1 A student carries out an experiment using a simple pendulum.

Fig. 4.1 shows the apparatus.

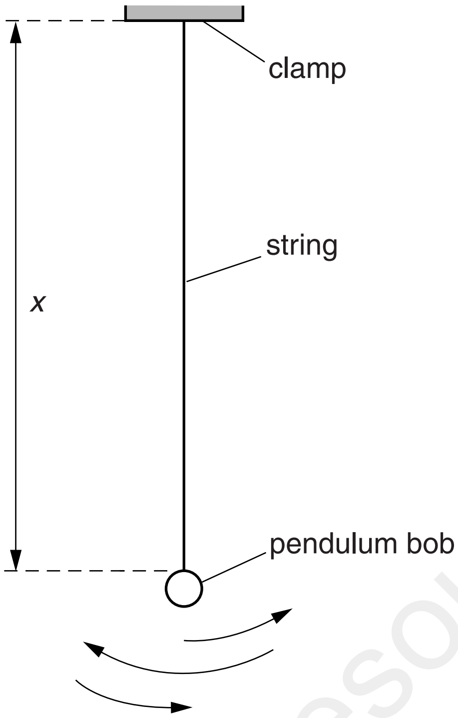


Fig. 4.1

The student records the time *t* taken for 20 complete oscillations of the pendulum for a range of different lengths *x* of the string. The readings are shown in Table 4.1.

Table 4.1

x/cm	*t*/s	*T*/s
90.0	38.5	
80.0	36.0	
70.0	33.4	
60.0	31.4	
50.0	28.2	
40.0	25.5	

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

For each set of readings in the table, calculate the period *T* and enter the results in the table. [2]

(b) Suggest a reason for measuring the time for twenty oscillations rather than just one.

....

....

....[1]

(c) In this experiment, the length *x* of the string is measured with a metre rule.

Suggest one precaution that you would take when measuring the length in order to obtain an accurate reading.

....

....[1]

(d) The student decides that a more useful result is possible if the length is measured to the centre of mass of the pendulum bob.

The pendulum bob is a small metal ball. The student has a 30 cm ruler and two rectangular blocks of wood that are about 10 cm long.

Suggest how the student can use this equipment to measure accurately the diameter of the pendulum bob. You may draw a diagram.

....

....

....[2]

[Total: 6]

(a) 1.925, 1.800, 1.670, 1.570, 1.410, 1.275 (2 or more sig. figs.) [1]
all *T* values consistently to 2 or 3 significant figures [1]

(b) any one from:
gives a more accurate <u>value of *T*</u>
gives an average value (of *T*)
reduces (effect of) human reaction error
reaction time less significant
T too small / oscillations are too quick / bob swings too fast [1]

(c) avoidance of parallax error <u>explained</u> [1]

(d) blocks arranged parallel either side of bob and touching bob [1]
rule correctly placed, touching the blocks and spanning the gap [1]

[Total: 6]

2 The IGCSE class is investigating the oscillation of a pendulum.

The apparatus is set up as shown in Fig. 2.1.

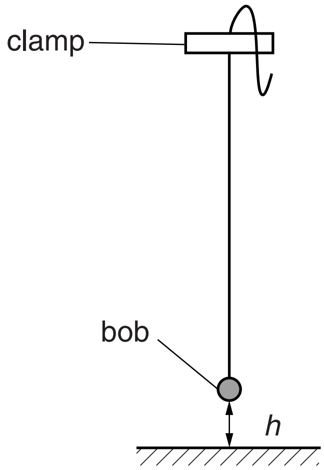


Fig. 2.1

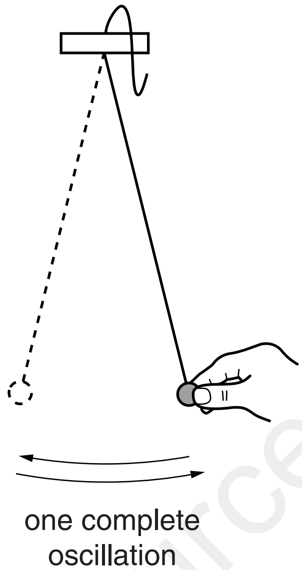


Fig. 2.2

The height *h* of the pendulum bob above the bench is measured and recorded.

