

Angular momentum and rolling motion

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

Name: _____ Date: _____ Class: _____

A solid cylinder and a hollow tube are released together on a ramp. Which one wins, and by how much? This lab measures the rolling acceleration of both and turns it into a measurement of the moment-of-inertia factor β , testing the energy argument from the lesson with simple equipment.

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

Aim

To measure the acceleration of a solid cylinder and of a hollow tube rolling down the same ramp, and to use it to find the shape factor β in $I = \beta mR^2$.

Equipment

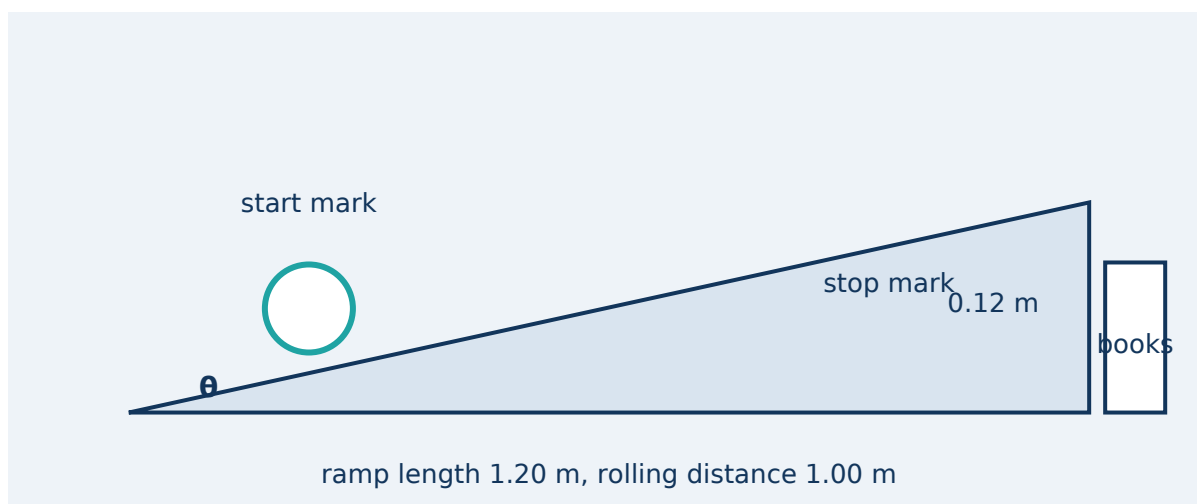
- A smooth wooden board 1.20 m long
- A solid aluminium rod and a thin-walled aluminium tube of the same outer diameter
- Books to raise one end, a metre rule, masking tape for marks
- A stopwatch or phone timer

Safety

Safety

Stand the ramp on a non-slip surface and keep feet clear of the bottom end. Place a cushion or box at the end to stop the rollers, and do not release them towards other people.

Method



Set-up: ramp 1.20 m long raised 0.12 m; the roller travels 1.00 m between two marks.

1. Raise one end of the board by 0.12 m using books and measure the board length to find $\sin\theta = 0.12 / 1.20 = 0.100$.
2. Mark a start line and a stop line 1.00 m apart along the board.
3. Release the solid rod from rest at the start line without pushing it and time it to the stop line.
4. Repeat five times, then do the same with the hollow tube.
5. Calculate the mean time for each and use $a = 2s / t^2$ with $s = 1.00$ m.

Results

Sample measurements for a ramp with $\sin\theta = 0.100$:

Trial	Solid aluminium rod: t (s)	Hollow tube: t (s)
1	1.76	2.03
2	1.73	2.00
3	1.78	2.05
4	1.75	2.02
5	1.74	2.04
Mean	1.752	2.028

Analysis questions

Question 1 Mean time and spread

Check the means in the table. State the range of the solid-rod times and the uncertainty in its mean time.

Question 2 Acceleration

Calculate the acceleration of each roller from $a = 2s / t^2$ and the percentage uncertainty in

the solid rod's value.

Question 3 Experimental shape factor

Use $a = g \sin\theta / (1 + \beta)$ to find β for each roller.

Question 4 Compare with theory

State the theoretical β for each roller and compare your values.

Question 5 Ratio of accelerations

Calculate $a_{\text{solid}} / a_{\text{tube}}$ and compare with the theoretical ratio.

Question 6 Effect of mass

Explain whether the rod would reach the bottom sooner if its mass were doubled.

Question 7 Improving the lab

Suggest two improvements that would reduce the uncertainty.