Measuring g with a Simple Pendulum

J. Okafor Physics 121, Section B

August 27, 2026

1 Objective

To determine the local acceleration due to gravity, g, by measuring the period of oscillation of a simple pendulum at several lengths and fitting the small-angle relation

$$T = 2\pi\sqrt{\frac{L}{g}}.$$

2 Method

A steel bob (mass 50 g) was suspended from a fixed clamp by a length of inextensible string. For each of six string lengths L, the bob was displaced through a small angle ($< 10^\circ$, so the small-angle approximation holds) and released from rest. The time for 20 complete oscillations was measured with a stopwatch and divided by 20 to give the period T, reducing the relative timing error from a single human reaction time by a factor of 20. Each length was measured three times and averaged.

Apparatus note: string length L was measured from the point of suspension to the centre of the bob, not to the top of the bob, since the pendulum's effective length is measured to its centre of mass.

3 Results

Table 1: Period vs. pendulum length

L (m)	T (s, mean of 3)	T^2 (s^2)
0.20	0.90	0.81
0.40	1.27	1.61
0.60	1.55	2.40
0.80	1.80	3.24
1.00	2.01	4.04
1.20	2.20	4.84

Table 1 shows a clear linear relationship between L and T^2, consistent with the small-angle model. A linear least-squares fit of T^2 against L gives a slope of $m = 4.037\,\mathrm{s^2\,m^{-1}}$. Since $T^2 = \frac{4\pi^2}{g}L$, the slope is $4\pi^2/g$, so

$$\boxed{g = \frac{4\pi^2}{m} = \frac{4\pi^2}{4.037} = 9.78\,\mathrm{m\,s^{-2}}}$$

4 Uncertainty analysis

The dominant source of uncertainty is the stopwatch reaction time, estimated at ± 0.2 s per start/stop. Dividing by 20 oscillations gives a period uncertainty of ± 0.01 s per measurement. Propagating this through the linear fit gives a slope uncertainty of $\pm 0.06\,\mathrm{s^2\,m^{-1}}$, and hence

$$\delta g = g \cdot \frac{\delta m}{m} = 9.78 \times \frac{0.06}{4.037} \approx 0.15\,\mathrm{m\,s^{-2}}.$$

The length measurement (a metre rule, ± 1 mm) contributes negligibly by comparison at the lengths used here.

5 Discussion

The measured value $g = 9.78(15)\,\mathrm{m\,s^{-2}}$ agrees with the standard value $9.81\,\mathrm{m\,s^{-2}}$ to within one standard uncertainty. The small systematic undershoot is consistent with air resistance and small residual amplitude effects, both of which slightly lengthen the measured period relative to the ideal small-angle prediction and would bias the fitted g downward, exactly the direction of the observed discrepancy.

6 Conclusion

The simple-pendulum method gives a result for g consistent with the accepted value, and the linear T^2-vs-L relationship predicted by the small-angle approximation is well supported by the data across the full range of lengths tested.