	25.4333; 3 sf ;	**2**
(b)(ii)	1.27(s) ;	**1**
(b)(iii)	1.61 ;	**1**
(c)(i)	40.25 ;	**1**
(c)(ii)	10% of 40 is 4 / 10% of 40.3 is 4.03 **and** yes within 10% ;	**1**
(d)	disagree <u>and</u> doubling / does not double *T* ;	**1**
(e)	to avoid parallax / line-of-sight errors ;	**1**

OSCILLATIONS OF SIMPLE PENDULUM

2 A student investigates the oscillations of a simple pendulum.

The student sets up a pendulum as shown in Fig. 4.1.

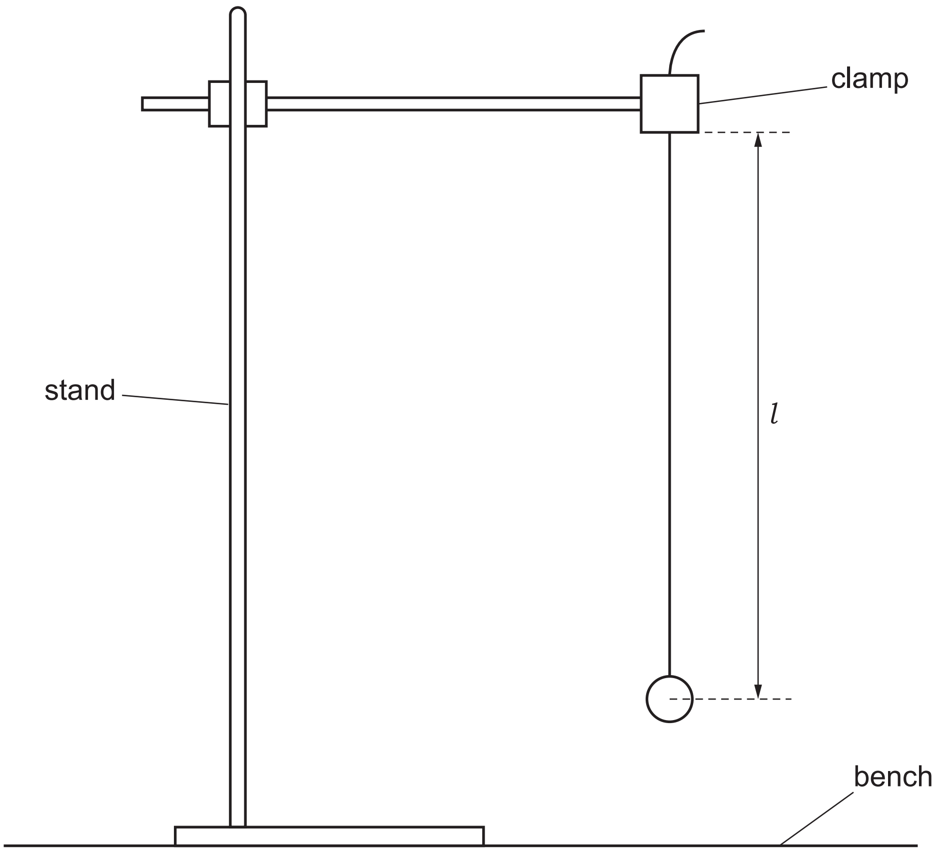


Fig. 4.1

The length l of the pendulum is the distance from the point of support to the centre of the pendulum bob.

(a) **(i)** Measure the length l of the pendulum in Fig. 4.1 to the nearest 0.1 cm.

l = ... cm [1]

(ii) Fig. 4.1 is drawn to a scale of **one-tenth** full size.

Record in Table 4.1 the actual length *L* of the pendulum.

Table 4.1

L / cm	time for 20 oscillations / s	period *T* / s
	34.8	1.7
60.0	31.0	1.6
50.0		
40.0	25.4	1.3
30.0	22.1	1.1
20.0	18.2	0.9

[1]

(iii) Describe **one** practical technique needed to measure *L* as accurately as possible.

....

.... [1]

(b) Procedure

(i) The student:

- gives the bob a small sideways displacement
- releases the bob so that it oscillates
- measures the time taken for 20 oscillations
- records the time in Table 4.1.

The student repeats this procedure for lengths *L* = 60.0 cm, 50.0 cm, 40.0 cm, 30.0 cm and 20.0 cm.