This is repeated, to obtain a total of five different values of *h*, by shortening the string of the pendulum but without changing the height of the clamp.

For each value of *h*, the pendulum bob is pulled to one side by a small distance, as shown in Fig. 2.2.

The pendulum is then released and the time *t* for 10 complete oscillations is measured and recorded.

(a) Describe a precaution which the IGCSE students might have taken in order to measure *h* as accurately as possible. You may draw a diagram.

....

....

....[1]

(b) Figs. 2.3 to 2.7 are scale diagrams showing the height *h* of the pendulum bob above the bench for each of the five experiments.

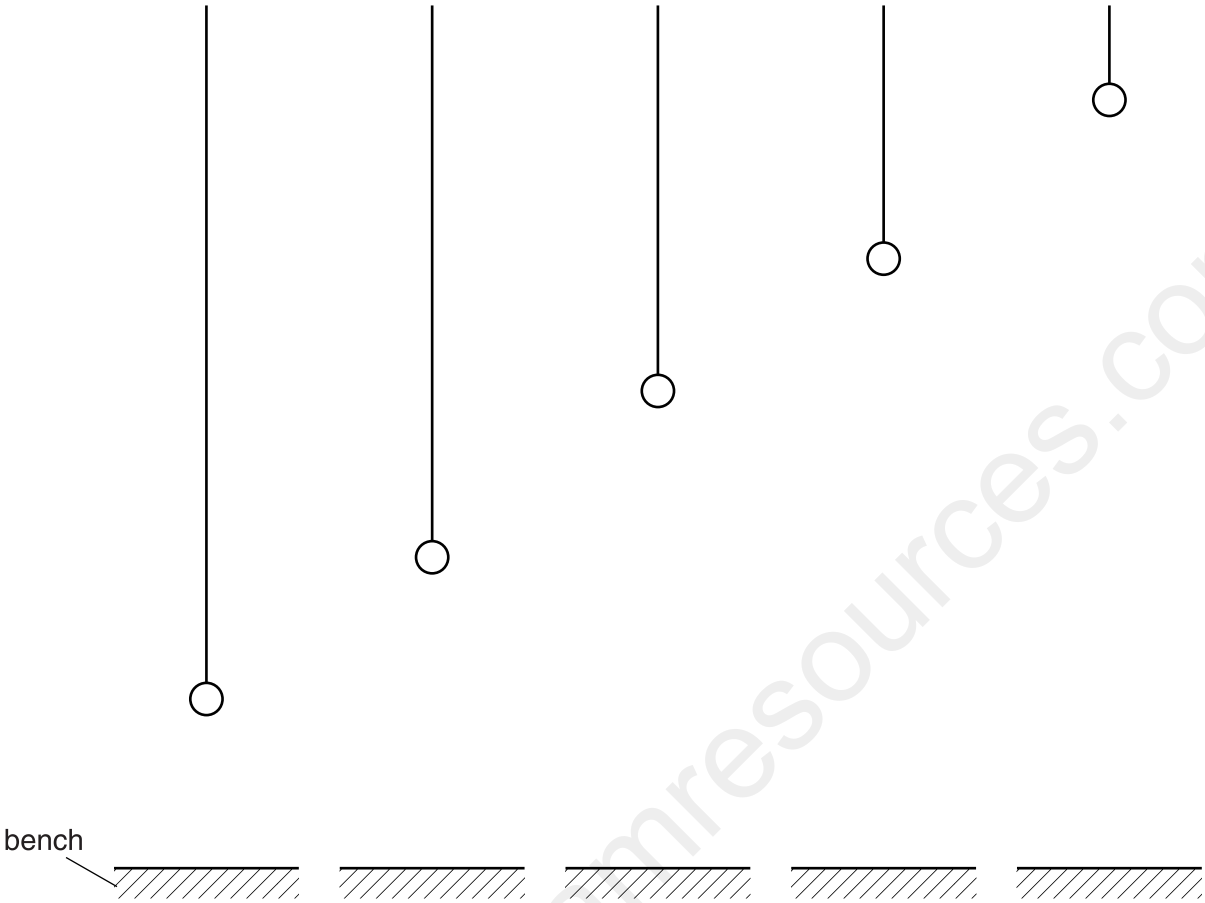


Fig. 2.3 **Fig. 2.4** **Fig. 2.5** **Fig. 2.6** **Fig. 2.7**

(i) Measure, and record in Table 2.1, the height *h* in each experiment.

(ii) The diagrams are drawn to 1/5 scale.

Calculate, and record in Table 2.1, the actual heights *H* of the pendulum bob above the bench. [2]

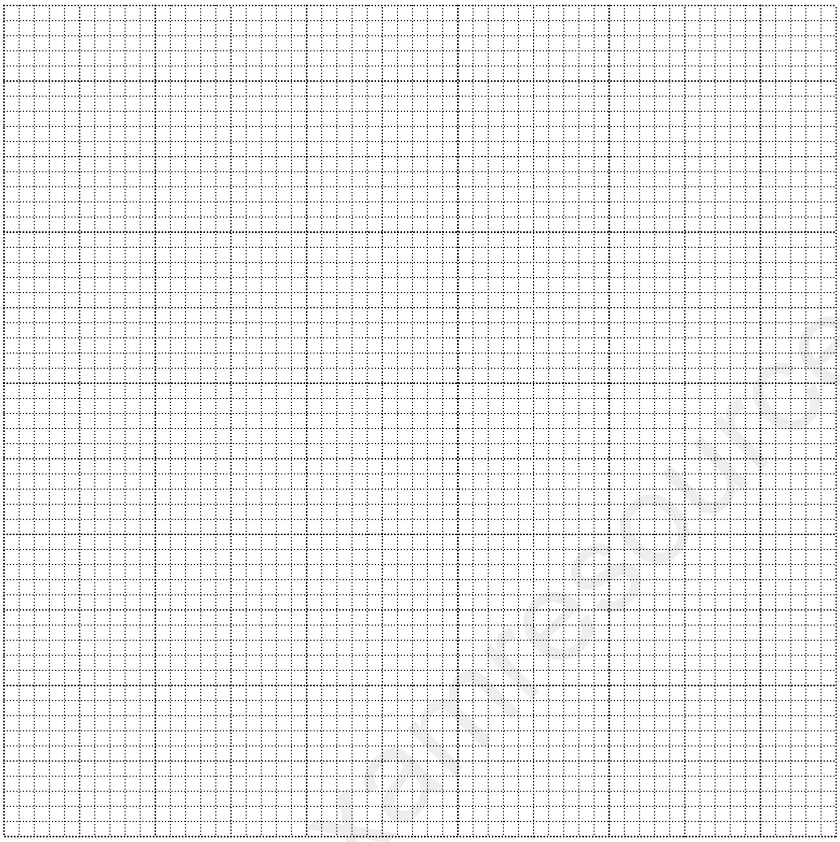
Table 2.1

	h/cm	*H*/cm	*t*/s	*T*/s	T^2/s^2
Fig. 2.3			14.01		
Fig. 2.4			12.39		
Fig. 2.5			10.85		
Fig. 2.6			8.93		
Fig. 2.7			6.30		

(c) (i) For each value of height h, calculate the time T for one complete oscillation, using the equation $T = \frac{t}{10}$. Record these values in Table 2.1.

