

How fast and how quickly speeding up

Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · Lesson

Quick answer: Speed is distance divided by time, while velocity is displacement divided by time and includes direction. Acceleration is the change in velocity per second, $a = (v - u) \div t$, measured in m/s^2 . Speed is a scalar; velocity and acceleration are vectors, so direction matters.

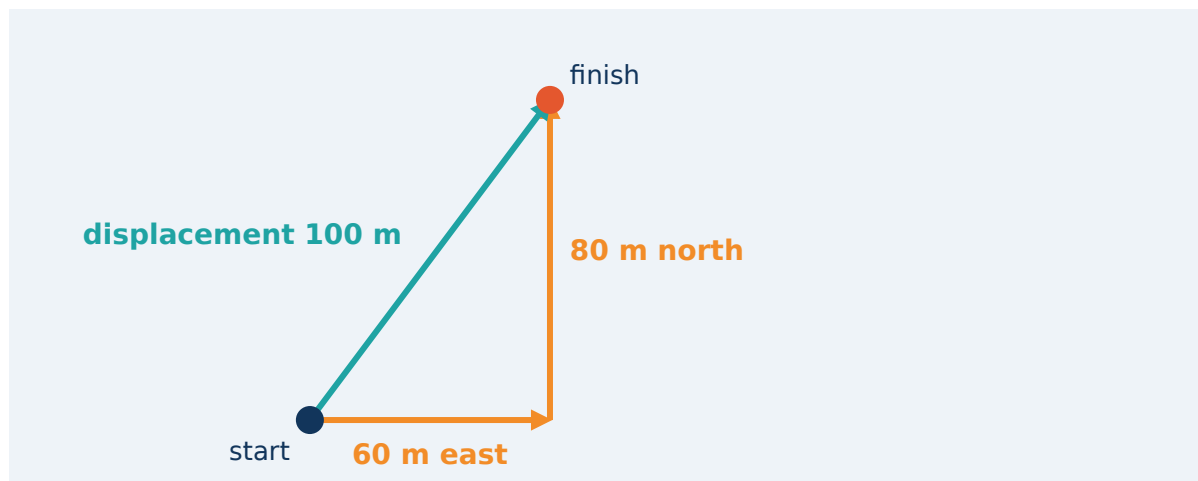
Level: Physics grades 9-10 (GCSE · IGCSE · O Level · Class 9-10) · **Curriculum:** IGCSE 1.2, HS-PS2-1

What is the difference between speed and velocity?

Some quantities need only a size, and others need a direction as well. A **scalar** has magnitude only, such as distance, speed, time and mass. A **vector** has magnitude and direction, such as displacement, velocity and acceleration.

Definition

Speed is the distance travelled per unit of time and is a scalar. **Velocity** is the displacement per unit of time, so it also tells you the direction. **Displacement** is the straight-line distance from start to finish, in a stated direction.



The walker covers 140 m of path but ends up only 100 m from the start. Distance and displacement are different.

How do you calculate speed?

Formula

speed = distance $\div$ time, or $v = s \div t$

v = speed (m/s), s = distance (m), t = time (s). Average velocity uses displacement in place of distance.

Most journeys are not at a steady speed, so $v = s \div t$ gives the **average speed**. A speedometer shows the **instantaneous speed** at one moment. To change km/h to m/s divide by 3.6, and to go back multiply by 3.6.

Worked example 1

Kofi cycles 3.6 km along a road in Accra in 15 minutes. Calculate his average speed in m/s.

