

Describing movement and average speed

Grade 6 science (Year 7 · Class 6) · Lesson

Quick answer: Average speed is the total distance an object travels divided by the total time it takes, written $v = d \div t$. It is measured in metres per second (m/s) or kilometres per hour (km/h). Motion is always described relative to a reference object, and the path followed is called the trajectory.

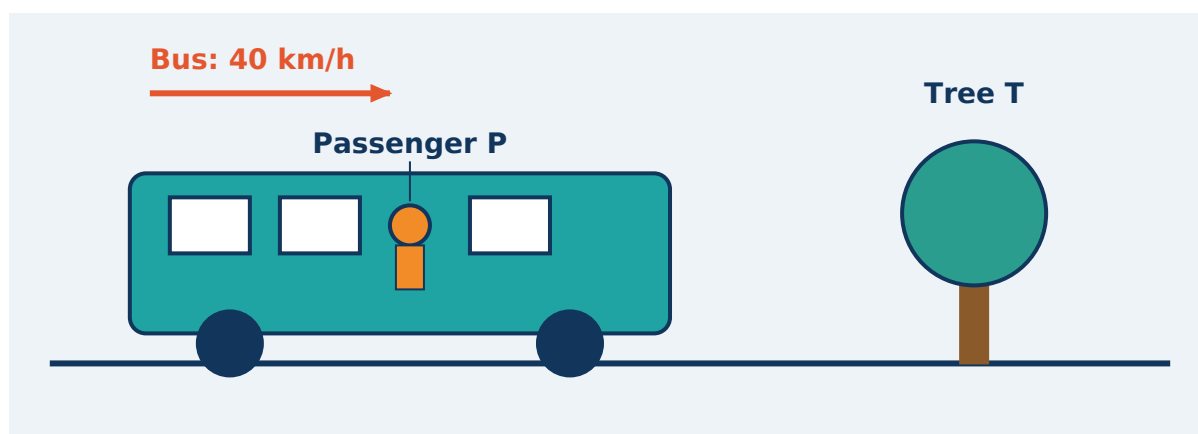
Level: Grade 6 science (Year 7 · Class 6) · **Curriculum:** MS-PS2-2

What does it mean to say that something is moving?

An object moves when its position changes compared with another object. That other object is the **reference object**. Mei sits in a bus in Singapore. Compared with her seat she does not move at all, but compared with a lamp post on the pavement she moves along the road. Both statements are true because each uses a different reference object.

Definition

A **reference object** is an object that we treat as fixed and use to decide whether another object is changing position. Movement and rest always depend on the reference object we choose.



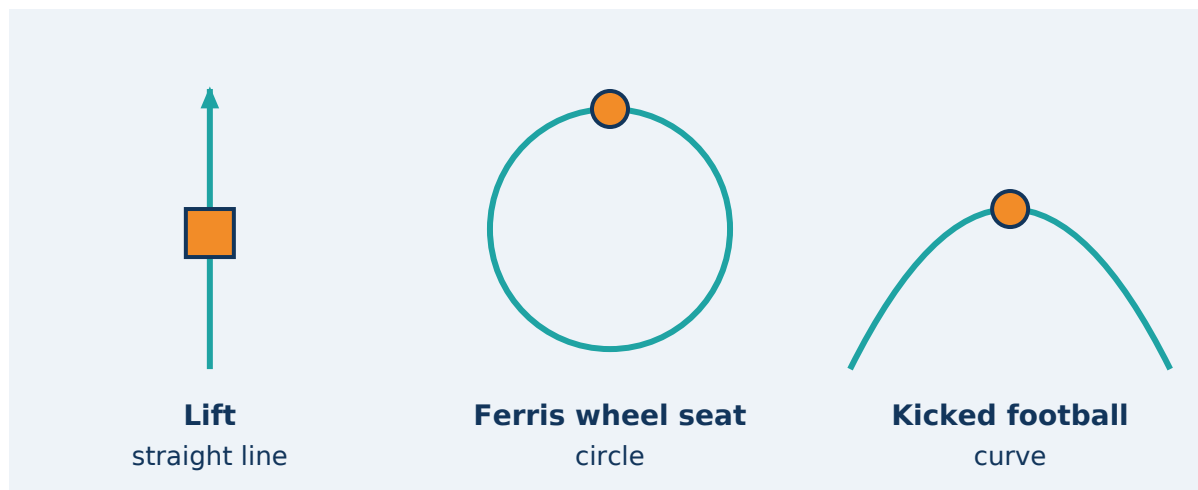
Relative to the bus seat, P is at rest. Relative to the tree T, P moves at 40 km/h.

What is a trajectory?

The **trajectory** of an object is the path it follows as it moves, the line joining all its successive positions. The shape of a trajectory also depends on the reference object. A pebble stuck in a bicycle tyre follows a circle when seen from the bike frame, but a looping curve when seen from the road.

Type of trajectory	Shape	Everyday example
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Type of trajectory	Shape	Everyday example
Straight	A line	A lift going up a building
Circular	A circle	A seat on a Ferris wheel
Curved	Any bend that is not a circle	A football kicked through the air



A trajectory is the line drawn by the successive positions of a moving object.

How do you calculate average speed?

Speed tells us how quickly an object covers distance. A cyclist does not travel at exactly the same speed every second, so we usually calculate the **average speed**: the total distance divided by the total time, including any stops.