(ii) Calculate the values of T^2 and record these in the table. [1]

(d) Plot a graph of T^2/s^2 (y-axis) against H/cm (x-axis).



[4]

(e) Determine the gradient G of the graph.

Show clearly on the graph how you obtained the necessary information.

G = ...
[1]

(f) One of the students wishes to carry out the experiment again to obtain results which are more reliable.

Describe one change she might make to the method to achieve this.

....

....

....[1]

[Total: 10]

(a) appropriate precaution (can be written or diagram):
e.g. take reading with eye line perpendicular to rule / use set square to ensure rule vertical [1]

(b) *h* recorded, increasing and with consistent 2 or 3 sig. figs. [1]
H = 10.0, 19.5, 30.5, 39.0, 49.5 [1]

(c) *T* seen and T^2 = 1.96, 1.54, 1.18, 0.80, 0.40 [1]

(d) axes labelled with appropriate scales [1]
plots correct [1]
well judged line [1]
thin neat line, fine plots [1]

(e) *G* recorded to 2 or 3 sig. figs. (expect range (–)0.032 to (–)0.047)
and triangle method seen on graph, using at least half of line [1]

(f) appropriate change which improves reliability:
e.g. repeat readings for each length (and take average) / greater no. of oscillations [1]

[Total: 10]

3 The class is investigating the oscillations of a pendulum.

Figs. 5.1 and 5.2 show the apparatus.

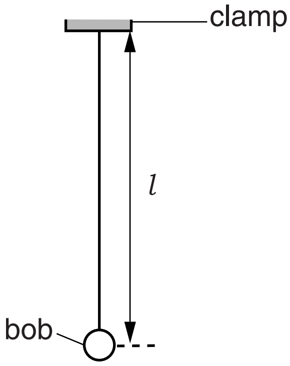


Fig. 5.1

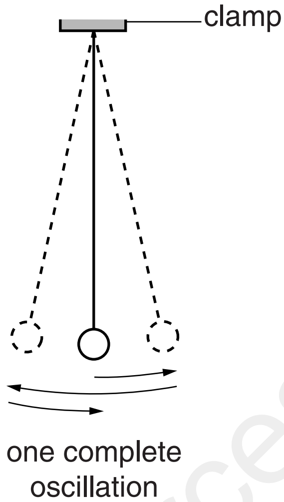


Fig. 5.2

A student measures the length l of the pendulum and takes readings of the time t for 20 complete oscillations. She calculates the period T of the pendulum. T is the time taken for one complete oscillation. She repeats the procedure for a range of lengths.

She plots a graph of T^2/s^2 against l/m. Fig. 5.3 shows the graph.

