

Angular momentum and rolling motion

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

Model answers use the sample data in the results table. Your own values will differ slightly, but the ratio of the accelerations should stay close to 4/3, and your β values should be near 0.5 and 1. Always state the uncertainty with the final result.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:M Unit 6

Question 1 Mean time and spread

Solid rod: $(1.76 + 1.73 + 1.78 + 1.75 + 1.74) / 5 = 1.752$ s. Range 1.73–1.78 s, so half-range 0.025 s. The mean time is **1.75 ± 0.03 s**.

Question 2 Acceleration

Solid: $a = 2.00 / 1.752^2 = 0.652$ m/s². Tube: $a = 2.00 / 2.028^2 = 0.486$ m/s². The time uncertainty is $0.025/1.752 = 1.4$ %, and $a \propto t^{-2}$, so the uncertainty in a is **2.9 %**.

Question 3 Experimental shape factor

$\beta = g \sin \theta / a - 1$. Solid: $0.981 / 0.652 - 1 = 0.505$, so $\beta = \mathbf{0.51}$. Tube: $0.981 / 0.486 - 1 = 1.02$, so $\beta = \mathbf{1.02}$.

Question 4 Compare with theory

Theory gives 1/2 for a solid cylinder and about 1 for a thin-walled tube. The measured 0.51 and 1.02 agree with theory to **within about 2 %**, well inside the uncertainty.

Question 5 Ratio of accelerations

Measured: $0.652 / 0.486 = 1.34$. Theory: $(1 + 1) / (1 + 0.5) = 1.33$. The agreement is **within 1 %**.

Question 6 Effect of mass

Mass cancels in $a = g \sin \theta / (1 + \beta)$, so the time would be **unchanged**, provided the shape stays the same.

Question 7 Improving the lab

Use light gates or video analysis to time more accurately, and use a longer, steeper ramp so the times are larger compared with human reaction time. **Both reduce the percentage**

error in t.