# Acceleration

Acceleration is the rate at which an object's velocity is changing. It doesn't just mean speeding up. Slowing down and changing direction are forms of acceleration, too.

### Formula for acceleration

You can calculate acceleration using the formula below. The unit to use for acceleration is m/s$^2$ (meters per second squared).

$$\text{acceleration (m/s}^2\text{)} = \frac{\text{change in velocity (m/s)}}{\text{time taken (s)}}$$

Final velocity

Initial velocity

$$a = \frac{v_f - v_i}{t}$$

### Calculating acceleration

To work out "change in velocity" in the right side of the formula, you need two figures: final velocity and initial velocity. Take care to get these the right way around. For example, a car traveling at a velocity of 13 m/s speeds up to 25 m/s in 10 seconds. What's its acceleration?

$$a = \frac{v_f - v_i}{t}$$

Put final velocity first and initial velocity second.

$$= \frac{25\ \text{m/s} - 13\ \text{m/s}}{10\ \text{s}}$$

$$= 1.2\ \text{m/s}^2$$

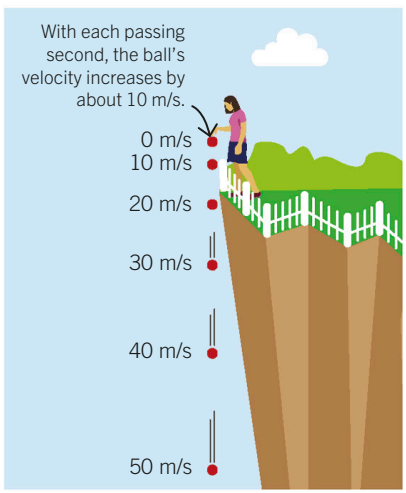
Acceleration is measured in meters per second squared (meters per second per second).

## Key facts

- ✓ **Acceleration is the rate at which velocity changes.**
- ✓ **The unit for acceleration is m/s$^2$.**
- ✓ **The uniform acceleration of a falling object at Earth's surface is 9.8 m/s$^2$ ($g$).**

## Acceleration due to gravity

When an object falls, the force of gravity at Earth's surface gives it a uniform acceleration of about 9.8 m/s$^2$. This means that with each passing second, its velocity increases by 9.8 m/s. This value is used so often in calculations that it has its own abbreviation, $g$. In real life, objects don't always accelerate uniformly at 9.8 m/s$^2$ because air resistance produces an upward force.



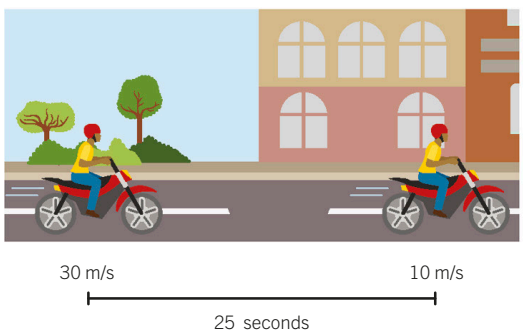

### Drogue parachute

Some high-speed aircraft must slow down (decelerate) very quickly in order to land in confined spaces. One solution is to deploy a drogue parachute—a small parachute that dramatically increases the force of drag.

## Slowing down

**Question**

If an object is slowing down, it has negative acceleration. A motorcycle is traveling at 30 m/s on a country road. It arrives at a town and the rider slows down to 10 m/s, taking 25 seconds to do so. What was the average acceleration?




**Answer**

$$a = \frac{v_f - v_i}{t}$$

$$= \frac{10\ \text{m/s} - 30\ \text{m/s}}{25\ \text{s}}$$

$$= -0.8\ \text{m/s}^2$$

Acceleration is negative here because the motorcycle was slowing down.

### Using distance

Sometimes we have to calculate acceleration from a change in velocity over a certain distance rather than over a period of time. We use the equation below to do this.

Displacement (distance traveled)

$$v_f^2 - v_i^2 = 2as$$

Final velocity — Initial velocity

## Finding acceleration

**Question**

A train pulls out from a station and accelerates uniformly for 1350 m until it reaches a velocity of 55 m/s. What is the train's acceleration?

**Answer**

Rearrange the formula to find $a$.

$$a = \frac{v_f^2 - v_i^2}{2s}$$

$$= \frac{(55\ \text{m/s})^2 - (0\ \text{m/s})^2}{2 \times 1350\ \text{m}}$$

$$= \frac{3025}{2700}$$

$$= 1.12\ \text{m/s}^2$$