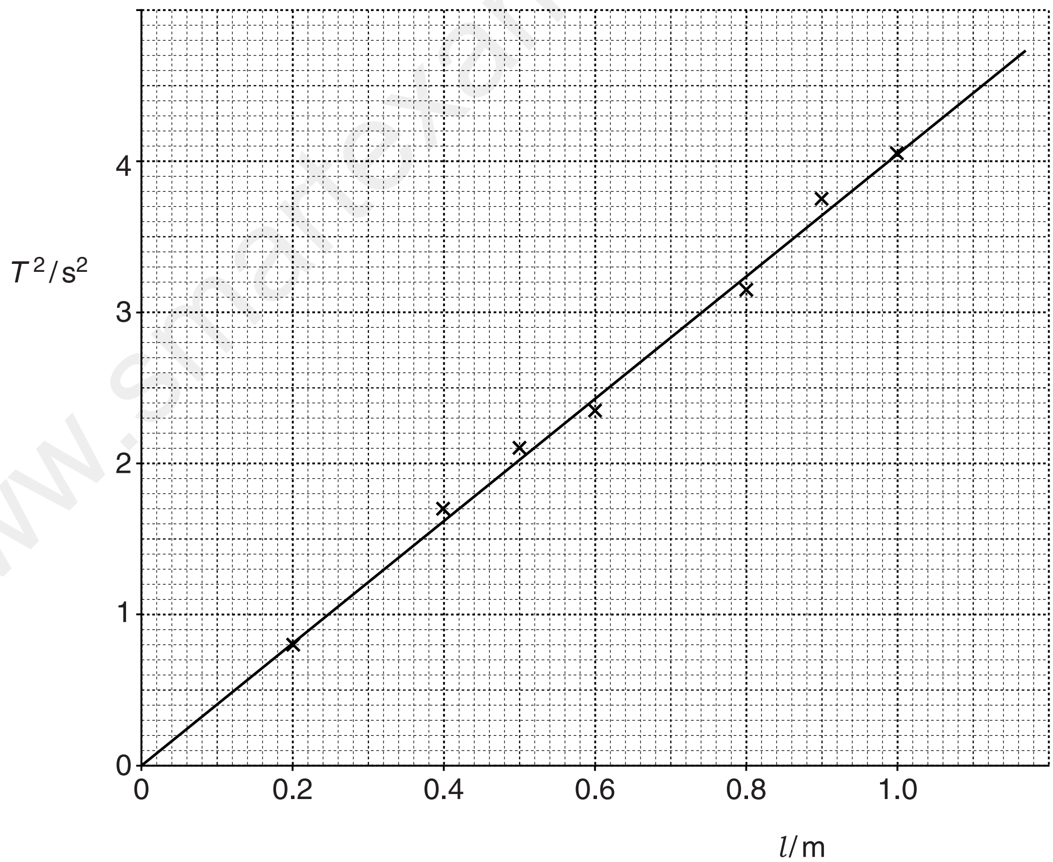


Fig. 5.3

(a) Using the graph, determine the length l of a pendulum that has a period T = 2.0 s. Show clearly on the graph how you obtained the necessary information.

l = ...[3]

(b) Explain why measuring the time for 20 swings, rather than for 1 swing, gives a more accurate value for T.

....

....[1]

(c) Another student investigates the effect that changing the mass m of the pendulum bob has on the period T of the pendulum.

(i) Suggest how many different masses the student should use for this laboratory experiment.

number of different masses = ...

(ii) Suggest a range of suitable values for the masses.

suitable range of masses = ...
[2]

[Total: 6]

(a) use of $T^2 = 4\,s^2$ [1]

correct method shown clearly on graph [1]

l = 0.99 (m) cao OR ecf 0.49 if $T^2 = 2\,s^2$ used [1]

(b) reduce (percentage) uncertainty OR reduce (the effect of) error due to starting/stopping [1]

(c) **(i)** 5 – 10 [1]

(ii) minimum not less than 10 g; maximum not more than 1000 g; maximum must be at least double the minimum [1]

[Total: 6]

4 The class is investigating a pendulum.

Figs. 1.1 and 1.2 show the pendulum.

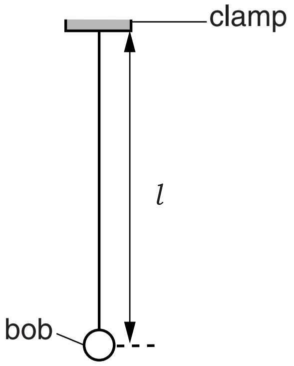


Fig. 1.1

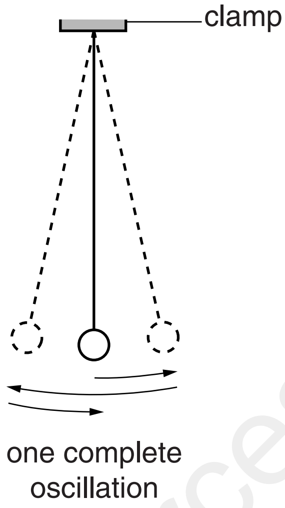


Fig. 1.2

(a) A student adjusts the pendulum until its length $l = 50.0\,\text{cm}$.