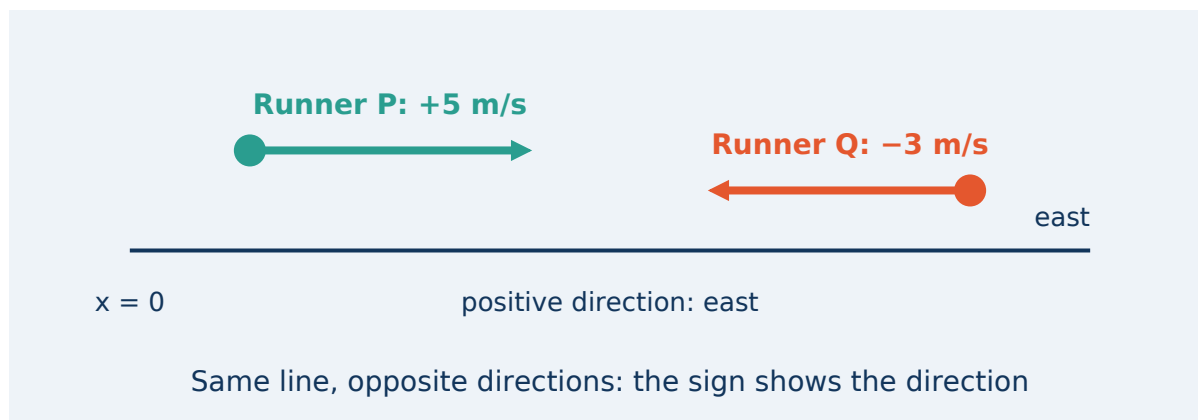
Distance = 3.6 km = 3600 m. Time = $15 \times 60 = 900$ s. Speed = $3600 \div 900 = \mathbf{4.0 \text{ m/s}}$.

The next table gives typical speeds to help you judge whether an answer is sensible.

Situation	Typical speed (m/s)
Walking	1.5
Cycling	6
Car in town	13
Airliner	250
Sound in air	330
Light in a vacuum	3.0×10^8

Why can velocity be positive or negative?

Velocity is a vector, so on a straight line we choose one direction as positive. Motion the other way has a negative sign. Speed has no sign because it is only a size.



With east as positive, P has velocity +5 m/s and Q has velocity -3 m/s. Their speeds are 5 m/s and 3 m/s.

Common mistake

Constant speed does not mean constant velocity. A car driving round a bend at 10 m/s keeps its speed but changes its direction, so its velocity changes and it is accelerating.

How do you calculate acceleration?

Definition

Acceleration is the rate of change of velocity. Slowing down is a negative acceleration,

often called deceleration.

Formula

$a = (v - u) \div t$, which can be rearranged to $v = u + a t$

a = acceleration (m/s^2), u = starting velocity (m/s), v = final velocity (m/s), t = time taken (s).



Speed gains 4 m/s every second, so $a = 4 \text{ m/s}^2$

The motorbike's speed rises by the same amount each second, which is a constant acceleration.

Worked example 2

An auto-rickshaw in Pune speeds up from 2.0 m/s to 14 m/s in 6.0 s . Calculate its acceleration.

$$a = (v - u) \div t = (14 - 2.0) \div 6.0 = 12 \div 6.0 = \mathbf{2.0 \text{ m/s}^2}.$$

Worked example 3

A bus travels at 15 m/s and brakes for 5.0 s to reach 5.0 m/s . Find the acceleration.

$$a = (5.0 - 15) \div 5.0 = \mathbf{-2.0 \text{ m/s}^2}.$$

The negative sign means the velocity is decreasing.

Lina's tip

Write the three quantities in a list first: u , v and t . Then check the units before you divide. If you get km/h , convert to m/s before using the acceleration formula.

Key points to remember

- Speed = distance $\div$ time, in m/s ; $\text{km/h} \div 3.6 = \text{m/s}$.
- Velocity is a vector: speed with direction, from displacement $\div$ time.
- Acceleration $a = (v - u) \div t$, in m/s^2 ; $v = u + a t$.
- Negative acceleration means slowing down in the positive direction.
- Changing direction at constant speed is still acceleration.

How fast and how quickly speeding up: frequently asked questions

What is the difference between speed and velocity?

Speed is the distance travelled per unit of time and has no direction. Velocity is displacement per unit of time, so it has a direction as well as a size.

What is the formula for acceleration?

Acceleration equals the change in velocity divided by the time taken: $a = (v - u) \div t$. Its unit is m/s^2 , which means each second the speed changes by that many metres per second.

Can an object accelerate at constant speed?

Yes. Acceleration is a change in velocity, and velocity includes direction. A car going round a circular track at steady speed is always changing direction, so it is accelerating.

How do you convert km/h to m/s?

Divide by 3.6. For example $72 \text{ km/h} \div 3.6 = 20 \text{ m/s}$. To go the other way, multiply by 3.6.

What does a negative acceleration mean?

It means the velocity is changing in the negative direction. If the object is moving in the positive direction, it is slowing down; this is called deceleration.