The reading on the stop-watch when *L* = 50.0 cm is shown in Fig. 4.2.

Fig. 4.2

Record in Table 4.1 the reading on the stop-watch to **one** decimal place. [1]

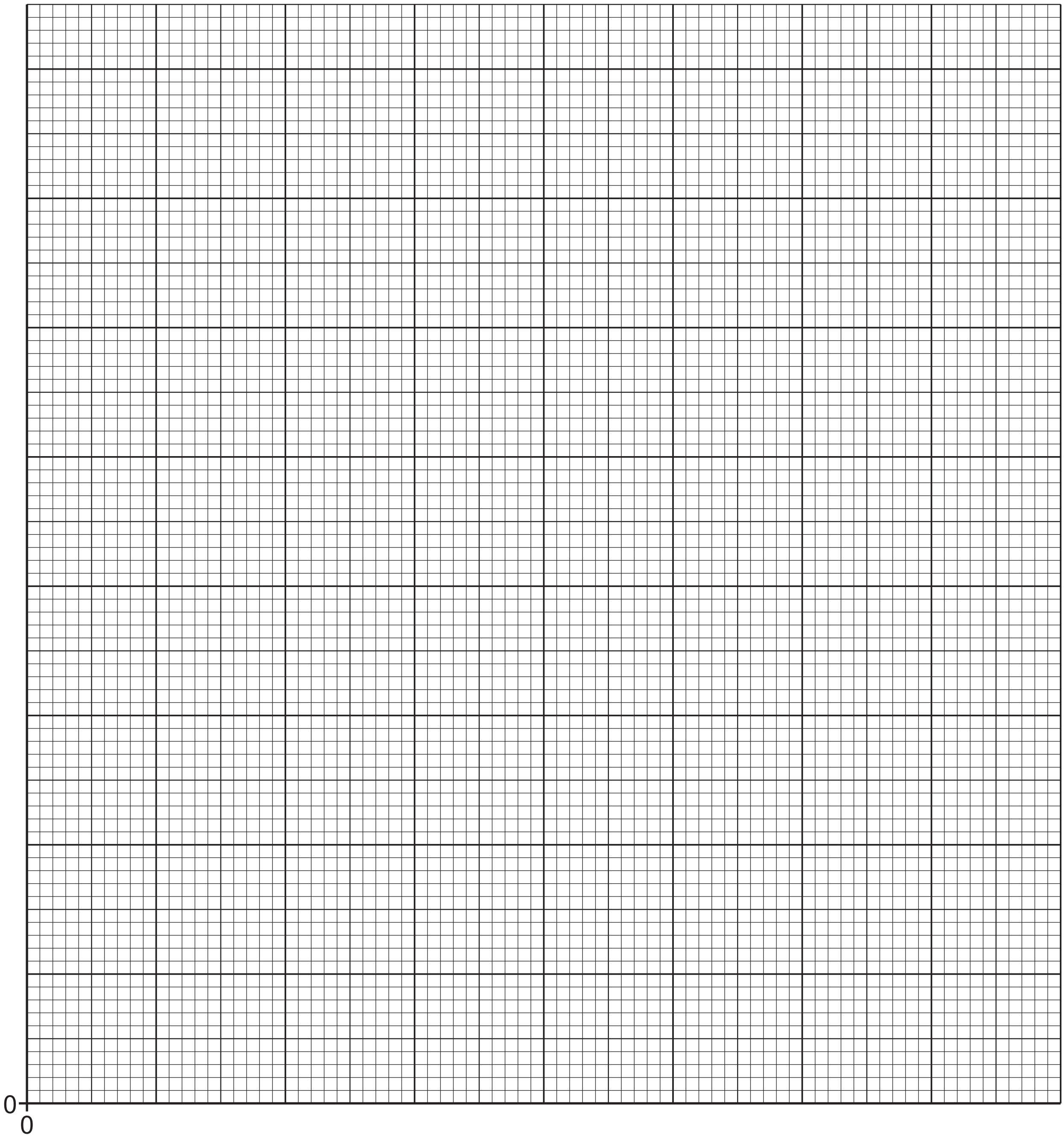
(ii) Calculate the period T of the pendulum when L = 50.0 cm.

The period is the time for **one** oscillation.

Record your answer in Table 4.1. [1]

(c) **(i)** On the grid, plot a graph of T (vertical axis) against L.

Start both axes of your graph from the origin (0, 0).