State one precaution that you would take to measure the length l as accurately as possible. You may draw a diagram.

....

....[1]

(b) The student displaces the pendulum bob slightly and releases it so that it swings. She measures the time t for 20 complete oscillations of the pendulum (see Fig. 1.2).

(i) Record the time t, in s, shown on the stopwatch in Fig. 1.3.

Fig. 1.3

t = ... s [1]

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

T = ...[1]

(iii) Explain why measuring the time for 20 oscillations, rather than 1 oscillation, gives a more accurate value for T.

....

....[1]

(c) The student adjusts the length of the pendulum until its length l = 100.0 cm. She repeats the procedure and obtains a value for the period T.

T = ...2.06 s..........................

Another student suggests that doubling the length l of the pendulum should double the period T.

State whether the results support this suggestion. Justify your answer by reference to the results.

statement ....

justification ....

....
[2]

(d) To continue the investigation of the relationship between the length l of the pendulum and the period T, it is necessary to use a range of values of length l.

List additional l values that you would plan to use in the laboratory.

....[2]

[Total: 8]

(a) any one from:

- reference to how to determine the centre of the bob
- measure to top of bob then add on half diameter measured with blocks and rule or callipers
- measure to top and bottom of bob and average
- reference to perpendicular viewing (reducing parallax)
- rule parallel with/close to string/appropriate use of set-square [1]

(b) **(i)** t = 28.4(0) NOT 28:4 [1]

(ii) T = 1.42 (s) allow ecf from **(i)** [1]

(iii) reduce effect of errors in starting/stopping stopwatch [1]

(c) statement to match results (expect no) [1]

justification using results, including idea of difference is beyond limits of experimental uncertainty owtte [1]

(d) minimum of three more values [1]

all values ≥ 20 cm and ≤ 300 cm, and three values are at least 10 cm apart [1]

[Total: 8]

5 A student carries out an experiment using a simple pendulum. Fig. 3.1 shows the apparatus.

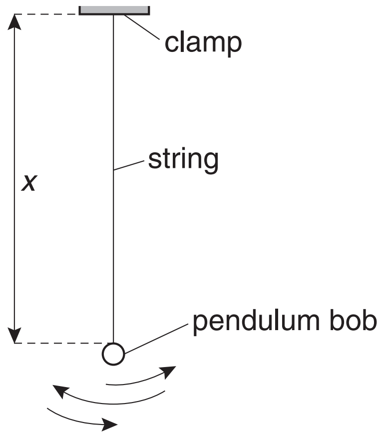


Fig. 3.1

The student records the time t taken for 20 complete oscillations for a range of different lengths x of the string. The readings are shown in the table.

x/cm	l/cm	t/s	T/s
90.0		38.5	
80.0		36.0	
70.0		33.4	
60.0		31.4	
50.0		28.2	
40.0		25.5	

The length l of the pendulum is given by the equation $l = x + r$, where r is the radius of the pendulum bob.

Fig. 3.2 shows the pendulum bob drawn actual size.

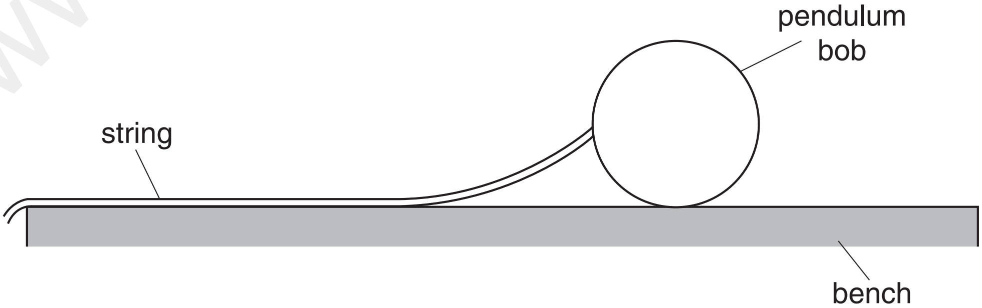


Fig. 3.2

(a) **(i)** Use your rule to measure the diameter *d* of the pendulum bob.

d = ...

