



**Record of  $L$ ,  $t_1$ ,  $t_2$ ,  $\langle t \rangle$ ,  $T$  and  $T^2$  (total 4 marks)**

- Neat table drawn with the headings and units ( $L/cm$ ,  $t_1/s$ ,  $t_2/s$ ,  $\langle t \rangle/s$ ,  $T/s$  and  $T^2/s^2$ ) [1]
- At least 6 sets of evenly spread readings of  $L$  taken with  $L$  between 30 and 100 cm (inclusive of 100 cm) with minimum range of 50 cm. [1]
- $L$  tabulated to 1 d.p in cm / 3 d.p in m;  $t_1$ ,  $t_2$ ,  $\langle t \rangle$  in 1 or 2 d.p in s [1]
- $T$  and  $T^2$  calculated correctly and tabulated to correct s.f. [1]

**Graph (total 4 marks)**

- **S:** Suitable scales used. [1]
- **P:** All points correctly plotted (give allowance of 1 error). [1]
- **L:** Best fitted line passing through the origin. [1]
- **A:** Axes correct ( $T^2$  on y-axis and  $L$  on x-axis); axes correctly labelled (with or without units) from origin with values labelled at regular intervals on both axes. [1]

**Conclusion**

$T^2$  is directly proportional to  $L$ . [1]

**Questions**

1 From your graph, what is the length of the pendulum which will give a period ( $T$ ) of 1.5 s?

Values read off the length  $L$  from the graph when  $T^2 = 1.5^2 = 2.25 \text{ s}^2$ . [1]  
 $L \approx 0.57 \pm 0.1$

2 State and explain **two** possible sources of error in this experiment.

- There could be human judgment error in judging when the pendulum has completed exactly one complete oscillation [1].
  - This may cause error in recording the period of oscillation [1]
- The thread used for the pendulum is elastic OR can be stretched. [1]
  - This may affect the accuracy of the length of pendulum measured. [1]

**Not acceptable!**

- Air currents in the laboratory may affect the oscillation of the pendulum. This may affect the accuracy of the timings measured.
  - **Expected to ensure no air currents (switched off fan, closed windows)!**
- The pendulum swing may not be steady or occur in an elliptical path. This may affect the accuracy of the timings measured.
  - **Expected to use only steady oscillations in a vertical plane!**
- **Blame a faulty/imperfect instrument/equipment**

3 State and explain **two** other precautions you took in this experiment to reduce the errors mentioned above.

- The pendulum bob was allowed to swing freely for several oscillations before starting to take readings [1]
- This ensured that the oscillation was regular OR this ensured the oscillations occurred steadily in a vertical plane, allowing more precise measurements of the period [1]
- The length of the pendulum was measured after suspending it from the split cork [1]
- This is to take into account any changes in length due to the extension of the string under tension. [1]

**Not acceptable!**

- The fans were switched off during the experiment. [1]
- This allowed the pendulum to oscillate steadily, allowing more precise measurements of the period [1]
  - **Expected procedure for proper experiment.**
- The retort stand was positioned behind the pendulum swing when viewed from the front. [1]
- This served as a reference line to count the number of swings accurately.
  - **This is already mentioned in the procedure. Otherwise, it would be acceptable.**
- *Repeat measurements & take average – This is part of standard procedure to reduce random errors.*

4 Given that  $T = 2\pi\sqrt{\frac{L}{g}}$ , explain how you can determine the gravitational acceleration  $g$  from your results.

Rearrange the equation to obtain  $T^2 = \frac{4\pi^2 L}{g}$  of the form  $Y = mX + c$

From the graph of  $T^2$  against  $L$  plotted, gradient of the graph  $m = \frac{4\pi^2}{g}$ . [1]

Hence, the gravitational acceleration  $g = \frac{4\pi^2}{\text{gradient}}$  [1]

**Extension:** Get students to determine the gradient and calculate  $g$ .