[3]

(ii) Draw the best-fit curve. [1]

(d) Use your graph to:

(i) determine the length L of the pendulum that has a period of 1.0 s.

L = ... cm [1]

(ii) describe what happens to the period T of a pendulum as its length L increases.

.... [1]

(e) State whether your graph shows that the period T of a pendulum is proportional to its length L.

Explain your answer.

....

.... [1]

[Total: 12]

MARKSCHEME:

(a)(i)	*l* = 7.5 (cm) ;	**1**
(a)(ii)	*L* = 75.0 ;	**1**
(a)(iii)	take reading / perpendicular to scale / rule close to pendulum / use of fiducial aid / use of set-square to ensure that rule is vertical ;	**1**
(b)(i)	*t* = 28.4 (s) ;	**1**
(b)(ii)	*T* = 1.4 (s) ;	**1**
(c)(i)	axes labelled, quantity and unit ; linear scales and plotted points ⩾ ½ the grid used ; points plotted correctly to ± ½ small square ;	**3**
(c)(ii)	good best-fit curve ;	**1**
(d)(i)	*L* read from graph correctly to ± ½ small square ;	**1**
(d)(ii)	as *L* increases *T* increases ;	**1**
(e)	NO **and** graph not a straight line through origin / doubling / doesn't double *T* (or equivalent) / ratio *T* / *L* is not constant ;	**1**

PLANNING EXPERIMENT; PERIOD OF A PENDULUM

3 Fig. 6.1 shows a pendulum.

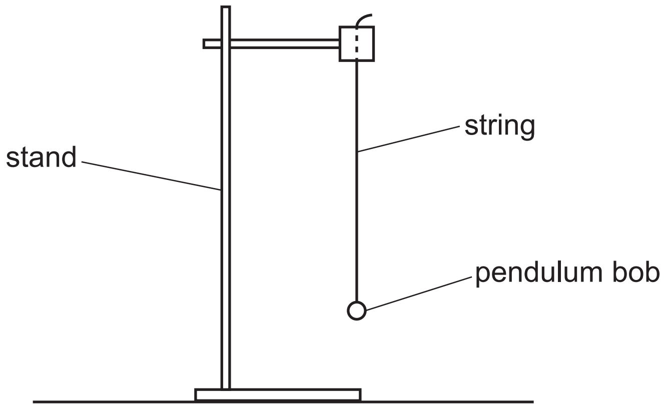


Fig. 6.1

The period of a pendulum is the time taken for one complete oscillation (swing) of the pendulum.

Fig. 6.2 shows one complete oscillation.

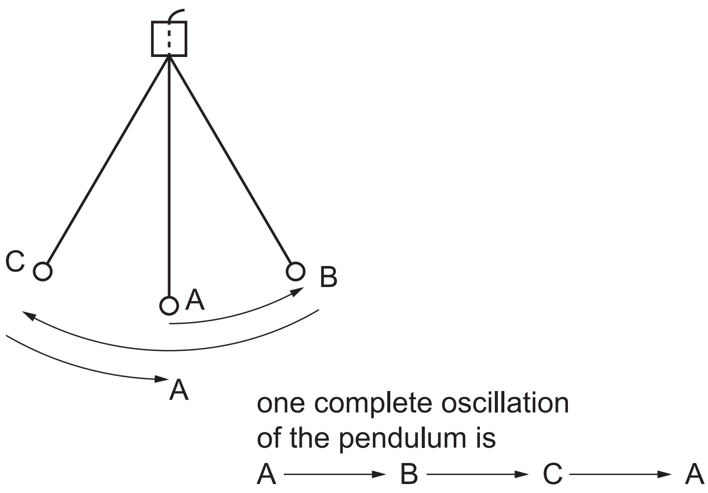


Fig. 6.2

Plan an experiment to investigate how the period of a pendulum depends upon the mass of its bob.

The apparatus available is listed. You are **not** required to do this investigation.

