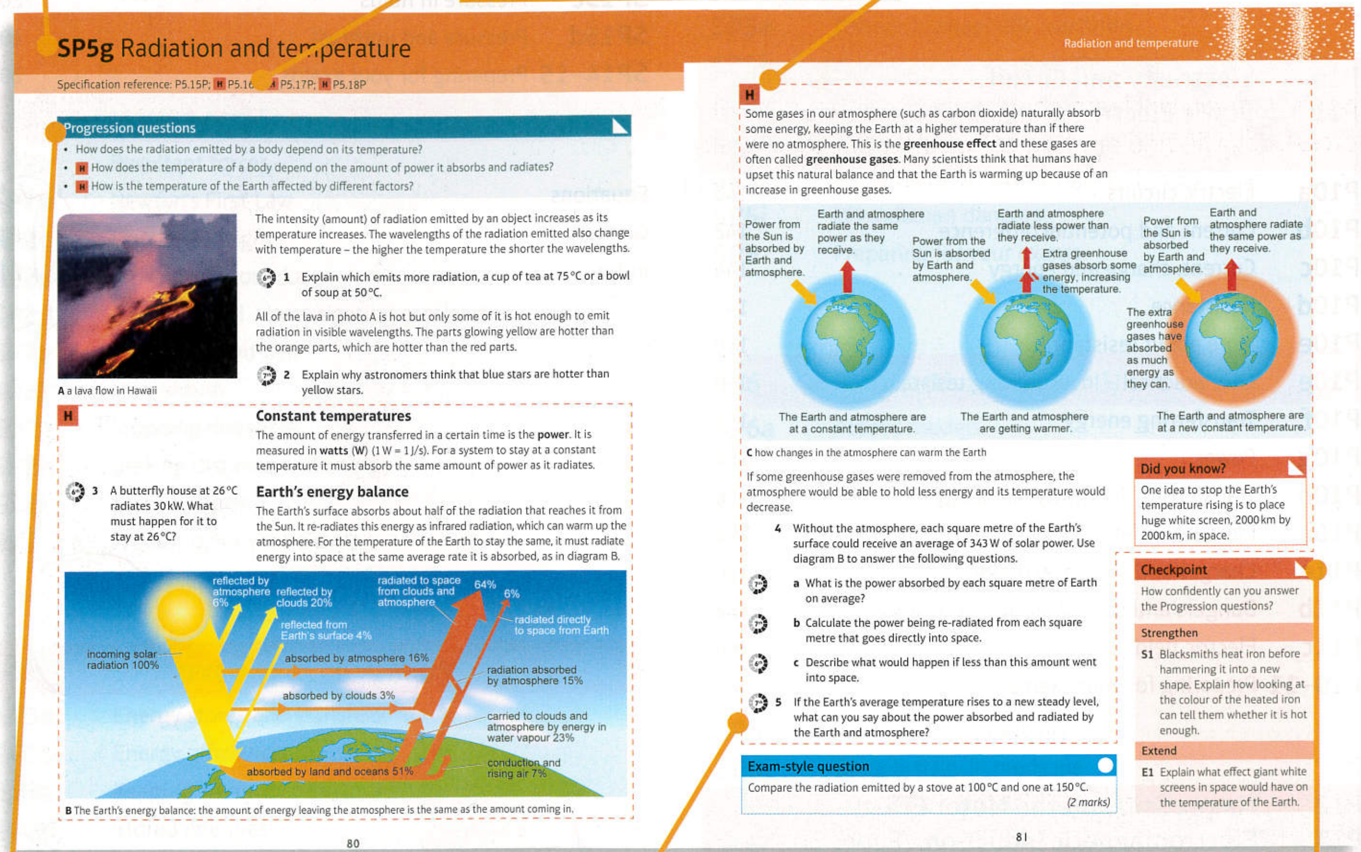
Teaching and learning

The **topic reference** tells you which part of the course you are in. 'SP5g' means, 'Separate Science, Physics, unit 5, topic g'.

The **specification reference** allows you to cross reference against the specification criteria so you know which parts you are covering. References that end in P, e.g. P7.2P, are in Physics only, the rest are also in the Combined Science specification criteria.

