Edexcel GCSE Physics

Your notes

Describing Motion

Contents

Scalars & Vectors

Your notes

Scalar & Vector Quantities

- All quantities can be one of two types:
  - A **scalar**
  - A **vector**

Scalars

- Scalars are quantities that have only a **magnitude**
  - For example, **mass** is a scalar since it is a quantity that has magnitude without a direction
  - **Distance** is also a scalar since it only contains a magnitude, not a direction

Vectors

- Vectors have both **magnitude** and **direction**
- **Velocity**, for instance, is a vector since it is described with both a magnitude and a direction
  - When describing the velocity of a car it is necessary to mention **both** its **speed** and the **direction** in which it is travelling
  - For example, the velocity might be 60 km per hour (magnitude) due west (direction)
- **Distance** is a value describing only how long an object is or how far it is between two points - this means it is a **scalar** quantity
- **Displacement** on the other hand also describes the **direction** in which the distance is measured - this means it is a **vector** quantity
  - For example, a displacement might be 100 km north

Examples of Scalars & Vectors

- The table below lists some common examples of scalar and vector quantities:

Scalars & Vectors Table

Scalar	Vector
Distance	Displacement
Speed	Velocity
Mass	Weight
Energy	
Volume	
Density	
Temperature	
Power	
	Force
	Acceleration
	Momentum

Your notes

- Some vectors and scalars are similar to each other
  - For example, the scalar quantity **distance** corresponds to the vector quantity **displacement**
- Corresponding vectors and their scalar counterparts are aligned in the table where applicable

Comparing Scalars & Vectors

- The table below compares some vector and scalar quantities related to moving objects

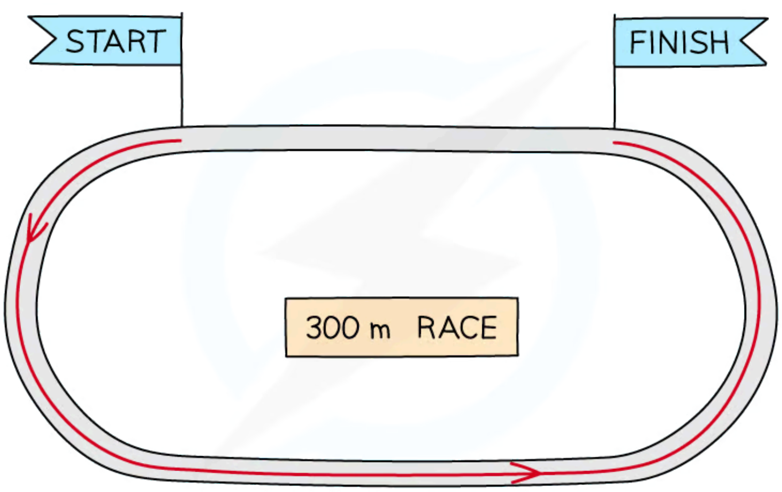
Table showing the difference between vector and scalar quantities

Your notes

Quantity	Type	Magnitude	Direction	Definition
Distance	Scalar	✓	✗	How far an object travels
Displacement	Vector	✓	✓	The distance of an object from its starting position, along with its direction
Speed	Scalar	✓	✗	The distance an object travels every second
Velocity	Vector	✓	✓	The speed of a moving object and its direction

Difference between distance and displacement

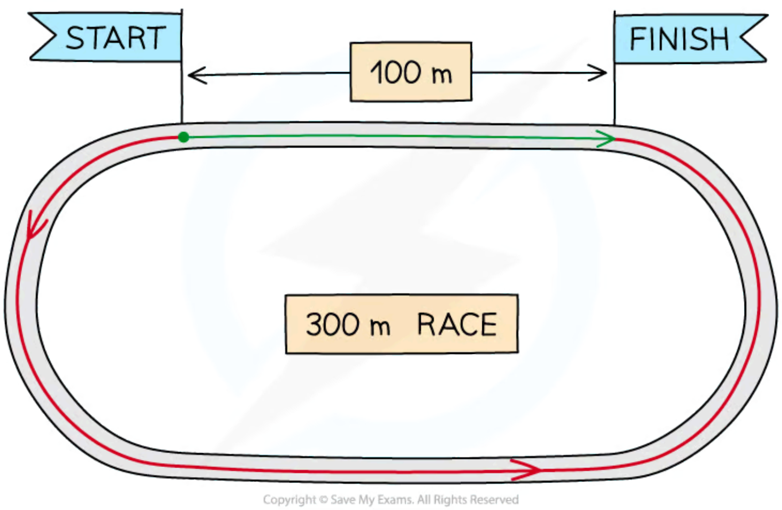
- **Distance** is a measure of how far an object travels
- It is a **scalar** quantity - it has a size (magnitude), but the direction is not important
- Consider a 300 m race:
  - From start to finish, the **distance** travelled by the athletes is **300 m**



The athletes run a total distance of 300 m

Your notes

- **Displacement** is a measure of how far something is from its starting position, along with its direction
- It is a **vector** quantity - it describes **both** magnitude and direction
- Consider the same 300 m race again
  - The athletes still run a total **distance** of **300 m** (indicated by the red arrow)
  - However, at the end of the race, their **displacement** is **100 m to the right** of the starting point (indicated by the green arrow)
  - If they had run the full 400 m, their displacement would have been **zero**



The athletes run a total distance of 300 m, but end up 100 m from where they started

Worked Example

Blu is in charge of training junior astronauts. For one of his sessions, he would like to explain the difference between mass and weight.

Suggest how Blu should explain the difference between mass and weight, using definitions of scalars and vectors in your answer.