- boss, clamp and stand
- pendulum bobs of different masses
- a ball of string
- a pair of scissors

Include in your answer:

- any other apparatus you will need
- a brief method, including how you will ensure your results are as accurate as possible
- the variables you will control
- how you will process and use your results (you are not required to enter any readings in the table)
- how you use your results to reach a conclusion.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

.... [7]

MARKSCHEME:

One mark from each section and any two others. **additional apparatus:** • stop-watch ; **method:** • attach bob to string (attach to clamp) and allow to oscillate ; • measure time for (a number of) oscillation(s) ; • repeat with different masses of bob ; • uses 5 different masses ; • repeat each mass ; **table:** • columns for mass / *m* and time taken / *t* ; • with units ; **key variables:** • length of string/pendulum ; • number of oscillations ; • same starting position (amplitude) ; **conclusion:** • plot graph of *m* against *t ;* • or use results in table to see if/how *t* changes when *m* changes ;	**7**

SIMPLE PENDULUM-ACCELERATION DUE TO GRAVITY

4 A student determines the acceleration due to gravity g by measuring the period of a pendulum.

The period of a pendulum is the time for one complete to and fro swing (oscillation).

(a) The student:

- sets up the pendulum with its point of support a fixed distance D above the bench as shown in Fig. 6.1
- does **not** adjust this distance, or the position of the clamp.

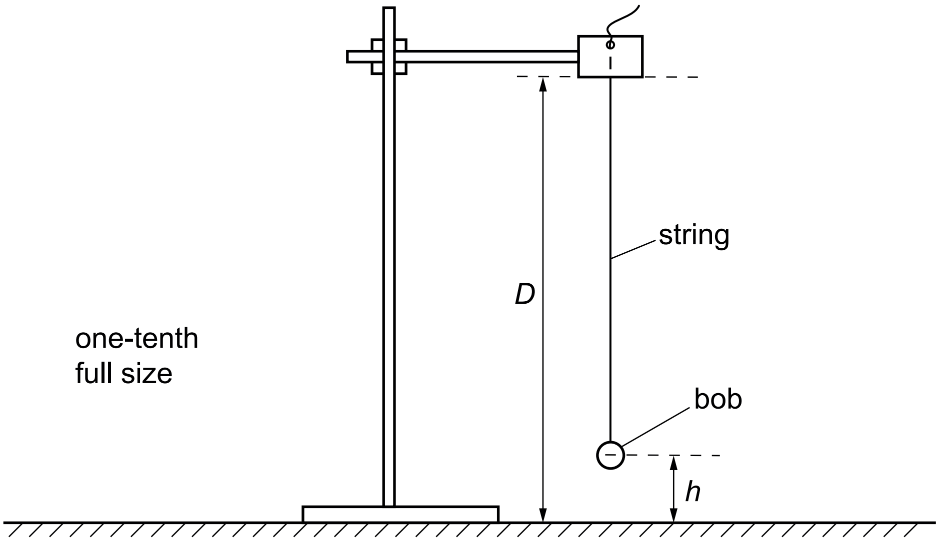


Fig. 6.1

Fig. 6.1 is drawn to a scale of one-tenth full size.

(i) On Fig. 6.1 measure the distance D, the height of the point of support of the pendulum above the bench, in centimetres to the nearest millimetre.

D = ... cm [1]

(ii) Calculate the actual distance d of the point of support of the pendulum above the bench in centimetres.

d = ... cm [1]

(b) The student:

- adjusts the length of the pendulum until the height *h* of the centre of the bob above the bench is 10.0 cm. Distance *D* is **not** changed.
- gives the bob a small sideways displacement and releases it
- measures the time taken for 20 oscillations of the pendulum.

The reading on the stop-watch is shown in Fig. 6.2.

Fig. 6.2

Read and record in Table 6.1 the time taken in seconds for 20 oscillations of the pendulum. [1]

Table 6.1

***h* / cm**	**time for 20 oscillations / s**	**period *T* / s**	**T^2 / s^2**
10.0			
20.0	25.4	1.27	1.6
25.0	23.8	1.19	1.4
30.0	20.2	1.10	1.2
40.0	18.0	0.90	0.81

(c) The student:

- repeats the procedure in **(b)** for heights *h* of 20.0 cm, 25.0 cm, 30.0 cm and 40.0 cm
- records the times for 20 oscillations in Table 6.1.

State how the student could check that the measured values of the time for 20 oscillations of the pendulum are reliable.