If you see an **H** icon that means that content will be assessed on the Higher Tier paper only.



SP5g Radiation and temperature

Specification reference: P5.15P; H P5.16 H P5.17P; H P5.18P

Progression questions

- How does the radiation emitted by a body depend on its temperature?
- H How does the temperature of a body depend on the amount of power it absorbs and radiates?
- H How is the temperature of the Earth affected by different factors?

A a lava flow in Hawaii

The intensity (amount) of radiation emitted by an object increases as its temperature increases. The wavelengths of the radiation emitted also change with temperature – the higher the temperature the shorter the wavelengths.

1 Explain which emits more radiation, a cup of tea at 75 °C or a bowl of soup at 50 °C.

All of the lava in photo A is hot but only some of it is hot enough to emit radiation in visible wavelengths. The parts glowing yellow are hotter than the orange parts, which are hotter than the red parts.

2 Explain why astronomers think that blue stars are hotter than yellow stars.

H

Constant temperatures

The amount of energy transferred in a certain time is the **power**. It is measured in **watts** (W) (1 W = 1 J/s). For a system to stay at a constant temperature it must absorb the same amount of power as it radiates.

3 A butterfly house at 26 °C radiates 30 kW. What must happen for it to stay at 26 °C?

Earth's energy balance

The Earth's surface absorbs about half of the radiation that reaches it from the Sun. It re-radiates this energy as infrared radiation, which can warm up the atmosphere. For the temperature of the Earth to stay the same, it must radiate energy into space at the same average rate it is absorbed, as in diagram B.

B The Earth's energy balance: the amount of energy leaving the atmosphere is the same as the amount coming in.

80

Radiation and temperature

H

Some gases in our atmosphere (such as carbon dioxide) naturally absorb some energy, keeping the Earth at a higher temperature than if there were no atmosphere. This is the **greenhouse effect** and these gases are often called **greenhouse gases**. Many scientists think that humans have upset this natural balance and that the Earth is warming up because of an increase in greenhouse gases.

C how changes in the atmosphere can warm the Earth

If some greenhouse gases were removed from the atmosphere, the atmosphere would be able to hold less energy and its temperature would decrease.

4 Without the atmosphere, each square metre of the Earth's surface could receive an average of 343 W of solar power. Use diagram B to answer the following questions.

a What is the power absorbed by each square metre of Earth on average?

b Calculate the power being re-radiated from each square metre that goes directly into space.

c Describe what would happen if less than this amount went into space.

5 If the Earth's average temperature rises to a new steady level, what can you say about the power absorbed and radiated by the Earth and atmosphere?

Did you know?

One idea to stop the Earth's temperature rising is to place huge white screen, 2000 km by 2000 km, in space.

Exam-style question

Compare the radiation emitted by a stove at 100 °C and one at 150 °C. *(2 marks)*

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Blacksmiths heat iron before hammering it into a new shape. Explain how looking at the colour of the heated iron can tell them whether it is hot enough.

Extend

E1 Explain what effect giant white screens in space would have on the temperature of the Earth.

