

# Independent horizontal and vertical motion of projectiles

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: \_\_\_\_\_ Date: \_\_\_\_\_ Class: \_\_\_\_\_

A marble rolling off a table follows a curved path, but its fall time depends only on the table height. In this lab you test that idea by launching the marble at three different speeds, and you use the measured ranges to calculate the launch speeds without a stopwatch.

**Level:** Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.4

## Aim

To show that the time a marble takes to fall from a table is the same for different launch speeds, and to find the launch speed from the measured range.

## Equipment

- Curved ramp or grooved ruler, marble
- Table of known height  $H$  (measure it with a metre rule)
- Sheet of paper with carbon paper on top, tape
- Metre rule, books to change the release height

## Safety

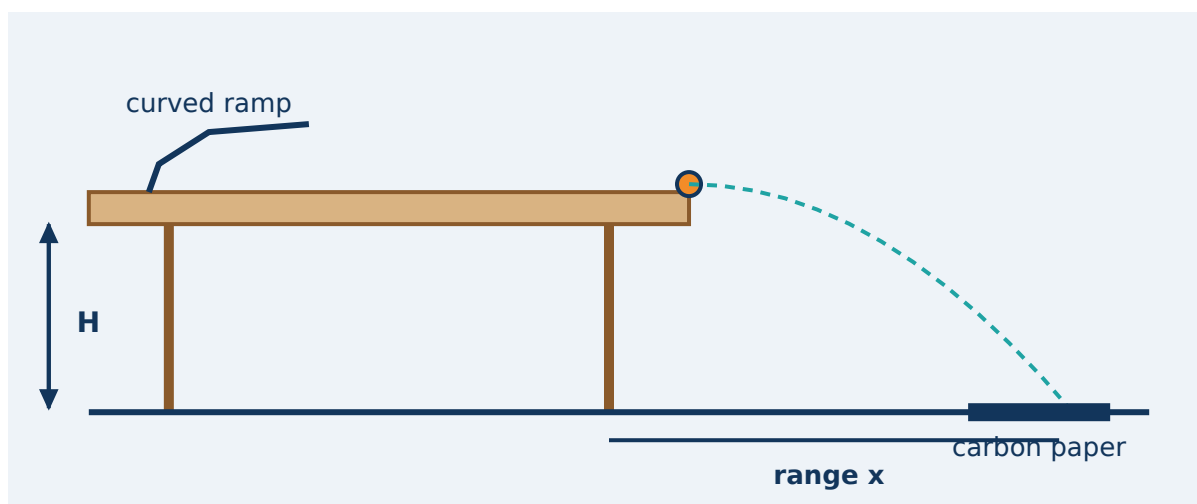
### Safety

Keep the floor around the landing area clear so that nobody slips on a rolling marble. Place a box behind the landing area to catch stray marbles, and do not stand in the line of the launch.

## Method

1. Measure the height  $H$  from the bottom of the marble at the table edge to the floor.
2. Fix the ramp so that the marble leaves the table edge horizontally.
3. Release the marble from rest at three different heights on the ramp: low, medium and high.
4. For each height, release the marble five times and mark where it lands on the carbon paper. Measure the average range from the table edge.
5. Calculate the time of fall  $t = \sqrt{2H \div g}$  and the launch speed  $v = x \div t$  for each release

height.



Marble leaving a table edge and landing on carbon paper.

## Results

The table height is  $H = 0.85$  m. Mean ranges (each from five landings):

| Release | Mean range $x$ (m) | Spread of landings (m) |
|---------|--------------------|------------------------|
| Low     | 0.62               | $\pm 0.01$             |
| Medium  | 0.84               | $\pm 0.01$             |
| High    | 1.03               | $\pm 0.01$             |

## Analysis questions

### Question 1 Time of fall

Calculate the time of fall of the marble from the table of height 0.85 m.

### Question 2 Launch speeds

Calculate the horizontal launch speed for each release height.

### Question 3 Same time of fall

Explain why the time of fall is the same for all three release heights.

### Question 4 Percentage uncertainty

Calculate the percentage uncertainty in the range for the low release and the high release.

**Question 5 Prediction**

Predict the range for the low release if the table were 1.20 m high.

**Question 6 Impact speed**

Calculate the speed of the marble as it hits the floor after the high release.

**Question 7 Sources of error**

Suggest two reasons why the marble might land slightly short of the predicted range.

**Question 8 Improvement**

Describe one improvement that would make the speeds more reliable.