Formula

$$v = d \div t$$

v is the average speed (m/s or km/h), d is the distance travelled (m or km) and t is the time taken (s or h). Rearranged: $d = v \times t$ and $t = d \div v$.

Worked example 1

Aarav cycles 12 km to school in 48 minutes. Calculate his average speed in km/h.

Data: $d = 12$ km; $t = 48$ min = $48 \div 60 = 0.8$ h.

$$v = d \div t = 12 \div 0.8 = \mathbf{15 \text{ km/h.}}$$

Worked example 2

A train travels at an average speed of 90 km/h. How long does it take to cover 225 km?

$$t = d \div v = 225 \div 90 = 2.5 \text{ h} = \mathbf{2 \text{ h } 30 \text{ min.}}$$

How do you convert between m/s and km/h?

The two most common units are metres per second (m/s), the SI unit, and kilometres per hour

(km/h). One kilometre is 1000 m and one hour is 3600 s, so $1 \text{ km/h} = 1000 \div 3600 \text{ m/s} = 1 \div 3.6 \text{ m/s}$.

Key rule

To change km/h into m/s, **divide by 3.6**. To change m/s into km/h, **multiply by 3.6**.

Worked example 3

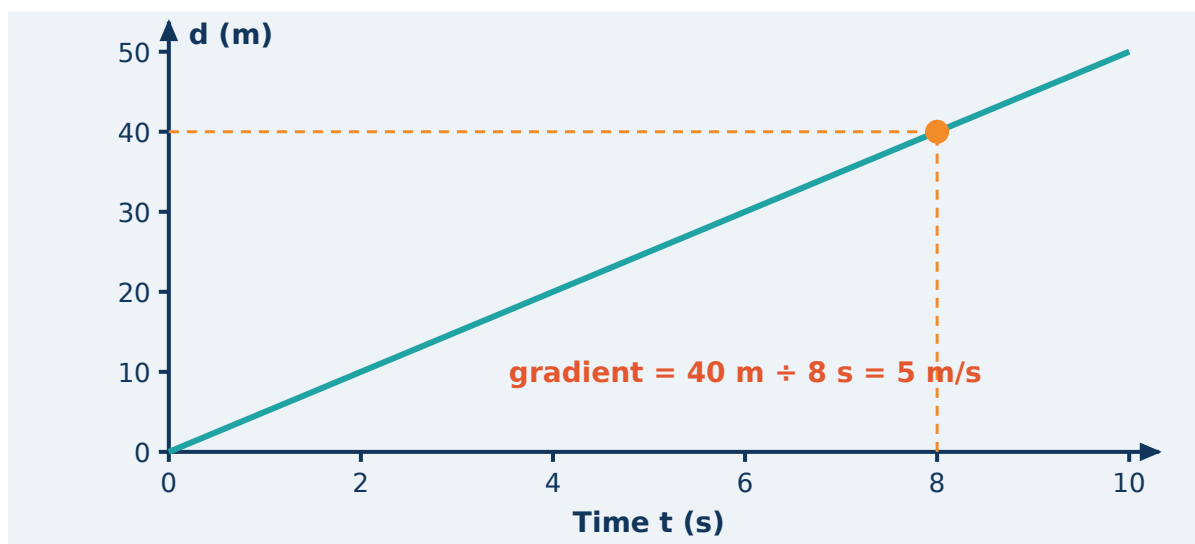
A motorbike taxi in Lagos moves at 72 km/h. Express this speed in m/s.

$$72 \div 3.6 = 20 \text{ m/s.}$$

Moving object	Typical speed (m/s)	Speed (km/h)
Person walking	1.5	5.4
Cyclist	6	21.6
Car on a motorway	25	90
Passenger jet	250	900

What does a distance-time graph show?

A distance-time graph plots time on the horizontal axis and distance on the vertical axis. A straight sloping line means constant speed, a horizontal line means the object is at rest, and a steeper line means a higher speed. The speed is the gradient: the rise in distance divided by the run in time. In the graph below the runner covers 40 m in 8 s, so $v = 40 \div 8 = 5 \text{ m/s}$.



On a distance-time graph the gradient of the line is the speed.

Common mistake

Do not divide minutes by kilometres or mix units. If the speed is wanted in km/h, change the time into hours first: 30 min is 0.5 h, not 30 h. Also remember that average speed is not the reading on a speedometer at one moment.

Lina's tip

Draw a triangle with d on top and v and t at the bottom. Cover the quantity you want: d is $v \times t$, v is $d \div t$ and t is $d \div v$. Always write the unit with every number.

Key points to remember

- Average speed $v = d \div t$, in m/s or km/h
- Motion is described relative to a reference object
- A trajectory can be straight, circular or curved
- km/h to m/s: divide by 3.6
- Distance-time graph: gradient = speed

Describing movement and average speed: frequently asked questions

What is the difference between speed and average speed?

Speed at one moment is what a speedometer shows. Average speed is the total distance divided by the total time of a journey, so it includes any stops and slow sections.

Why must we choose a reference object?

An object can be at rest compared with one object and moving compared with another. Choosing a reference object tells everybody what the motion is being compared with.

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

Divide by 3.6, because 1 km is 1000 m and 1 h is 3600 s. For example, 90 km/h is 25 m/s.

What does the slope of a distance-time graph mean?

The gradient of the line is the speed. A steeper line means a higher speed and a horizontal line means the object is at rest.

How do you find the time of a journey?

Divide the distance by the average speed, $t = d \div v$. Keep the units consistent, for example kilometres with km/h to get hours.