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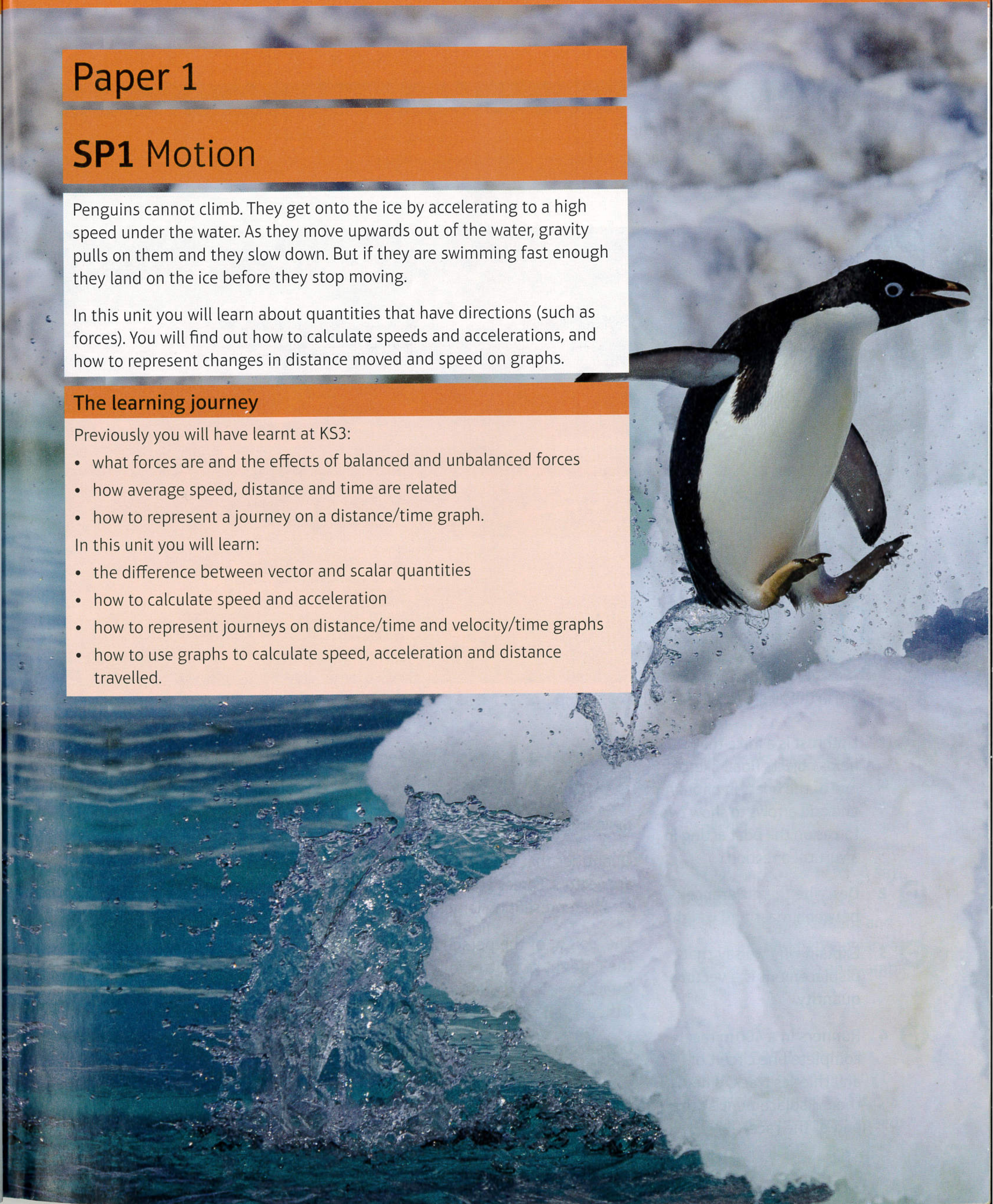
By the end of the topic you should be able to confidently answer the **Progression questions**. Try to answer them before you start and make a note of your answers. Think about what you know already and what more you need to learn.

Each question has been given a **Pearson Step** from 1 to 12. This tells you how difficult the question is. The higher the step the more challenging the question.

When you've worked through the main student book questions, answer the **Progression questions** again and review your own progress. Decide if you need to reinforce your own learning by answering the **Strengthen question**, or apply, analyse and evaluate your learning in new contexts by tackling the **Extend question**.



Paper 1

SP1 Motion

Penguins cannot climb. They get onto the ice by accelerating to a high speed under the water. As they move upwards out of the water, gravity pulls on them and they slow down. But if they are swimming fast enough they land on the ice before they stop moving.

In this unit you will learn about quantities that have directions (such as forces). You will find out how to calculate speeds and accelerations, and how to represent changes in distance moved and speed on graphs.

The learning journey

Previously you will have learnt at KS3:

- what forces are and the effects of balanced and unbalanced forces
- how average speed, distance and time are related
- how to represent a journey on a distance/time graph.