(ii) Calculate the radius *r* of the pendulum bob.

r = ...

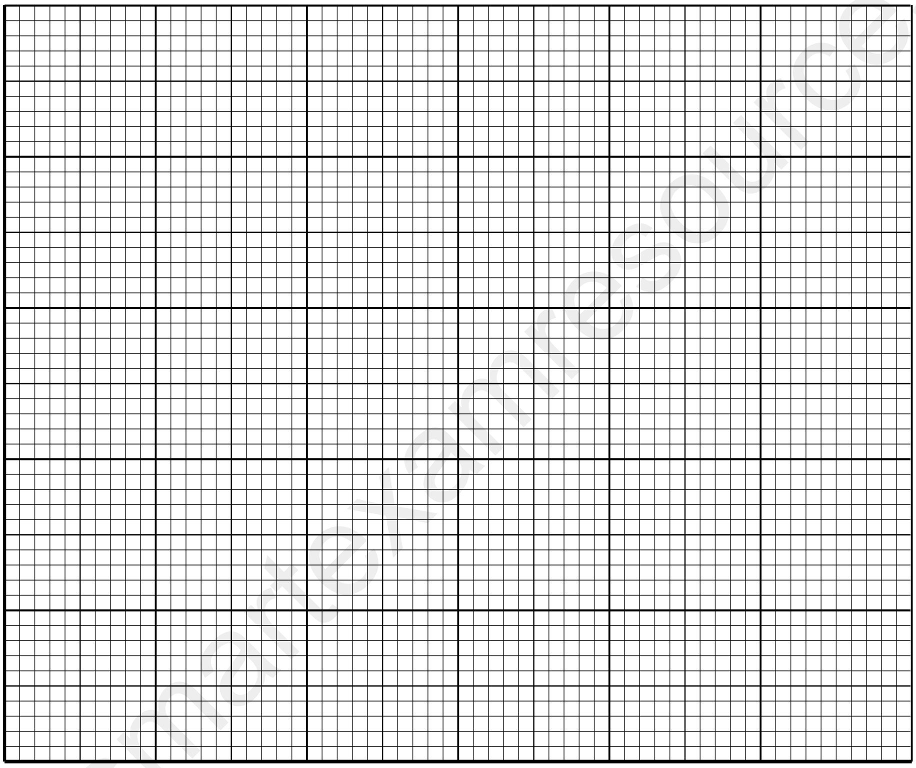
[2]

(b) **(i)** Complete the column for the length l/cm in the table using the equation $l = x + r$.

(ii) The period *T* is the time taken for one complete oscillation. Complete the column for the period *T*/s in the table.

[3]

(c) Plot the graph of *T*/s (*y*-axis) against l/cm (*x*-axis). Start the *T*/s axis at *T* = 1.0 s.



[5]

(d) Using the graph, find the length l_a of the pendulum that would have a period of 1.50 s.

l_a = ... cm [1]

(a) (i) 2.15 – 2.25	1
(ii) 1.1 (+ both with correct unit, cm/mm) ecf	1
(b) (i) all correct 1 values, 91.1, 81.1, 71.1, etc	1
(ii) all correct T values, 1.93, 1.80, 1.67, 1.57, 1.41, 1.28	1
3/4sf for T	1
(c) Graph:	
scales suitable T start at 1.0s, T: 10sq : 0.2s	
1: 10sq : 20cm; both labelled	
and correct way round	1
plots correct to ½ sq (-1 each error)	2
line judgement	1
line thickness	1
(d) 58 cm	1
	TOTAL 11