Answer:

Step 1: Recall the definitions of a scalar and vector quantity

- Scalars are quantities that have only a **magnitude**
- Vectors are quantities that have both **magnitude and direction**

Step 2: Identify which quantity has magnitude only

- **Mass** is a quantity with **magnitude** only
- So mass is a **scalar** quantity
  - Blu might explain to his junior astronauts that their mass will not change if they travel to outer space

Step 3: Identify which quantity has magnitude and direction

- **Weight** is a quantity with **magnitude and direction** (it is a force)
- So weight is a **vector** quantity
  - Blu might explain that to his junior astronauts that their weight - the force on them due to gravity - will vary depending on their distance from the centre of the Earth

Examiner Tips and Tricks

Make sure you are comfortable with the differences between **similar** scalars and vectors, the most commonly confused pairings tend to be:

- Distance and displacement
- Speed and velocity
- Weight and mass

Your notes

Your notes

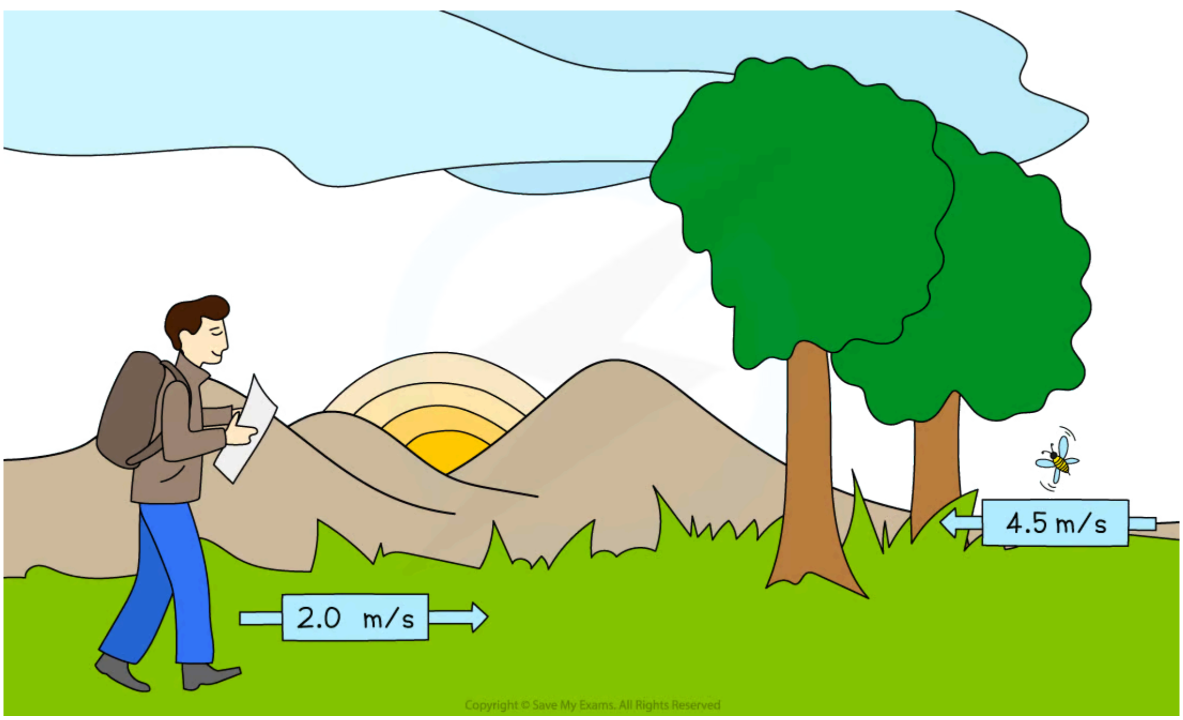
Speed

Calculating Speed

- The **speed** of an object is the distance it travels every second
- Speed is a **scalar** quantity
  - This is because it only contains a magnitude (without a direction)
- For objects that are moving with a constant speed, use the equation below to calculate the speed:

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

- Where:
  - Speed is measured in metres per second (m/s)
  - Distance travelled is measured in metres (m)
  - Time taken is measured in seconds (s)



A hiker might have an average speed of 2.0 m/s, whereas a particularly excited bumble bee can have average speeds of up to 4.5 m/s

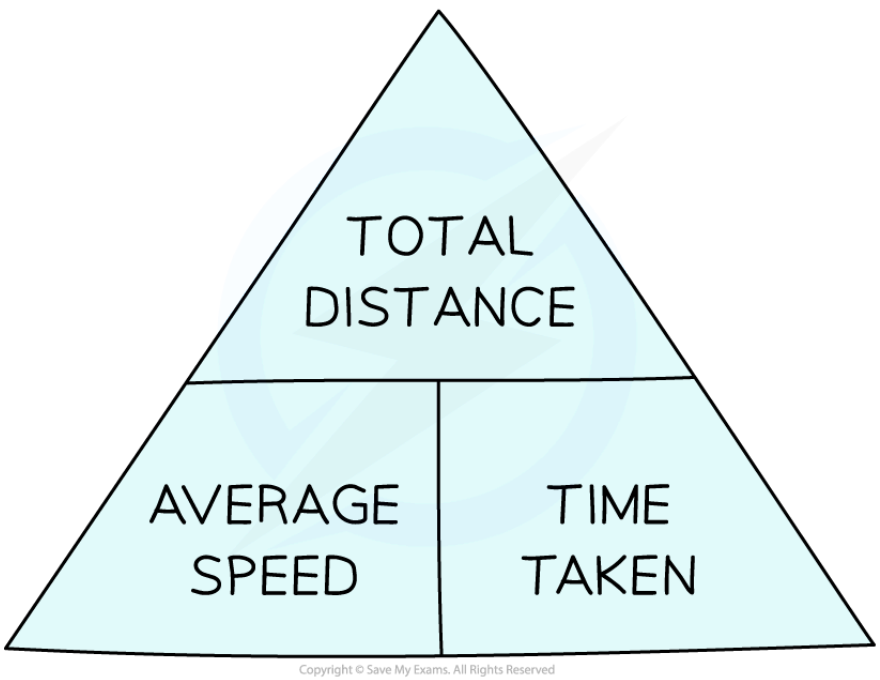
Your notes

Calculating Average Speed

- In some cases, the speed of a moving object is not constant
  - For example, the object might be moving faster or slower at certain moments in time (accelerating and decelerating)
- The equation for calculating the **average speed** of an object is:

