

Simple harmonic motion and the physical pendulum

AP Physics C (Mechanics and E&M, calculus-based) · Lab answers

Model answers use the sample data in the table. Your measurements will differ a little, but the graph of T^2d against d^2 should be a straight line with gradient close to $4.0 \text{ s}^2/\text{m}$. State the uncertainty in g and compare your value of k^2 with $L^2/12$.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 7

Question 1 Check the table

$d = 0.30 \text{ m}$: $T = 15.3 / 10 = 1.53 \text{ s}$ and $T^2d = 1.53^2 \times 0.30 = 0.702 \text{ s}^2 \text{ m}$. $d = 0.45 \text{ m}$: $T = 1.60 \text{ s}$ and $T^2d = 2.56 \times 0.45 = 1.152 \text{ s}^2 \text{ m}$. Both match the table: **0.702 and 1.152 s² m**.

Question 2 Straight-line graph

$T^2 = 4\pi^2(k^2 + d^2)/(g d)$, so $T^2d = (4\pi^2/g) d^2 + (4\pi^2/g)k^2$. The gradient is **$4\pi^2/g$** and the intercept is **$4\pi^2k^2/g$** .

Question 3 Find g

Gradient = $(1.152 - 0.376) / (0.2025 - 0.0100) = 0.776 / 0.1925 = 4.03 \text{ s}^2/\text{m}$. So $g = 4\pi^2 / 4.03 = \mathbf{9.8 \text{ m/s}^2}$.

Question 4 Radius of gyration

Intercept = $0.376 - 4.03 \times 0.0100 = 0.336 \text{ s}^2 \text{ m}$. Then $k^2 = \text{intercept} / \text{gradient} = 0.336 / 4.03 = 0.0834 \text{ m}^2$. The theory value is $1.00^2 / 12 = 0.0833 \text{ m}^2$, so they agree to **0.1 %**.

Question 5 Timing uncertainty

Timing 10 swings gives $\Delta T = 0.2 / 10 = 0.02 \text{ s}$. The percentage is $0.02 / 1.58 = \mathbf{1.3 \%}$.
Timing many swings reduces the percentage uncertainty.

Question 6 Shape of the data

Near the centre the restoring torque mgd is small, so T is large. Far from the centre, $I = M(k^2 + d^2)$ grows faster than mgd , so T rises again. The minimum lies at $d = k = \mathbf{0.289 \text{ m}}$.

Question 7 Amplitude check

The derivation uses $\sin\theta \approx \theta$. For amplitude θ_0 the period grows by about $\theta_0^2/16$, so at 40° (0.70 rad) it is **about 3 % longer**, which would bias the value of g .