

Projectiles and relative motion in a plane

AP Physics 1 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

A steel ball rolls down a ramp and leaves a table horizontally. By measuring where it lands, you find its launch speed and test how that speed depends on the release height. The lab uses only projectile equations, a metre rule and carbon paper.

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

Aim

To find how the launch speed of a rolling ball depends on its release height, using the range of a horizontal projectile.

Equipment

- steel ball (about 2 cm diameter)
- grooved ramp and clamp stand
- bench or table, height measured with a metre rule
- carbon paper and white paper
- plumb line, masking tape, metre rule

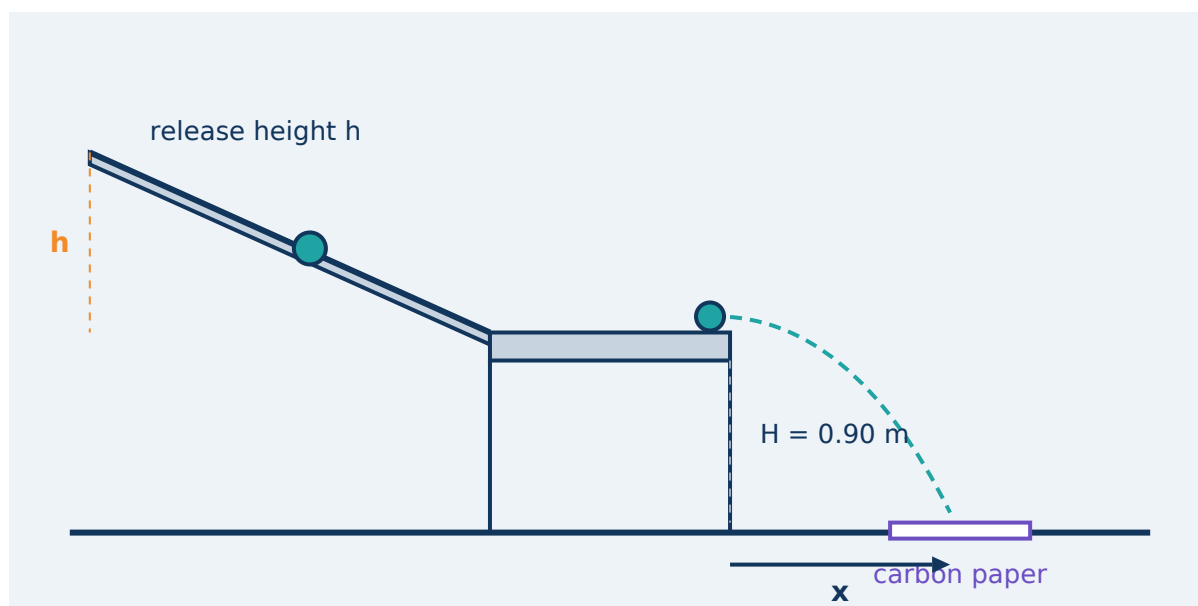
Safety

Safety

Stop the ball with a tray or a box so it does not roll across the floor, and clear the landing area of bags so nobody slips on a loose ball.

Method

1. Fix the ramp so the end is level with the table top and the ball leaves horizontally.
2. Use the plumb line to mark on the floor the point directly below the table edge, and measure the table height H .
3. Tape the white paper to the floor 0.4 m from the mark and cover the expected landing area with carbon paper.
4. Release the ball from a height $h = 0.10$ m above the table top, measured to the ball centre, and repeat five times.
5. Measure the range x from the plumb mark to the centre of the group of marks.
6. Repeat for $h = 0.15, 0.20, 0.25$ and 0.30 m.



Set-up: a steel ball leaves the table edge horizontally.

Results

The table height was $H = 0.90 \text{ m}$. Sample averages of five trials:

$h \text{ (m)}$	$x \text{ (m)}$	$x^2 \text{ (m}^2\text{)}$
0.10	0.49	0.240
0.15	0.60	0.360
0.20	0.69	0.476
0.25	0.77	0.593
0.30	0.84	0.706

Analysis questions

Question 1 Fall time

Calculate the time the ball takes to fall from the table edge to the floor.

Question 2 Launch speed

Calculate the launch speed of the ball for $h = 0.20 \text{ m}$.

Question 3 Why x^2

Show that $x^2 = (v^2) \times (2H \div g)$ and explain why x^2 against h should be a straight line through the origin.

Question 4 Gradient

Calculate the gradient of the x^2 against h graph using the first and last data points.

Question 5 Energy check

Use the gradient to find $v^2 \div h$, then compare with the value 14.0 m/s^2 expected for a solid ball rolling without slipping ($v^2 = 10gh \div 7$).

Question 6 Uncertainty

Estimate the percentage uncertainty in x if the five marks for $h = 0.20 \text{ m}$ spread over 0.67 to 0.71 m .

Question 7 Improvement

Suggest two improvements that would make the experiment more accurate.