

EQUIPMENT BUILD PLAN

MOTION & FORCES

Projectile Curve Model

Balls hang from evenly spaced points on a long bar on strings whose lengths grow as the square numbers (0, 1, 4, 9 ... 100 cm). Together they freeze a projectile's parabolic path, showing steady forward motion combined with accelerating fall. It makes a permanent classroom display and a starting point for velocity calculations.

Written from Bruce's original workshop handout. Bruce's final review of this plan is in progress.



DIFFICULTY Beginner	BUILD TIME 1-2 hours
COST About \$15	SAFETY Adult build / supervision
GOOD FOR Teachers, Families	

What it shows

Eleven balls hanging from a ceiling bar trace the exact curve of a thrown ball, and you can throw a real one right alongside it.

Key ideas: projectile motion, parabola, acceleration due to gravity, independence of horizontal and vertical motion

Safety (Adult build / supervision). An adult should mount the bar overhead, using hardware rated for the job, and keep it out of walkways so no one walks into the hanging balls.

CONSTRUCTION

Build it

Materials

- ☐ **Long wooden bar** · 6-8 ft
- ☐ **Lightweight balls (wood, plastic or ping-pong)** · 11
- ☐ **Fishing line or thin string** · About 6 m
- ☐ **Small screw hooks or screw eyes** · 11 for the balls, plus 2 for hanging
Bruce lists 2 small brass hooks
- ☐ **Meter stick** · 1
Becomes the vertical scale
- ☐ **Red tape** · 1 roll
For marking the positions
- ☐ **Wall or ceiling supports for the bar** · 2

Tools

Tape measure or meter stick

Pencil

Drill or awl for pilot holes

Scissors

Ladder (for mounting)

1

Mark the time positions

Mark 11 evenly spaced positions along the bar and flag each with a small piece of red tape. Each space stands for the distance the projectile travels forward in one equal moment of time. In Bruce's worked example the first and last positions are 1.4 m apart.



2

Add hooks

Screw a small hook or screw eye into the underside of the bar at each mark.

3

Cut and tie the strings

Tie a string to each ball. Measure each string so the distance from the bar to the ball matches the table: ball 1 = 0 cm, 2 = 1 cm, 3 = 4 cm, 4 = 9 cm, 5 = 16 cm, 6 = 25 cm, 7 = 36 cm, 8 = 49 cm, 9 = 64 cm, 10 = 81 cm, 11 = 100 cm. These are the whole numbers 0 to 10 squared.

4

Hang the balls

Tie each string to its hook in order, starting with ball 1 (fixed right against the bar) at one end. Ball 1 represents the launch point, moving horizontally with no downward speed yet.

5

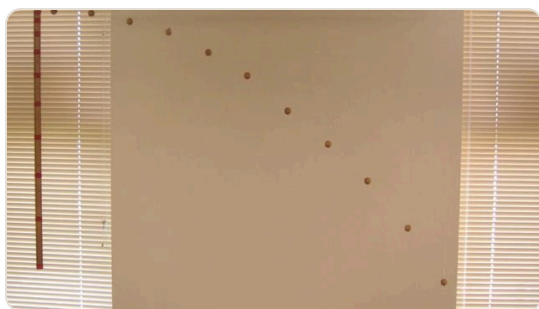
Make the vertical scale

Put red tape marks on a meter stick at 1, 4, 9, 16, 25, 36, 49, 64, 81 and 100 cm. Hang it vertically from the bar at the launch end; it shows how far the ball has dropped after each moment of time.

6

Mount the display

Hang the bar level from the ceiling or from wall-mounted supports. Bruce's hangs about 1/2 m below the ceiling, close to a wall, so students do not walk under or through it.



THE PHYSICS

How it works

A projectile's motion can be split into two independent parts. Sideways, nothing pushes or pulls it (ignoring air resistance), so it covers the same distance in each moment of time. That is why the hanging points are evenly spaced.

Downward, gravity makes it speed up steadily. Starting from rest, the total distance fallen grows with the square of the time: after 1, 2, 3,

Using it

- With a little practice, toss a tennis ball from the launch end so it follows the line of balls. That takes a forward speed of about 3 m/s.
- Ask: how would the curve change with a faster or slower throw? With

4 moments it has fallen 1, 4, 9, 16 units. That is why the strings follow the square numbers.

Put the two motions together and the balls trace a parabola. A faster sideways speed stretches the curve out; a slower one makes it drop more steeply.

You can work out the speed the model represents. The last ball has fallen 1 m, which takes $t = \sqrt{2y/g} = \sqrt{2 \times 1 \text{ m} / 9.8 \text{ m/s}^2}$, about 0.45 s. If it has also traveled 1.4 m forward, its horizontal speed is $1.4 \text{ m} / 0.45 \text{ s}$, about 3.1 m/s.

weaker gravity, or none? If the ball reached terminal velocity?

- Tilt the bar at an angle to show the path of a projectile launched upward at an angle, and try matching it with a throw.
- Have students calculate the horizontal speed for their own spacing, as shown above.
- Remind students the model is ideal: in real flight, air resistance slowly reduces the forward speed.

GO FURTHER

Variations

- Rolling-ball version: prop up one end of a table, dip a steel ball in thin tempera paint and roll it across the slope on large paper to record a parabola, including upward launches.
- Video version: film a ball dropped by someone riding a skateboard and trace its path on the screen with a washable marker; discuss how the path looks to the rider versus a bystander.

IF IT DOESN'T WORK

Troubleshooting

IF THIS HAPPENS

The curve looks lumpy.

TRY THIS

Re-measure from the underside of the bar to the center of each ball, not the top, and keep all measurements to the same point.

IF THIS HAPPENS

Balls twist and swing.

TRY THIS

Use fishing line, and let the display settle; a small dab of glue at each knot keeps lengths from creeping.

IF THIS HAPPENS

Thrown balls never match the curve.

TRY THIS

Throw horizontally from the launch end at an easy, steady speed; it usually takes a few tries.