In this unit you will learn:

- the difference between vector and scalar quantities
- how to calculate speed and acceleration
- how to represent journeys on distance/time and velocity/time graphs
- how to use graphs to calculate speed, acceleration and distance travelled.

SP1a Vectors and scalars

Specification reference: P2.1; P2.2; P2.3; P2.4; P2.5

Progression questions

- What are vector and scalar quantities?
- What are some examples of scalar quantities and their corresponding vector quantities?
- What is the connection between the speed, velocity and acceleration of an object?

A The person in the air stays there because of the force provided by the jets of water.

1 Upthrust is a force that helps objects float. Sketch one of the boats in photo A and add arrows to show two forces on the boat acting in a vertical direction.

2 Describe the differences between mass and weight.

3 Explain why we say that displacement is a vector quantity.

4 Runners in a 400 m race complete one circuit of an athletics track. What is their displacement at the end of the race?

The **force** needed to keep the person in photo A in the air depends on his **weight**. Weight is a force that acts towards the centre of the Earth. All forces have both a **magnitude** (size) and a direction, and are measured in newtons (N).

Quantities that have both size and direction are **vector quantities**. So forces are vectors. Forces are often shown on diagrams using arrows, with longer arrows representing larger forces.

The weight of the person in photo A depends on his **mass**. Mass measures the amount of matter in something and does not have a direction. Quantities that do not have a direction are called **scalar quantities**. Other scalar quantities include **distance**, **speed**, **energy** and time.

Displacement is the distance covered in a straight line, and has a direction. The displacement at the end of a journey is usually less than the distance travelled because of the turns or bends in the journey.

B The bend in the road means that the distance the cyclists cover is greater than their final displacement.

The speed of an object tells you how far it moves in a certain time. **Velocity** is speed in a particular direction. For example a car may have a velocity of 20 m/s northwards.

D These skaters maintain a constant speed around the bend, but their velocity is changing.

Other vector quantities include:

- **acceleration** – a measure of how fast velocity is changing
- **momentum** – a combination of mass and velocity.

Exam-style question

Weight and upthrust are both vector quantities.

a Name one other vector quantity that is not a force. *(1 mark)*

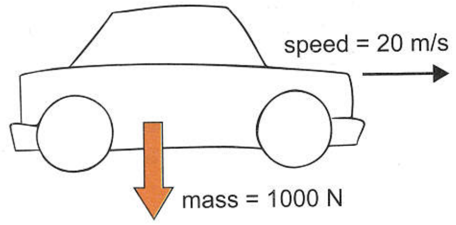
b Explain why you do not need to state a direction when describing a weight. *(1 mark)*

Did you know?

Cyclists can achieve speeds of up to 70 mph (that's over 100 km/h and approximately 30 m/s).

5 Look at photo B. Explain why the cyclists' velocity will change even if they maintain the same speed.

6 A student draws the diagram below. Explain what is wrong with it.



C

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Sally walks 1 km from her home to school. When she arrives, she tells her science teacher 'My velocity to school this morning was 15 minutes'. What would her teacher say?

S2 Explain the difference between displacement and distance, and between speed and velocity. Give an example of each.

Extend

E1 A car is going around a roundabout. Explain why it is accelerating even if it is moving at a constant speed.

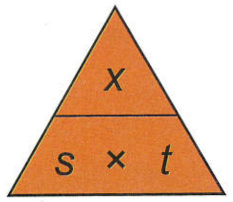
SP1b Distance/time graphs

Specification reference: P2.6; P2.7; P2.11; P2.12

Progression questions

- How do you use the equation relating average speed, distance and time?
- In metres per second, what are the typical speeds that someone might move at during the course of a day?
- How do you represent journeys on a distance/time graph?

A *ThrustSSC* broke the land speed record in 1997 at a speed of 1228 km/h (341 m/s). This was faster than the speed of sound (which is approximately 330 m/s).



B This equation triangle can help you to rearrange the equation for speed (s), where *x* is used to represent distance and *t* represents time. Cover up the quantity you want to calculate and write what you see on the right of the = sign.