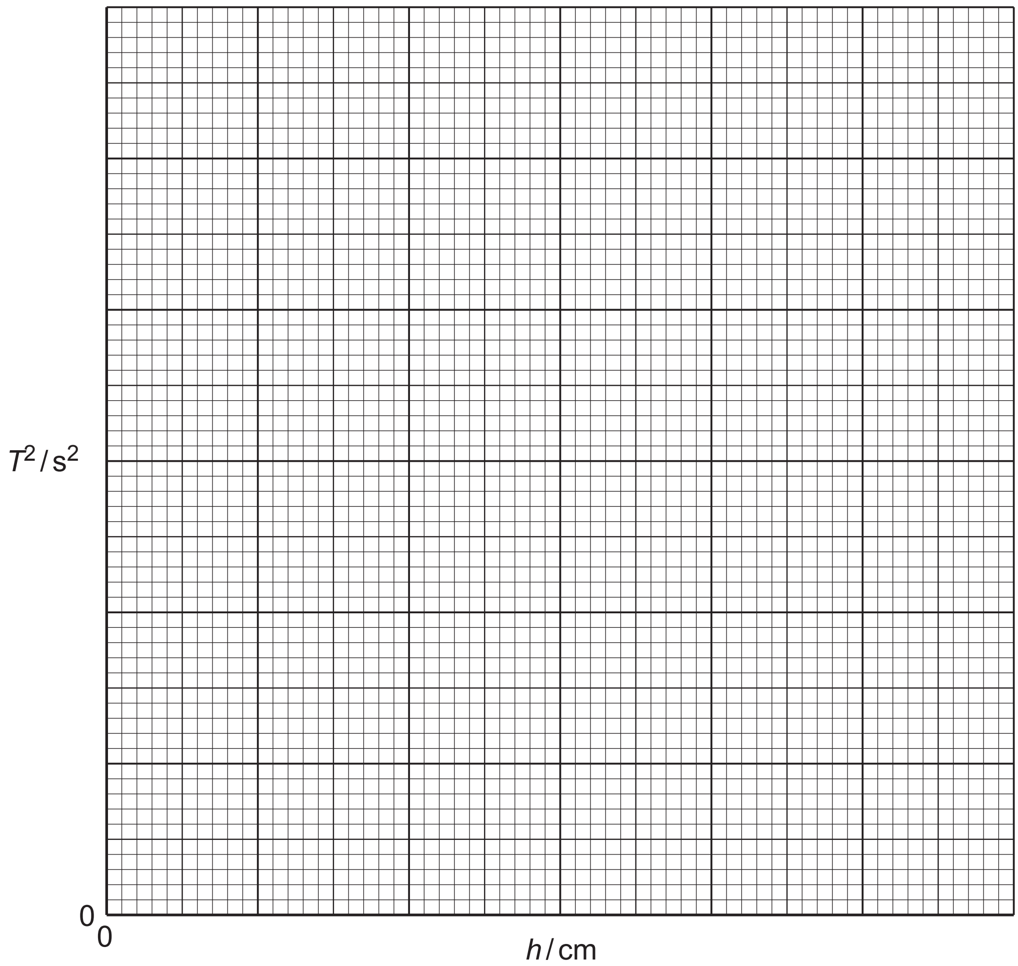
.... [1]

(d) **(i)** Use the result in **(b)** to calculate the period *T* of the pendulum for *h* = 10.0 cm. The period is the time for **one** complete oscillation.

Record your value in Table 6.1. [1]

(ii) Calculate the value of T^2 for *h* = 10.0 cm and enter your value in Table 6.1 to 1 decimal place. [1]

(e) **(i)** On the grid provided, plot a graph of T^2 (vertical axis) against h. [2]



(ii) Draw the best-fit straight line. [1]

(f) Calculate the gradient of your line.

Indicate on your graph the values you chose to enable the gradient to be calculated.
Show all your working

gradient = ... [2]

(g) Calculate the value of the acceleration due to gravity g.
Use the equation shown.

$$g = \frac{0.395}{\text{gradient}}$$

g = ... m/s^2 [1]

[Total: 12]

MARKSCHEME:

(a)(i)	5.9 ;	**1**
(a)(ii)	59 ;	**1**
(b)	28.4 ;	**1**
(c)	repeat (the measurement) ;	**1**
(d)(i)	1.42 ;	**1**
(d)(ii)	2.0 ;	**1**
(e)(i)	suitable scales, point plotted cover ≥ ½ the grid used ; 5 points plotted correctly to ± ½ small square ;	**2**
(e)(ii)	good judgement best-fit line ;	**1**
(f)	indication on graph of how data were obtained **and** ≥ ½ the line used ; 0.04 ± 0.01 ;	**2**
(g)	9.875 ;	**1**