$$\text{Average speed} = \frac{\text{total distance}}{\text{time taken}}$$

- The formula for **average speed** (and the formula for **speed**) can be rearranged with the help of the formula triangle below:



How to Use Formula Triangles

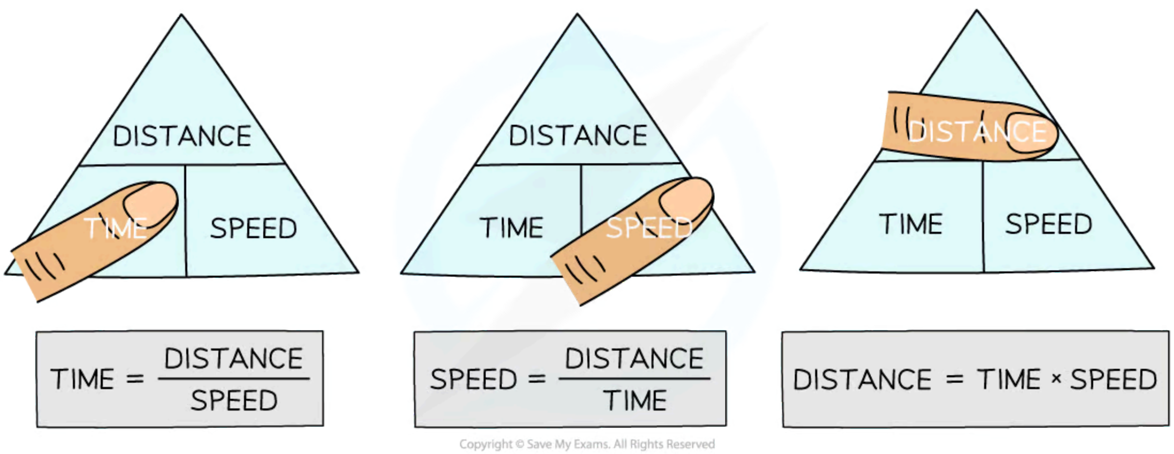
- Formula triangles are really useful for knowing how to rearrange physics equations

Your notes

- To use them:

1. Cover up the quantity to be calculated, this is known as the 'subject' of the equation
2. Look at the position of the other two quantities
   - If they are on the same line, this means they are **multiplied**
   - If one quantity is above the other, this means they are **divided** - make sure to keep the order of which is on the top and bottom of the fraction!

- In the example below, to calculate speed, cover-up 'speed' and only distance and time are left
  - This means it is equal to distance (on the top) ÷ time (on the bottom)



How to use formula triangles

Worked Example

Planes fly at typical speeds of around 250 m/s.Calculate the total distance travelled by a plane moving at this average speed for 2 hours.

Answer:

Step 1: List the known quantities

- Average speed = 250 m/s
- Time taken = 2 hours

Step 2: Write the relevant equation

$$\text{Average speed} = \frac{\text{total distance}}{\text{time taken}}$$

Step 3: Rearrange for the total distance

$$\text{total distance} = \text{average speed} \times \text{time taken}$$

Step 4: Convert any units

- The time given in the question is not in standard units
- Convert 2 hours into seconds:

$$2 \text{ hours} = 2 \times 60 \times 60 = 7200 \text{ s}$$

Step 5: Substitute the values for average speed and time taken

$$\text{total distance} = 250 \times 7200 = 1\,800\,000 \text{ m}$$

Your notes

Your notes

Velocity

Velocity

- The **velocity** of a moving object is similar to its speed, except it also describes the object's **direction**
  - The speed of an object only contains a magnitude - it's a **scalar** quantity
  - The velocity of an object contains both **magnitude and direction**, e.g. '15 m/s south' or '250 mph on a bearing of 030°'
- Velocity is therefore a **vector** quantity because it describes both magnitude and direction