Worked example W1

How far would *ThrustSSC* have travelled in 5 seconds during its record-breaking run?

distance = average speed × time

= 341 m/s × 5 s

= 1705 m

1 A car travels 3000 m in 2 minutes (120 seconds). Calculate its speed in m/s.

2 Look at diagram C. How far does a high speed train travel in 10 minutes?

The speed of an object tells you how quickly it travels a certain distance. Common units for speed are metres per second (m/s), kilometres per hour (km/h) and miles per hour (mph).

The speed during a journey can change, and the **average speed** is worked out from the total distance travelled and the total time taken. The **instantaneous speed** is the speed at a particular point in a journey.

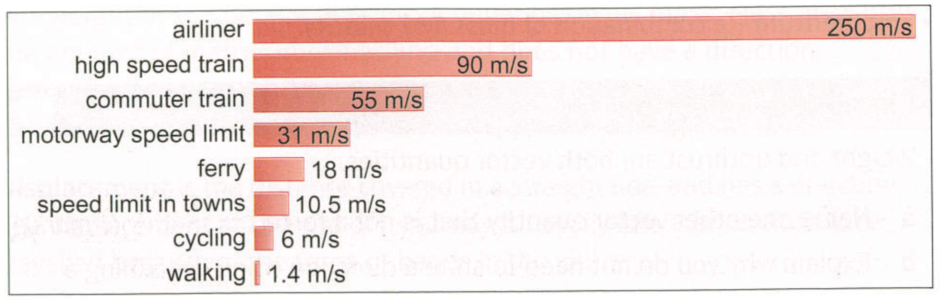
Speed can be calculated using the following equation:

$$\text{(average) speed (m/s)} = \frac{\text{distance (m)}}{\text{time taken (s)}}$$

The equation can be rearranged to calculate the distance travelled from the speed and the time.

$$\underset{\text{(m)}}{\text{distance travelled}} = \underset{\text{(m/s)}}{\text{average speed}} \times \underset{\text{(s)}}{\text{time}}$$

To measure speed in the laboratory you need to measure a distance and a time. For fast-moving objects, using **light gates** to measure time will be more accurate than using a stopwatch.

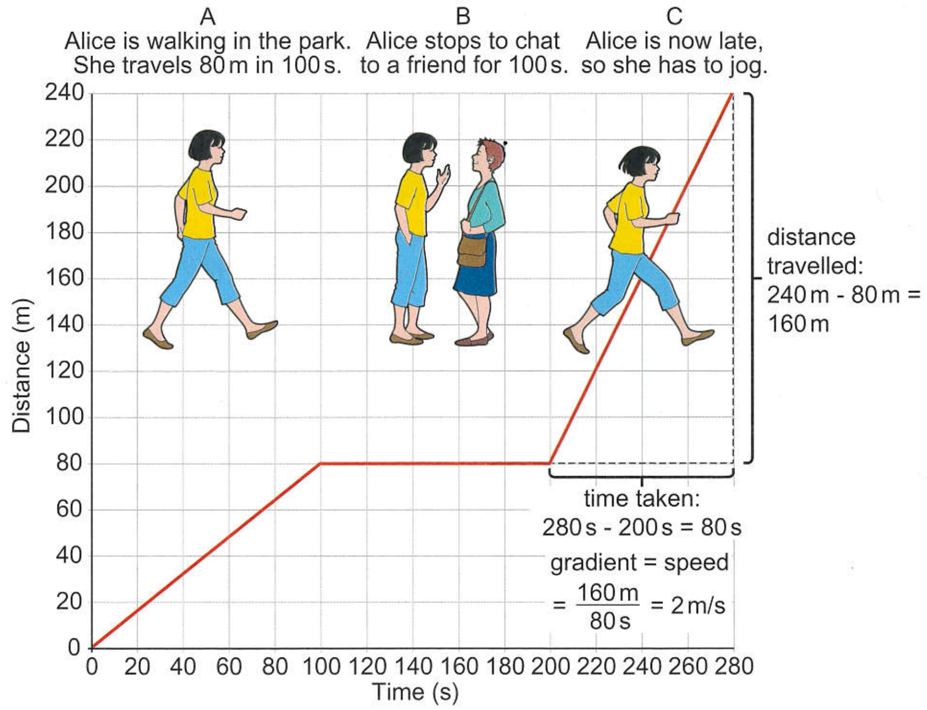


C some typical speeds

Distance/time graphs

A journey can be represented on a **distance/time graph**. Since time and distance are used to calculate speed, the graph can tell us various things about speed:

