

Reading motion graphs and acceleration

Grade 8 science (Year 9 · Class 8) · Lesson

Quick answer: On a distance-time graph the gradient is the speed and a flat line means stopped. On a speed-time graph the gradient is the acceleration, a flat line means constant speed and the area under the line is the distance travelled. Acceleration is $a = (v - u) \div t$, measured in m/s^2 .

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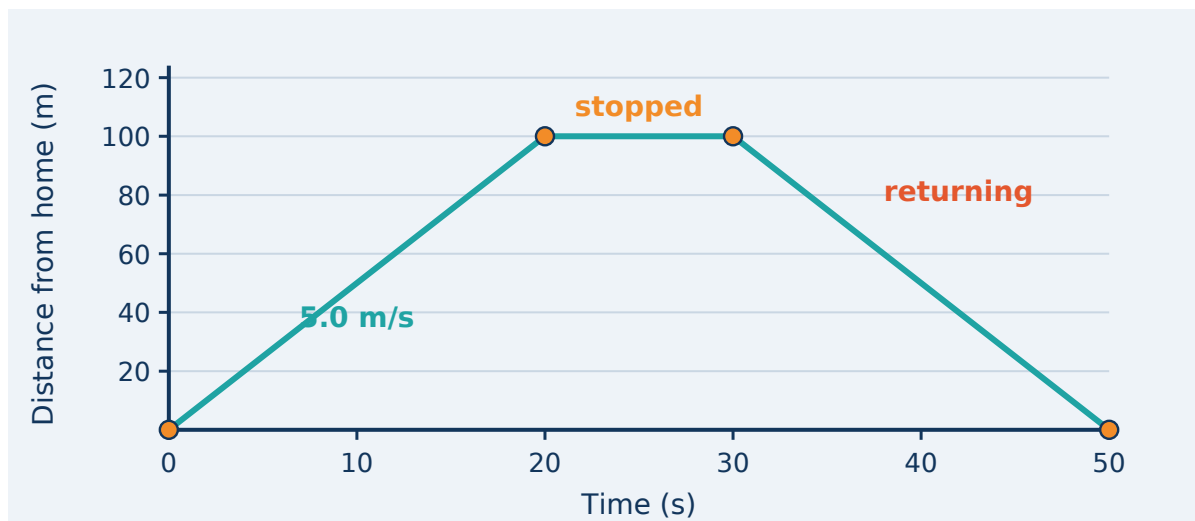
How do you read a distance-time graph?

A distance-time graph shows how far an object has travelled as time passes. Time goes along the horizontal axis and distance goes up the vertical axis.

Definition

On a distance-time graph, the gradient (slope) of the line equals the speed. $\text{gradient} = \text{change in distance} \div \text{change in time}$.

A steeper line means a higher speed. A horizontal line means the distance is not changing, so the object is stationary. A straight sloping line means constant speed, and a curved line means the speed is changing.



A distance-time graph. The slope shows the speed and a flat line shows the cyclist is stopped.

Worked example 1

In the graph, the cyclist covers 100 m between 0 s and 20 s. Find the speed.

$\text{speed} = 100 \text{ m} \div 20 \text{ s} = 5.0 \text{ m/s}$.

From 20 s to 30 s the line is flat, so the cyclist is stopped. From 30 s to 50 s the distance falls from 100 m to 0, so the cyclist returns home at $100 \div 20 = 5.0 \text{ m/s}$.

What is acceleration?

Speed does not always stay the same. A bus speeds up when it leaves the stop and slows down when it arrives at the next one.

Definition

Acceleration is the rate at which velocity changes. Speeding up gives positive acceleration; slowing down gives negative acceleration, also called deceleration.

Formula

$$a = (v - u) \div t$$

a = acceleration in m/s^2 , v = final speed in m/s , u = starting speed in m/s , t = time taken in s .

Worked example 2

A bus speeds up from 4 m/s to 16 m/s in 6 s . Find its acceleration.

$$a = (16 - 4) \div 6 = 12 \div 6 = \mathbf{2.0 \text{ m/s}^2}.$$

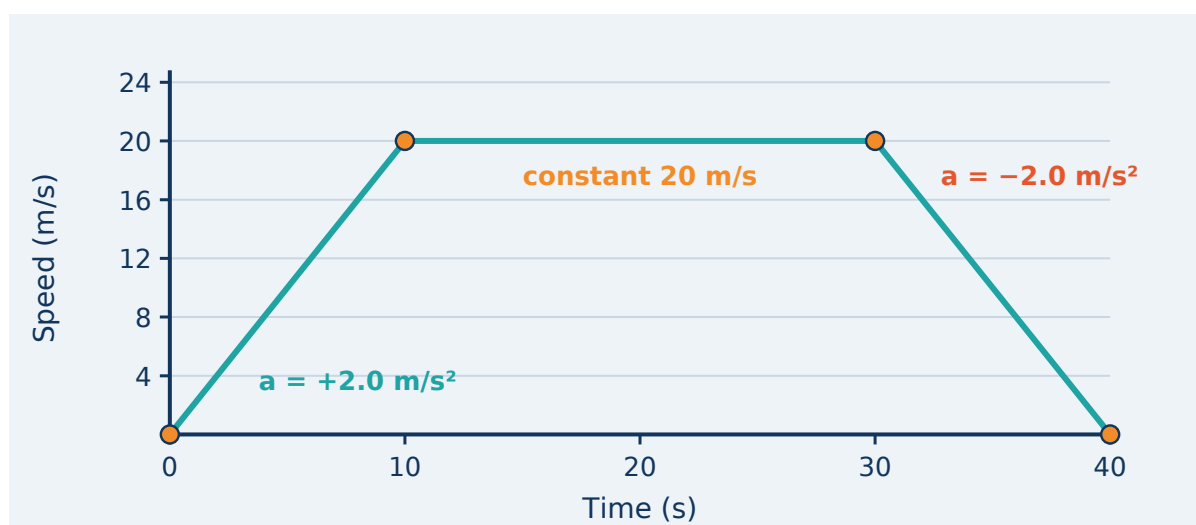
Speed has only a size. Velocity is speed in a stated direction, so travelling back towards the start can be shown as a negative velocity.