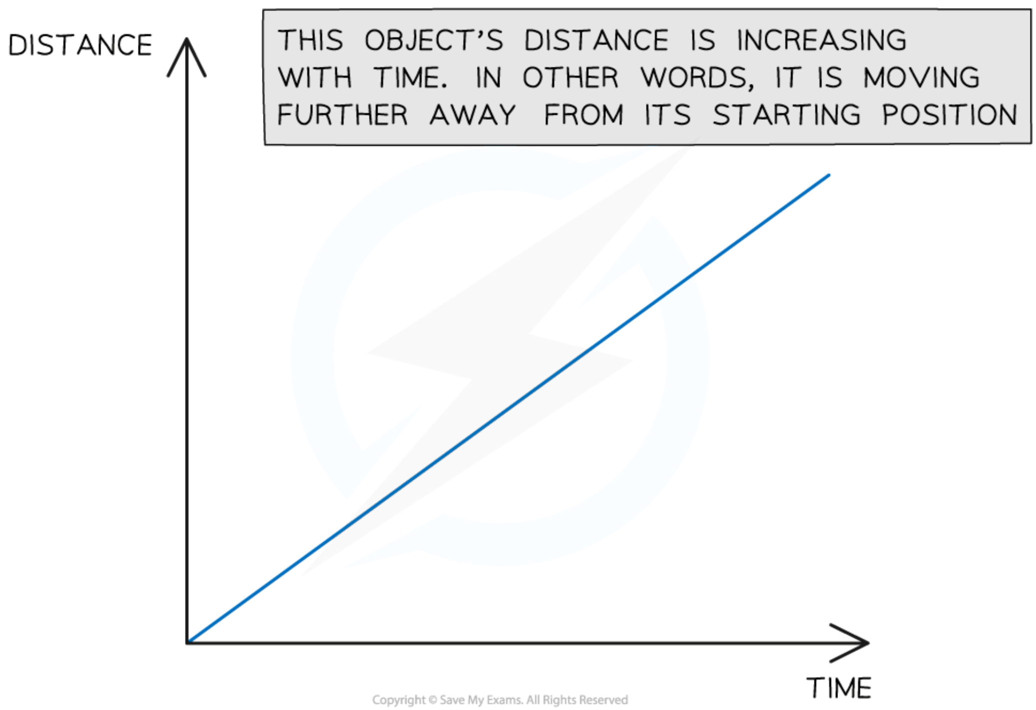
The cars in the diagram above have the same speed (a scalar quantity) but different velocities (a vector quantity). Fear not, they are in different lanes!

Your notes

Distance-Time Graphs

Distance-Time Graphs

- A distance-time graph shows how the **distance** of an object moving in a straight line (from a starting position) varies over time



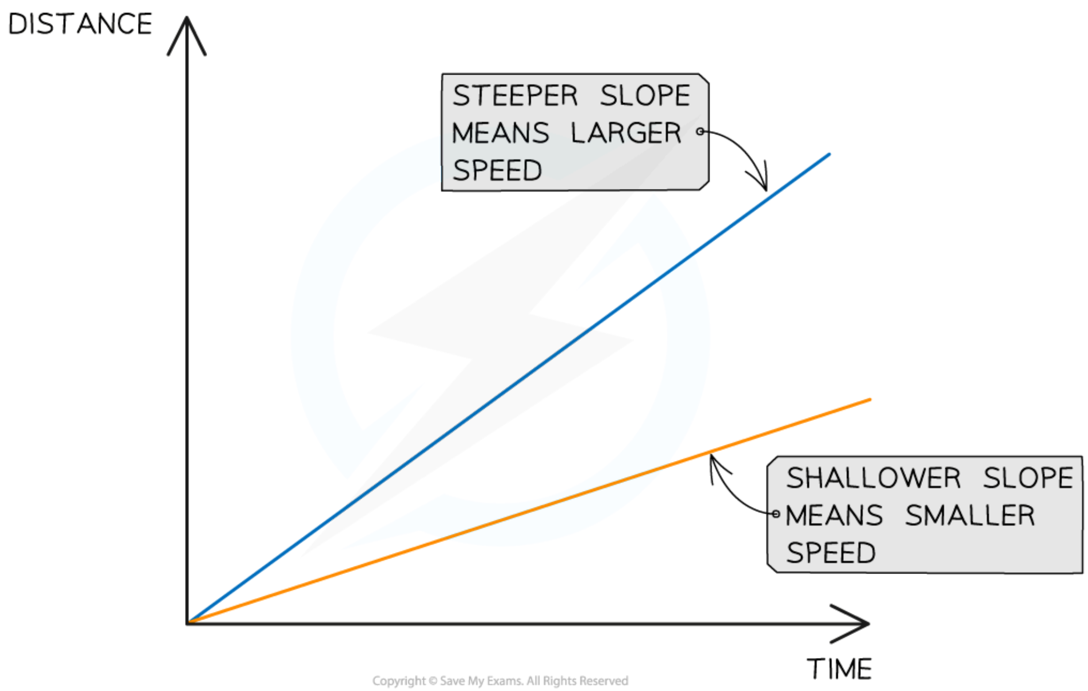
This graph shows a moving object moving further away from its origin

Constant Speed on a Distance-Time Graph

- Distance-time graphs also show the following information:
  - If the object is moving at a **constant speed**
  - How **large** or **small** the speed is
- A **straight line** represents **constant speed**
- The slope of the straight line represents the **magnitude** of the speed:
  - A very **steep** slope means the object is moving at a **large** speed

Your notes

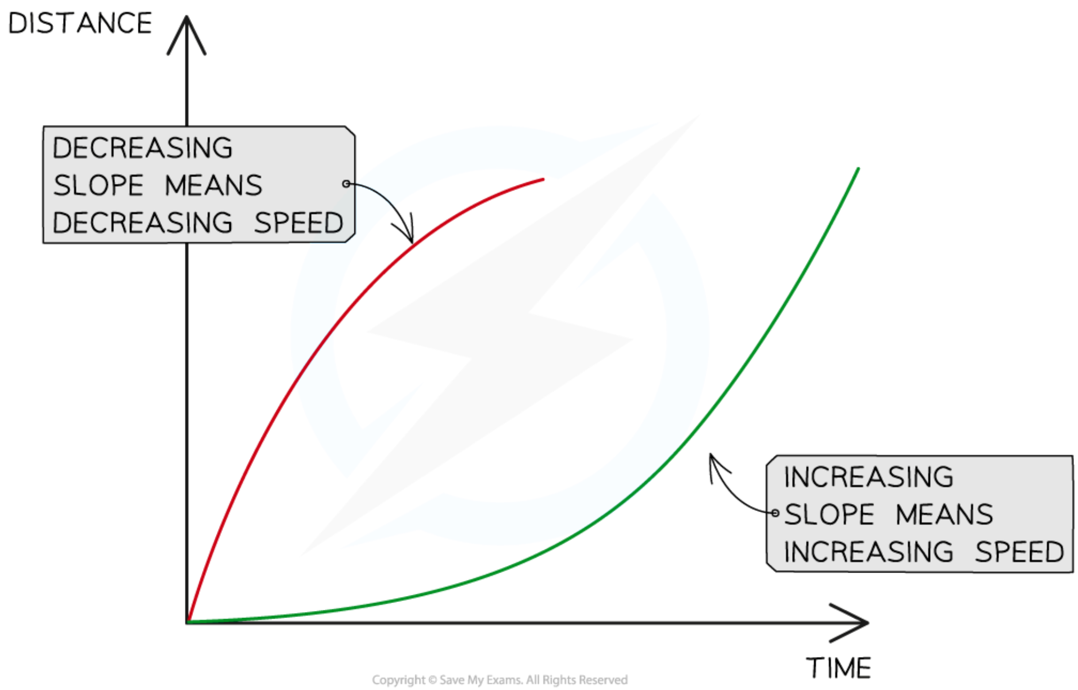
- A **shallow** slope means the object is moving at a **small** speed
- A **flat**, **horizontal line** means the object is **stationary** (not moving)