- horizontal lines mean the object is stationary (its distance from the starting point is not changing)
- straight, sloping lines mean the object is travelling at constant speed
- the steeper the line, the faster the object is travelling
- the speed is calculated from the **gradient** of the line.



D The gradient of a distance/time graph gives the speed.

Worked example W2

In graph D, what is Alice's speed for part C of her walk?

$$\text{gradient} = \frac{\text{vertical difference between two points on a graph}}{\text{horizontal difference between the same two points}}$$

$$= \frac{240\text{ m} - 80\text{ m}}{280\text{ s} - 200\text{ s}}$$

Make sure you take the starting value away from the end value each time.

$$\text{speed} = \frac{160\text{ m}}{80\text{ s}}$$

speed = 2 m/s

Exam-style question

A snail travels 300 cm in 4 minutes. Calculate the speed of the snail in m/s. *(3 marks)*

Did you know?

The fastest wind speed recorded was 113 m/s, in Australia in 1996. There may be higher wind speeds than this inside tornados, but they have never been recorded. A gale force wind blows at around 20 m/s.

3 Look at graph D. Calculate Alice's speed for:

a part A on the graph

b part B on the graph.

4 If Alice had not stopped to chat but had walked at her initial speed for 280 s, how far would she have travelled?

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 A peregrine falcon flies at 50 m/s for 7 seconds. How far does it fly?

S2 Zahir starts a race fast, then gets a stitch and has to stop. When he starts running again he goes more slowly than before. Sketch a distance/time graph to show Zahir's race if he runs at a constant speed in each section of the race.

Extend

E1 Look at question S2. Zahir's speeds are 3 m/s for 60 seconds, 2 m/s for 90 seconds and his rest lasted for 30 seconds. Plot a distance/time graph on graph paper to show his race.

SP1c Acceleration

Specification reference: P2.8; P2.9; P2.13

Progression questions

- How do you calculate accelerations from a change in velocity and a time?
- How are acceleration, initial velocity, final velocity and distance related?
- What is the acceleration of free fall?

A A fighter plane can accelerate from 0 to 80 m/s (180 mph) in 2 seconds.

Fighter planes taking off from aircraft carriers use a catapult to help them to accelerate to flying speed.

A change in velocity is called acceleration. Acceleration is a vector quantity – it has a size (magnitude) and a direction. If a moving object changes its velocity or direction, then it is accelerating.

The acceleration tells you the change in velocity each second, so the units of acceleration are metres per second per second. This is written as m/s² (metres per second squared). An acceleration of 10 m/s² means that each second the velocity increases by 10 m/s.

1 How are velocity and acceleration connected?

Acceleration is calculated using the following equation:

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

This can also be written as:

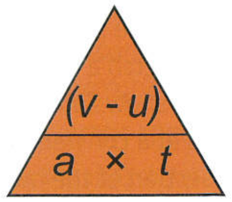
$$a = \frac{v - u}{t}$$

where a is the acceleration

v is the final velocity

u is the initial velocity

t is the time taken for the change in velocity.



B This triangle can help you to rearrange the equation.

Worked example W1

An airliner's velocity changes from 0 m/s to 60 m/s in 20 seconds. What is its acceleration?

$$a = \frac{v - u}{t}$$

$$= \frac{60 \text{ m/s} - 0 \text{ m/s}}{20 \text{ s}}$$

$$= 3 \text{ m/s}^2$$

2 Calculate the take-off acceleration of the fighter plane in photo A.

Acceleration does not always mean getting faster. An acceleration can also cause an object to get slower. This is sometimes called a **deceleration**, and the acceleration will have a negative value.

