SCIENCE FOUNDATIONS

# Projectile motion

### Difficulty level: Advanced

### Science Foundations

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## *Overview of the concept*

This is how a basketball player judges a free throw and a golfer aims a long drive, because the ball keeps moving forward steadily while gravity pulls it down. A free throw works when the player gives the ball enough height to drop through the hoop as it comes down. A golfer aiming into a headwind knows the wind will shorten the flight. Knowing projectile motion tells you why the best path is an arc, not a straight line, and how speed and angle decide where the ball lands.



## *Rule*

**Projectile motion: the horizontal and vertical motions of a projectile are independent and share only time.**

Ignoring air, the horizontal velocity stays constant and the vertical motion accelerates downward at 9.8 $m/s^2$, so the path is a curve called a parabola.

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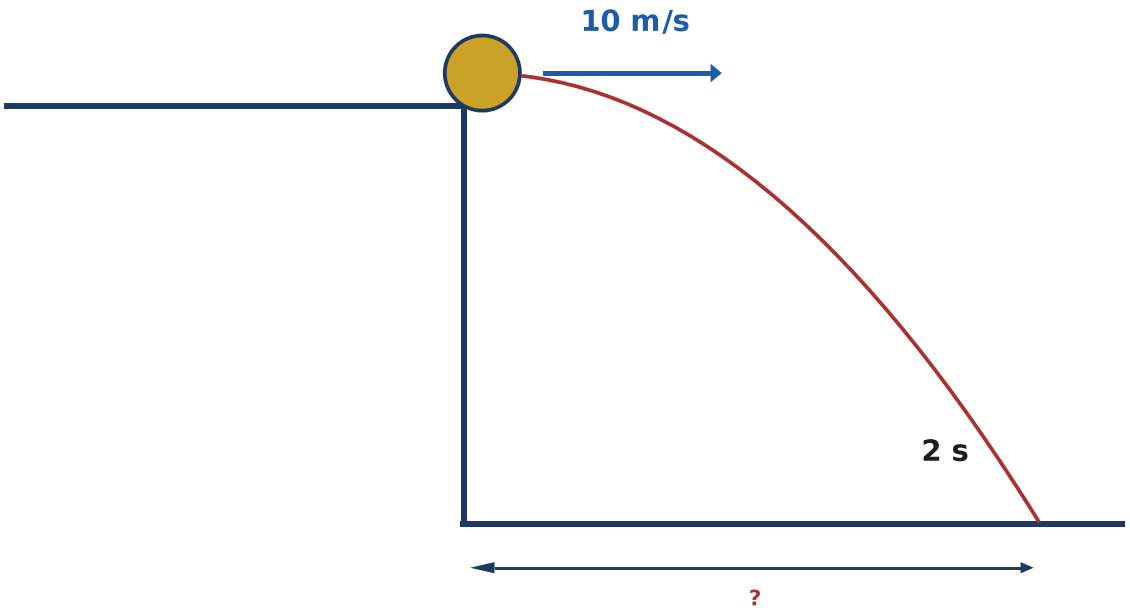
## Worked examples

EXAMPLE 1

**Q** A ball is thrown horizontally at 10 m/s from a cliff, falling for 2 s. Horizontal distance?




### SOLUTION

Separate the motions: horizontal velocity stays 10 m/s.

Time is shared: 2 s.

Horizontal distance = velocity × time

10 × 2 = 20 m

The result is 20 m horizontally.