This graph shows how the slope of a line is used to interpret the speed of moving objects. Both of these objects are moving with a constant speed, because the lines are straight.

Changing Speed on a Distance-Time Graph

- Objects sometimes move at a **changing speed**
  - This is represented by a **curve**
- In this case, the slope of the line will be changing
  - If the slope is **increasing**, the **speed** is **increasing** (accelerating)
  - If the slope is **decreasing**, the **speed** is **decreasing** (decelerating)
- The image below shows two different objects moving with changing speeds



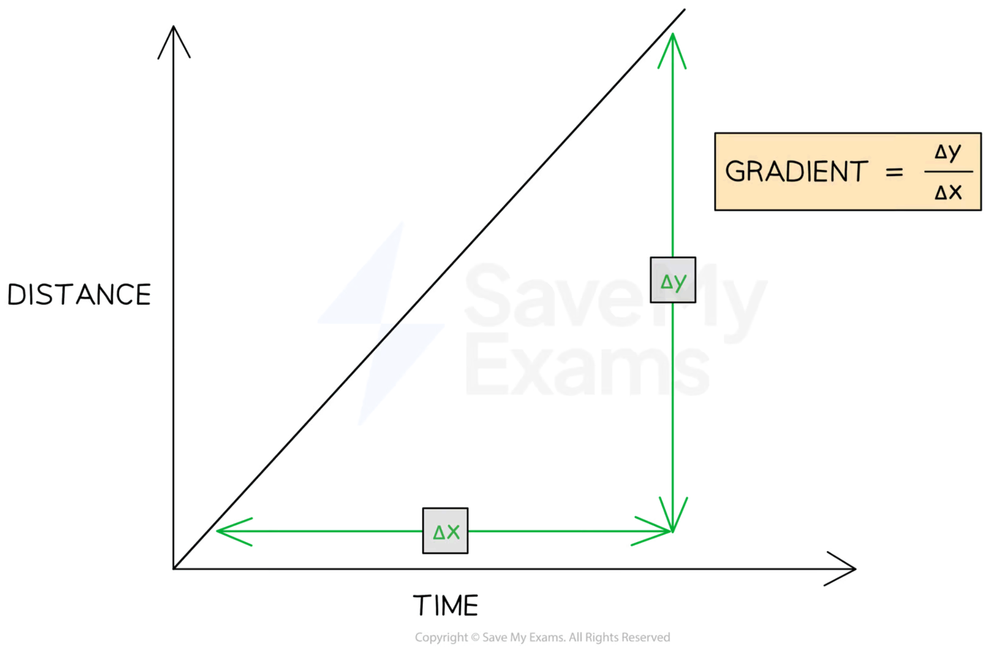
Changing speeds are represented by changing slopes. The red line represents an object slowing down and the green line represents an object speeding up.

Gradient of a Distance-Time Graph

- The **speed** of a moving object can be calculated from the **gradient** of the line on a **distance-time** graph:

$$\text{speed} = \text{gradient} = \frac{\Delta y}{\Delta x}$$

Your notes

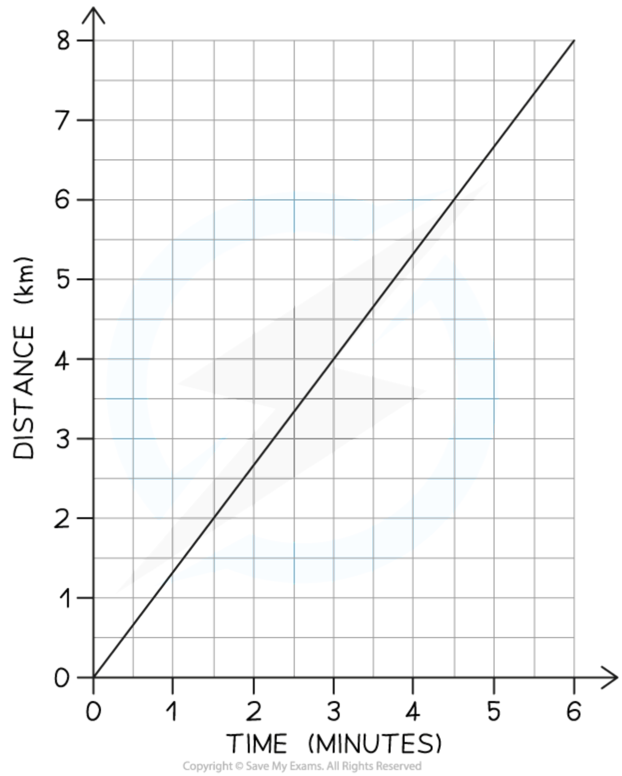


The speed of an object can be found by calculating the gradient of a distance-time graph

- Δy is the **change** in y (distance) values
- Δx is the **change** in x (time) values

Worked Example

A distance-time graph is drawn below for part of a train journey. The train is travelling at a constant speed.