How do you read a speed-time graph?

A speed-time graph plots speed on the vertical axis against time on the horizontal axis. It tells a different story from a distance-time graph.

Key rules

On a speed-time graph: the gradient equals the acceleration, a horizontal line means constant speed, and the area under the line equals the distance travelled.



A speed-time graph. The slope gives acceleration and the area under the line gives distance.

Worked example 3

Use the car graph. Find the distance travelled in the 40 s.

Speeding up: area of a triangle = $\frac{1}{2} \times 10 \times 20 = 100$ m.

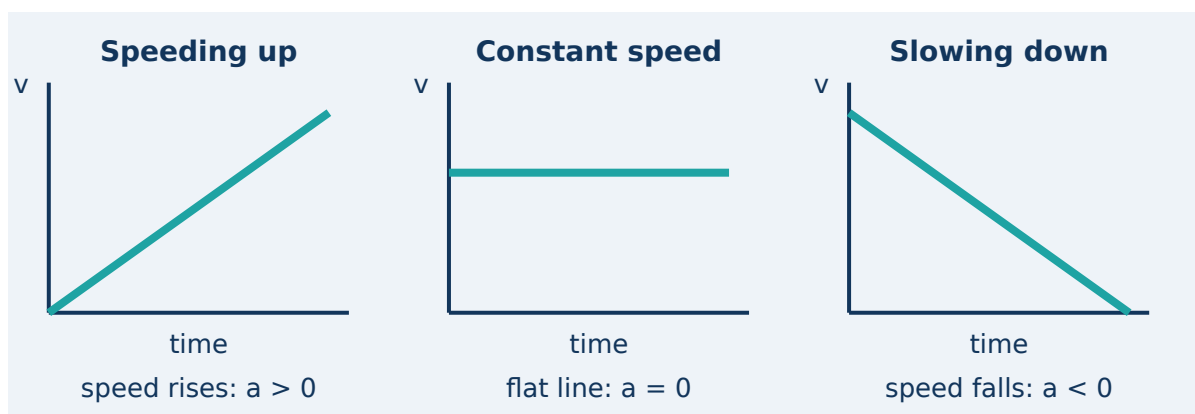
Constant speed: rectangle = $20 \times 20 = 400$ m.

Slowing down: triangle = $\frac{1}{2} \times 10 \times 20 = 100$ m.

Total distance = $100 + 400 + 100 = 600$ m.

The same shape means different things on different graphs, which is why you must always check the axes first.

Feature of the line	Distance-time graph	Speed-time graph
Horizontal line	Stationary	Constant speed
Straight sloping line	Constant speed	Constant acceleration
Curved line	Speed is changing	Acceleration is changing
Gradient	Speed	Acceleration
Area under line	Not used	Distance travelled



Three common shapes on a speed-time graph.

Common mistake

A flat line on a distance-time graph does not mean the object is moving at a steady speed. It means the object is stopped. Steady speed is a flat line on a speed-time graph.

Lina's tip

Read the axes first. Then ask two questions: what does the slope mean on this graph, and what does a flat part mean? Write the units next to every gradient you calculate.

Key points to remember

- Distance-time graph: gradient = speed; flat line = stationary
- Speed-time graph: gradient = acceleration; flat line = constant speed
- Area under a speed-time graph = distance travelled
- $a = (v - u) \div t$, in m/s^2

- To change km/h to m/s, divide by 3.6

Reading motion graphs and acceleration: frequently asked questions

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

The slope, or gradient, is the speed. A steeper line means a faster object, and a flat line means the object is stationary.

How do you find acceleration from a speed-time graph?

Find the gradient: change in speed divided by change in time. A line going up gives positive acceleration, and a line going down gives deceleration.

How do you find the distance from a speed-time graph?

Work out the area under the line. Split the shape into triangles and rectangles, then add the areas to get the distance in metres.

What is the difference between speed and velocity?

Speed is how fast an object moves and has no direction. Velocity is speed in a stated direction, so it can be positive or negative.

What is the unit of acceleration?

Metres per second squared (m/s^2). An acceleration of 2 m/s^2 means the speed increases by 2 m/s every second.