

Moment of inertia by integration and torque

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

Model answers based on the sample data. A best-fit line through the five points gives a gradient close to $4.0 \text{ s}^2/\text{m}$ and an intercept near $0.34 \text{ s}^2\cdot\text{m}$. Your own data may vary slightly, but g should come out within a few per cent of 9.8 m/s^2 .

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 5

Question 1 Period equation

$I = Mk^2 + Md^2$, and for small swings $T = 2\pi\sqrt{I/(Mgd)}$. Squaring gives $T^2 = 4\pi^2(k^2 + d^2)/(gd)$, so **$T^2d = (4\pi^2/g)(k^2 + d^2)$** .

Question 2 Plot the graph

The points lie on a straight line. Gradient $\approx (1.152 - 0.376)/(0.2025 - 0.0100) = \mathbf{4.0 \text{ s}^2/\text{m}}$ and intercept $\approx 0.34 \text{ s}^2\cdot\text{m}$.

Question 3 Find g

Gradient $= 4\pi^2/g$, so $g = 39.48/4.03 = \mathbf{9.8 \text{ m/s}^2}$.

Question 4 Radius of gyration

Intercept/gradient $= k^2 = 0.34/4.03 = 0.084 \text{ m}^2$, so $k = \mathbf{0.29 \text{ m}}$. For a rod, $L/\sqrt{12} = 1.00/3.464 = 0.289 \text{ m}$, which agrees.

Question 5 Why small angles

The equation uses $\sin \theta \approx \theta$, so the torque is proportional to the angle and the motion is simple harmonic. At large angles **the period depends on amplitude**.

Question 6 Uncertainty

Percentage uncertainty $= 0.2/31.5 = 0.6 \%$, the same as in T , because dividing by 20 is exact. The uncertainty in T^2d is about **1.3 %**.

Question 7 Evaluation

The rule may twist or the pivot may rub; amplitude may be above 10° . Using a smoother pivot and timing 30 oscillations reduces both. **Smoother pivot, longer timing.**