Your notes

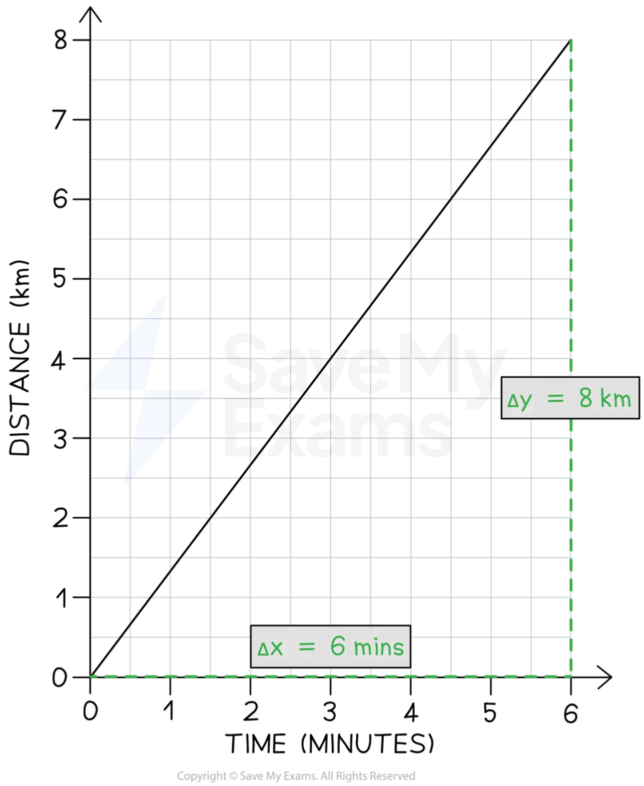
Calculate the speed of the train.

Answer:

Step 1: Draw a large gradient triangle on the graph

- The image below shows a large **gradient triangle** drawn with dashed lines
- Δy and Δx are labelled, using the **units** as stated on each axis

Your notes



Step 2: Convert units for distance and time into standard units

- The distance travelled = 8 km = **8000 m**
- The time taken = 6 mins = **360 s**

Step 3: State that speed is equal to the gradient of a distance-time graph

- The **gradient** of a **distance-time** graph is equal to the **speed** of a moving object:

$$\text{speed} = \text{gradient} = \frac{\Delta y}{\Delta x}$$

Step 4: Substitute values to calculate the speed

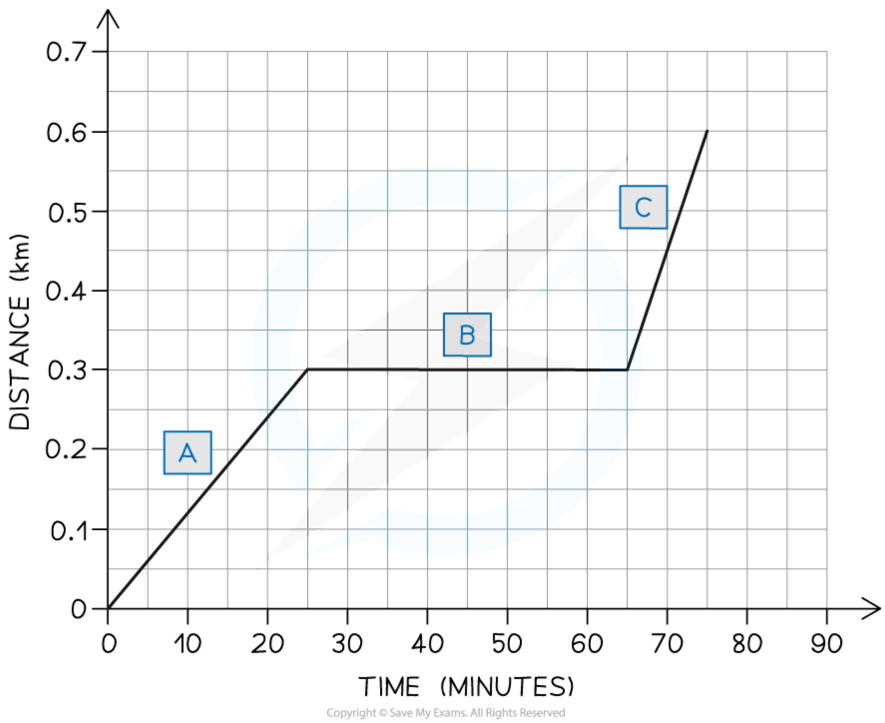
$$\text{speed} = \frac{8000}{360}$$

$$\text{speed} = 22.2 \text{ m/s}$$

Your notes

Worked Example

Ose decides to take a stroll to the park. He finds a bench in a quiet spot and takes a seat, picking up where he left off reading his book on Black Holes. After some time reading, Ose realises he lost track of time and runs home. A distance-time graph for his trip is drawn below:



a) How long does Ose spend reading his book?There are three sections labelled on the graph: A, B and C.