3 A car slows down from 25 m/s to 10 m/s in 5 seconds. Calculate its acceleration.

Acceleration can be related to initial velocity, final velocity and distance travelled by this equation:

$$(\text{final velocity})^2 - (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$$

$$(\text{m/s})^2 \qquad (\text{m/s})^2 \qquad (\text{m/s}^2) \qquad (\text{m})$$

This can also be written as $v^2 - u^2 = 2 \times a \times x$, where x represents distance.

Worked example W2

A car travelling at 15 m/s accelerates at 1.5 m/s² over a distance of 50 m. Calculate its final velocity.

$v^2 = (2 \times a \times x) + u^2$

$= (2 \times 1.5 \text{ m/s}^2 \times 50 \text{ m}) + (15 \text{ m/s} \times 15 \text{ m/s})$

$v^2 = 375 \text{ (m/s)}^2$

$v = \sqrt{375 \text{ (m/s)}^2}$

$= 19.4 \text{ m/s}$

4 A cyclist accelerates from 2 m/s to 8 m/s with an acceleration of 1.5 m/s². How far did she travel while she was accelerating? Use the equation $x = \frac{v^2 - u^2}{2 \times a}$.

Acceleration due to gravity

An object in free fall is moving downwards because of the force of gravity acting on it. If there are no other forces (such as air resistance), the acceleration due to gravity is 9.8 m/s². This is represented by the symbol g, and is often rounded to 10 m/s² in calculations.

5 Look at photo C.

a Calculate the acceleration on the ejecting pilot in m/s².

b How does this compare to everyday accelerations?

Exam-style question

A cheetah accelerates from rest to 30 m/s in 3 seconds. Calculate the acceleration of the cheetah. *(2 marks)*

Did you know?

Large accelerations are often compared to the acceleration due to gravity (g). The ejector seat in this aircraft can subject the pilot to accelerations of up to 12g or more.

C

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Explain how positive, negative and zero accelerations change the velocity of a moving object.

S2 A car travelling at 40 m/s comes to a halt in 8 seconds. What is the car's acceleration and how far does it travel while it is stopping?

Extend

E1 A train is travelling at 35 m/s. It slows down with an acceleration of –0.5 m/s². How much time does it take to stop and how far does it travel while it is stopping?

SP1d Velocity/time graphs

Specification reference: P2.10

Progression questions

- How do you compare accelerations on a velocity/time graph?
- How can you calculate acceleration from a velocity/time graph?
- How can you use a velocity/time graph to work out the total distance travelled?

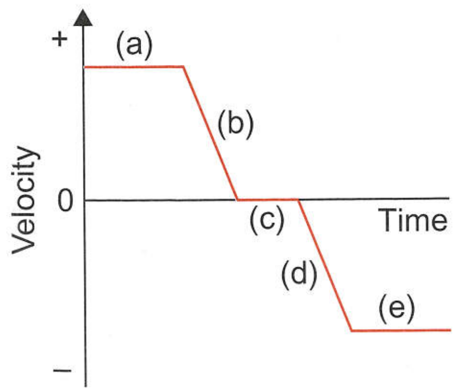
A Top Fuel dragsters can reach velocities of 150 m/s (335 mph) in only 4 seconds.

In a drag race, cars accelerate in a straight line over a short course of only a few hundred metres.

The changing velocity of a dragster during a race can be shown using a **velocity/time graph**.

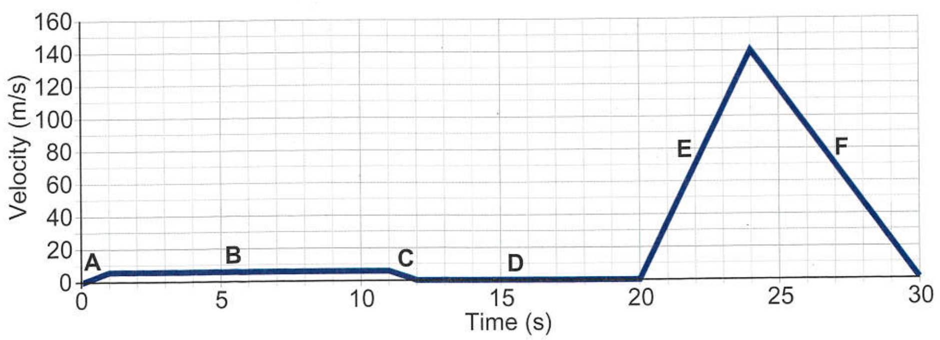
On a velocity/time graph:

