

Free fall acceleration from a V-shaped pendulum

Name: _____ Class: _____ Date: _____

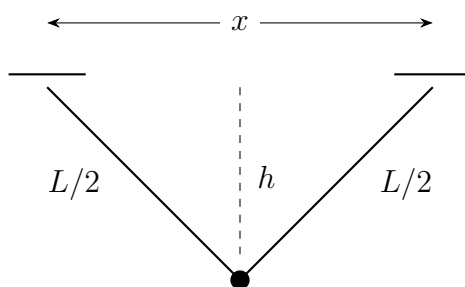
Aim Plan a linearised experiment to estimate g . Allow 70–90 minutes.

Model A bob is fixed at the midpoint of a string of total effective length L , whose ends are fixed at equal height, separation x . Swing it perpendicular to the plane of the V through a small angle. With vertical drop h , $T = 2\pi\sqrt{h/g}$ and $h^2 = (L^2 - x^2)/4$. Hence

$$T^4 = \frac{4\pi^4 L^2}{g^2} - \frac{4\pi^4}{g^2} x^2.$$

Both equal arms have length $L/2$, measured from support to the bob's centre.

Apparatus Two weighted stands with clamps, secure bob and fixed-length string, stopwatch, metre rule and set square; protractor if needed.



small swing perpendicular
to the plane of this page

Safety Weight the stands, secure the bob and keep its path clear. Do not make the arms almost horizontal: tension increases sharply. Stop if a support shifts, a string slips or the bob hits anything.

1 Plan and obtain approval

Describe how to fix equal arms, measure effective L , keep supports at equal height and vary x without changing arm lengths. Choose at least six well-spread safe separations $0 < x < L$. Explain your small-amplitude and repeat timing method.

Predict the sign of the graph gradient. State which quantities you will hold constant and how you will test that the intended swing is stable.

Teacher method/safety check: _____ Date: _____.

2 Record and process

$L =$ _____ m $\Delta L =$ _____ m Length resolution: _____.

Time 10 complete cycles in the same direction. Reset and repeat. $T = \bar{t}/10$.

x/m	t_1/s	t_2/s	$\bar{t}/\text{s}$	T/s

x^2/m^2	T^4/s^4	$\Delta(T^4)/\text{s}^4$

Uncertainty Estimate ΔT from repeat spread and timing limits. Use $\Delta(T^4)/T^4 \simeq 4\Delta T/T$ and $\Delta(x^2) \simeq 2x\Delta x$.

Validity check Record evidence that the bob swung perpendicular to the support plane and that L did not change.

3 Graph

Plot T^4 against x^2 . Include uncertainty bars, the best-fit straight line and an extreme acceptable line. A negative gradient and positive intercept are expected.



Choose scales and label both axes with quantities and units. Mark a large gradient triangle on the best-fit line where appropriate.

4 Analyse and evaluate

1. Find gradient s and intercept b , with units. Calculate $g = \sqrt{-4\pi^4/s}$. Show substitutions and quote a justified precision.

2. Estimate Δs and use $\Delta g/g \simeq \frac{1}{2}\Delta s/|s|$. Compare with 9.81 m s^{-2} . Judge agreement using your uncertainty, not a fixed percentage rule.

3. Use $L_{\text{graph}} = \sqrt{-b/s}$ as a second geometry check. Compare it with measured L . Explain why slope and intercept estimates are linked rather than independent measurements.

4. Identify two limitations and matched improvements. Consider finite bob size, unequal arms, knot slipping, mixed swing directions and timing. Plan an alternative graph using measured h and T^2 , including its gradient and controls.

Before you leave Return the apparatus, clear the bench and submit your recorded data.