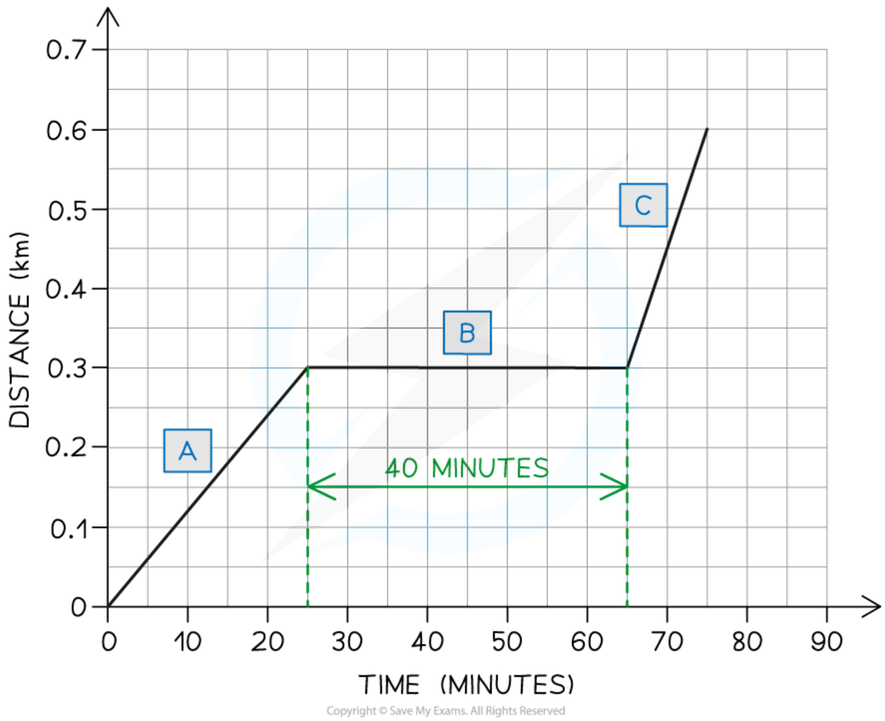
b) Which section represents Ose running home?

c) What is the total distance travelled by Ose?

Answer:

Part (a)

- Ose spends **40 minutes** reading his book
- The **flat** section of the line (section B) represents an object which is **stationary** - so section B represents Ose sitting on the bench reading
- This section lasts for **40 minutes** - as shown in the graph below



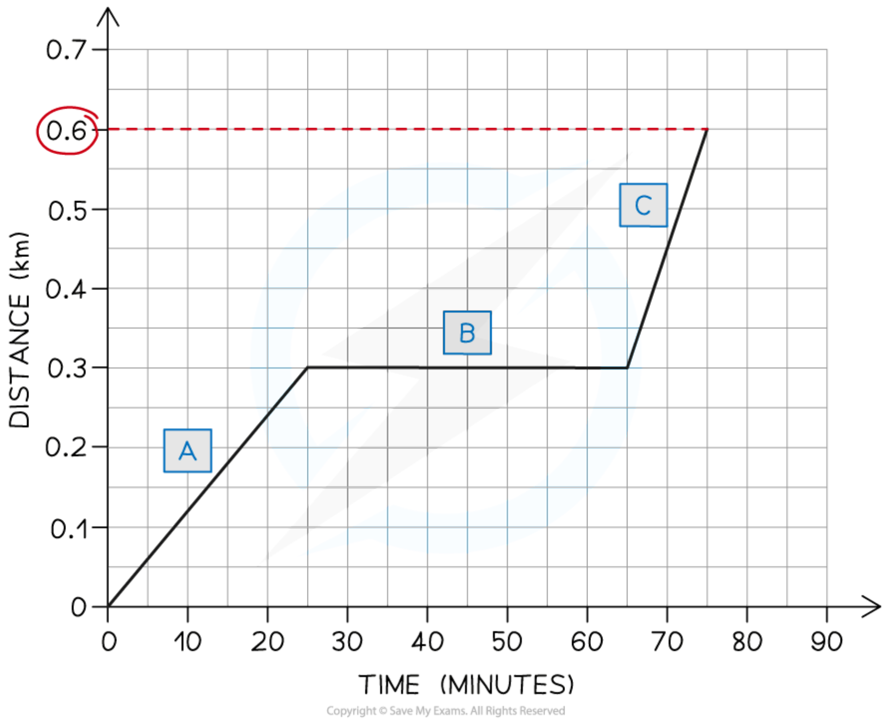
Your notes

Part (b)

- **Section C** represents Ose running home
- The **slope** of the line in section C is **steeper** than the slope in section A
- This means Ose was moving with a **larger** speed (running) in section C

Part (c)

- The total distance travelled by Ose is **0.6 km**
- The total **distance** travelled by an object is given by the final point on the line - in this case, the line ends at **0.6 km** on the **distance** axis. This is shown in the image below:



Your notes

Examiner Tips and Tricks

- Use the **entire line**, where possible, to calculate the gradient. Examiners tend to award credit if they see a **large gradient triangle** used - so remember to draw these directly on the graph itself!
- Remember to check the **units** of variables measured on each axis. These may not always be in standard units - in our example, the unit of distance was **km** and the unit of time was **minutes**. Double-check which units to use in your answer.