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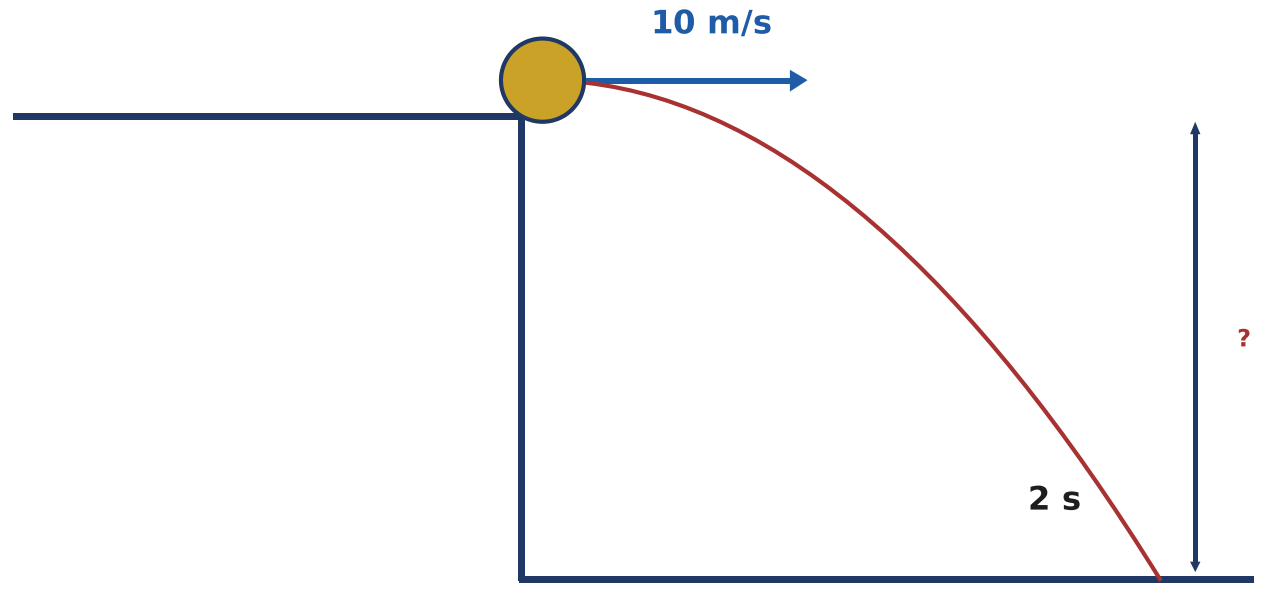
EXAMPLE 2

## Q Same ball: vertical distance fallen in 2 s?




### SOLUTION

Separate the motions: vertical starts at 0 and accelerates at 9.8.

Use:

$$s = \frac{1}{2} \times a \times t^2$$

Substitute:

$$s = \frac{1}{2} \times 9.8 \times 4 = 19.6 \text{ m}$$

The result is 19.6 m vertically.

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## Practice questions

**1** A ball is thrown horizontally at 12 m/s from a cliff and falls for 3 s. How far does it travel horizontally?

- **A** 45 m
- **B** 36 m
- **C** 12 m
- **D** 3 m

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**2** A ball is thrown horizontally at 10 m/s. How long does it take to travel 30 m horizontally?

- **A** 3 s
- **B** 30 s
- **C** 300 s
- **D** 0.3 s

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**3** The same ball thrown at 12 m/s falls for 3 s. How far does it fall vertically? Use $g = 9.8\ \frac{m}{s^2}$

- **A** 19.6 m
- **B** 29.4 m
- **C** 44.1 m
- **D** 88.2 m

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**4** A ball is dropped from rest. After 1 s its vertical speed is 9.8 m/s. What is its vertical speed after 3 s?

- **A** 29.4 m/s
- **B** 9.8 m/s
- **C** 19.6 m/s
- **D** 39.2 m/s

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**5** What is the horizontal acceleration of a projectile (ignoring air)?

- **A** 0
- **B** 9.8 $m/s^2$
- **C** 12 m/s
- **D** -9.8 $m/s^2$

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**6** What is the vertical acceleration of a projectile?

- **A** 9.8 $m/s^2$ upward
- **B** 9.8 $m/s^2$ downward
- **C** 0
- **D** 9.8 $m/s^2$ horizontally

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## What is the shape of a projectile's path?

A A straight line

B A circle

C A parabola

D A zigzag

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## What is shared between the horizontal and vertical motions?

A Distance

B Speed

C Acceleration

D Time

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**9** At the top of a projectile path, what is the vertical velocity?

- **A** 9.8 m/s
- **B** 0
- **C** 20 m/s
- **D** 12 m/s

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**10** A ball is thrown horizontally at 20 m/s and falls for 1 s. How far does it travel horizontally, and how far does it fall vertically? Use $g = 9.8\ \frac{m}{s^2}$

- **A** 20 m horizontally, 4.9 m vertically
- **B** 4.9 m horizontally, 20 m vertically
- **C** 20 m horizontally, 9.8 m vertically
- **D** 9.8 m horizontally, 4.9 m vertically

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## ANSWER KEY

**1.** 36 m

**2.** 3 s

**3.** 44.1 m

**4.** 29.4 m/s

**5.** 0

**6.** 9.8 $\frac{m}{s^2}$ downward

**7.** A parabola

**8.** Time

**9.** 0

**10.** 20 m horizontally, 4.9 m vertically

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