- a horizontal line means the object is travelling at constant velocity
- a sloping line shows that the object is accelerating. The steeper the line, the greater the acceleration. If the line slopes down to the right, the object is decelerating (slowing down). You can find the acceleration of an object from the gradient of the line on a velocity/time graph.
- a negative velocity (a line below the horizontal axis) shows the object moving in the opposite direction.



B The graph shows a lift moving up at a constant speed (a), slowing to a stop (b) and waiting at a floor (c) then accelerating downwards (d) and then travelling downwards at a constant speed (e).

Graph C is a simplified velocity/time graph for a dragster. It shows the car driving slowly to the start line, waiting for the signal, and then racing.



C simplified velocity/time graph for a drag race

1 What does a horizontal line on a velocity/time graph tell you about an object's velocity?

2 a In which part of graph C is the dragster travelling at a constant velocity?

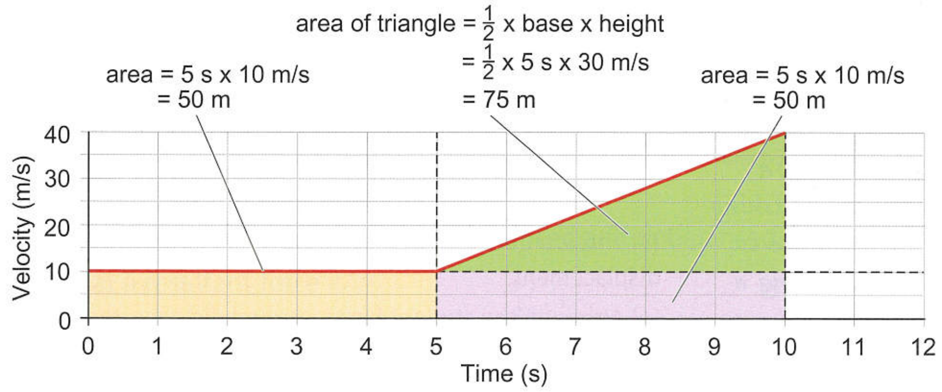
b In which part of the graph does the dragster have its greatest acceleration?

c Which part(s) of the graph show that the dragster is slowing down?

3 Look at graph C. Calculate the acceleration during part F of the journey.

Calculating distance travelled from a graph

The area under a velocity/time graph is the distance the object has travelled (distance is calculated by multiplying a velocity and a time). In graph D, the distance travelled in the first 5 seconds is the area of a rectangle. The distance travelled in the next 5 seconds is found by splitting the shape into a triangle and a rectangle, and finding their areas separately.



D

The total distance travelled by the object in graph D is the sum of all the areas.

total distance travelled = 50 m + 50 m + 75 m = 175 m

4 Look at graph C. The dragster travels at 5 m/s as it approaches the start line.

a How far does it travel to get to the start line?

b What is the distance travelled by the dragster during the race and slowing down afterwards?

5 Mel draws a graph showing a bus journey through town. Explain why this should be called a speed/time graph, not a velocity/time graph.

Exam-style question

Explain why the area under part of a velocity/time graph gives you the distance covered. *(3 marks)*

Checkpoint

How confidently can you answer the Progression questions?

Strengthen

S1 Table E below gives some data for a train journey. Draw a velocity/time graph from this and join the points with straight lines. Label your graph with all the things you can tell from it. Show your working for any calculations you do.

Time (s)	Velocity (m/s)
0	0
20	10
30	30
60	30
120	0

E

Extend

E1 In a fitness test, students run up and down the sports hall. They have to run faster after each time they turn around. Sketch a velocity/time graph for 4 lengths of the hall, if each length is run at a constant speed.