

Straight-line motion with graphs and equations

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How can you prove that a ball rolling down a ramp has a constant acceleration, and measure it with a stopwatch and a ruler? In this lab you time the ball over five distances, convert the times to t^2 , and use a straight-line graph of distance against t^2 to find the acceleration and its uncertainty.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 1

Aim

To measure the constant acceleration of a ball rolling from rest down a ramp, and to show that the displacement is proportional to t^2 .

Equipment

- smooth straight board or track, about 1.3 m long
- books to raise one end by a few centimetres
- steel ball or marble
- metre rule and marker
- stopwatch (a phone timer is fine)

Safety

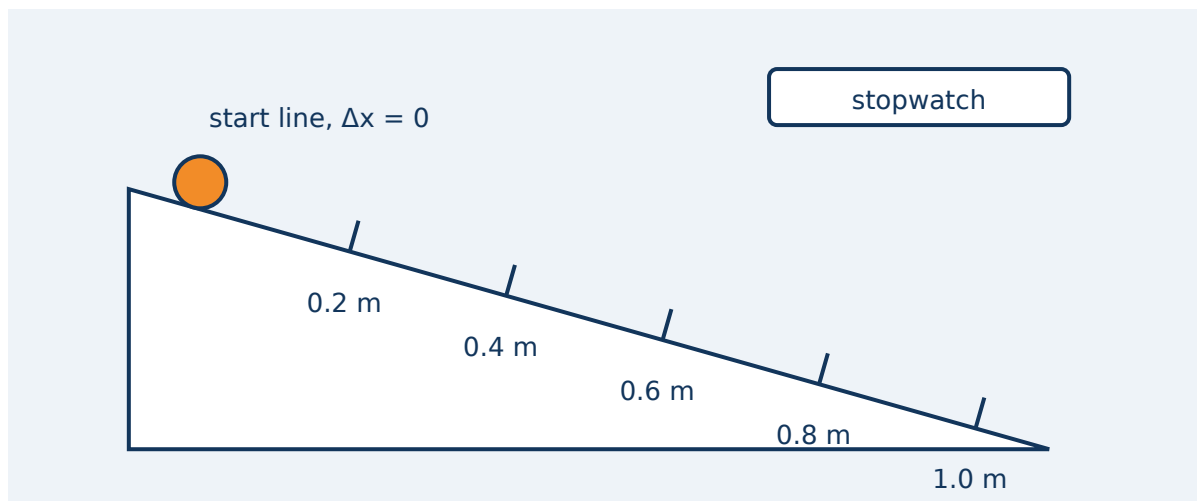
Safety

Place a tray or a stop block at the bottom of the ramp so the ball cannot roll across the floor. Pick up any ball that lands on the ground at once so nobody slips on it.

Method

1. Mark a start line near the top of the ramp and mark points 0.20, 0.40, 0.60, 0.80 and 1.00 m below it.
2. Release the ball from rest at the start line, without pushing it.
3. Start the stopwatch at release and stop it when the ball passes the first mark.
4. Repeat three times for this distance and record all three times.
5. Repeat for each of the other marks, keeping the ramp angle fixed.

6. Calculate the mean time and t^2 for each distance.



Set-up: the ball starts at rest at the start line; distances are measured along the slope.

Results

Sample measurements:

Δx (m)	t_1 (s)	t_2 (s)	t_3 (s)	mean t (s)	t^2 (s ²)
0.20	0.72	0.70	0.71	0.71	0.504
0.40	1.02	1.00	1.01	1.01	1.020
0.60	1.22	1.19	1.22	1.21	1.464
0.80	1.43	1.41	1.42	1.42	2.016
1.00	1.58	1.55	1.58	1.57	2.465

Analysis questions

Question 1 Why plot against t^2

Explain why plotting Δx against t^2 is better than plotting Δx against t .

Question 2 A check on the table

Use the three times for $\Delta x = 0.60$ m to confirm the mean time and t^2 in the table.

Question 3 Finding the acceleration

Use the first and last rows to find the slope of the Δx - t^2 graph and calculate the acceleration.

Question 4 Timing uncertainty

The three times for 0.20 m range from 0.70 s to 0.72 s. Estimate the uncertainty in the mean

time and its percentage uncertainty.

Question 5 Prediction

Use your acceleration to predict the time for the ball to travel 1.50 m from rest.

Question 6 An intercept

Another group finds that its best-fit line crosses the t^2 axis at a positive value instead of passing through the origin. Suggest a reason.

Question 7 Improving the method

Propose two changes to the set-up that would make the measured acceleration more precise, and say why each helps.