Your notes

Acceleration

Acceleration

- **Acceleration** is defined as the **rate of change of velocity**
- In other words, it describes how much an object's velocity **changes** every **second**
- The equation below is used to calculate the average acceleration of an object:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$a = \frac{\Delta v}{t}$$

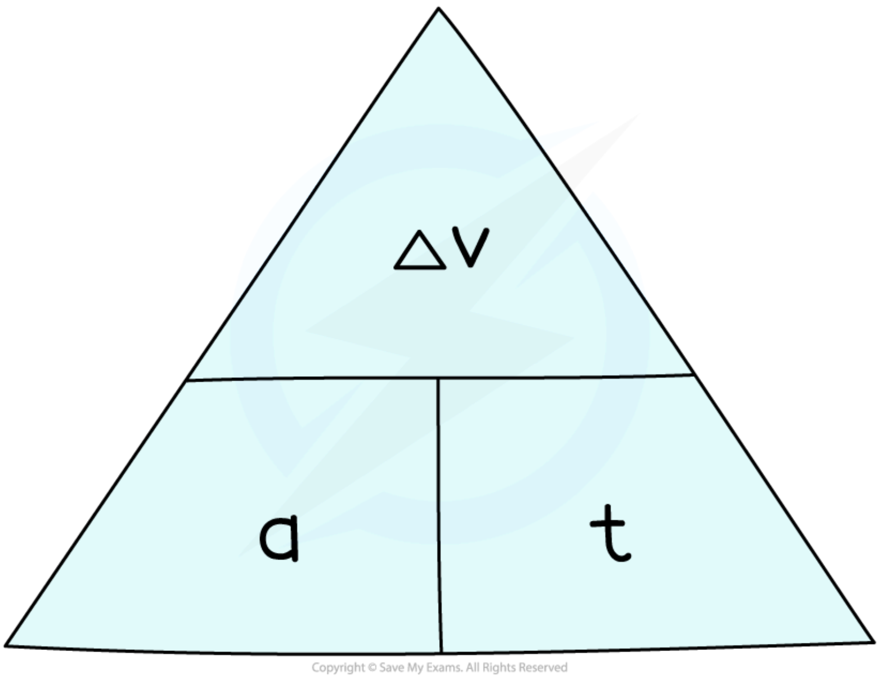
- Where:
  - a = acceleration in metres per second squared (m/s^2)
  - Δv = change in velocity in metres per second (m/s)
  - t = time taken in seconds (s)
- The **change in velocity** is found by the **difference** between the initial and final velocity, as written below:

change in velocity = final velocity – initial velocity

$$\Delta v = v - u$$

- Where:
  - v = final velocity in metres per second (m/s)
  - u = initial velocity in metres per second (m/s)
- The equation for acceleration can be rearranged with the help of a formula triangle as shown:

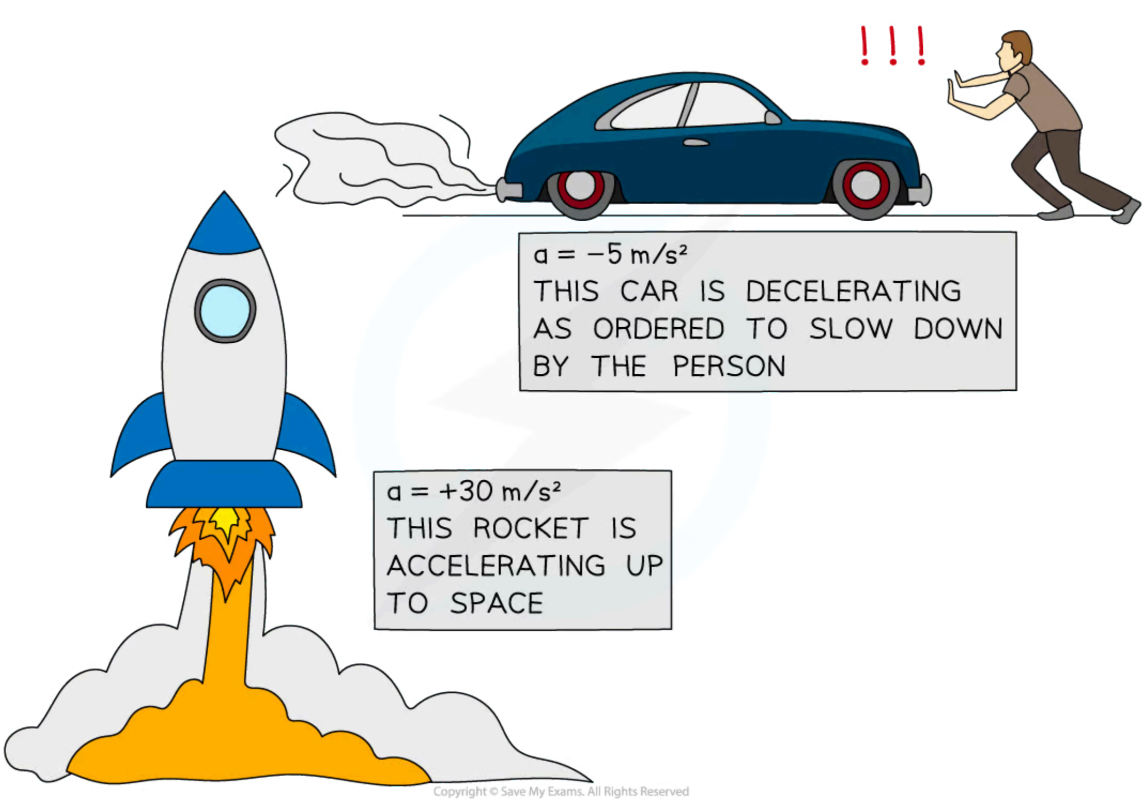
Your notes



Speeding Up & Slowing Down

- An object that speeds up is **accelerating**
- An object that slows down is **decelerating**
- The **acceleration** of an object can be **positive** or **negative**, depending on whether the object is speeding up or slowing down
  - If an object is **speeding up**, its acceleration is **positive**
  - If an object is **slowing down**, its acceleration is **negative** (sometimes called **deceleration**)

Your notes



A rocket speeding up (accelerating) and a car slowing down (decelerating)

Worked Example

A Japanese bullet train decelerates at a constant rate in a straight line. The velocity of the train decreases from 50 m/s to 42 m/s in 30 seconds.

(a) Calculate the change in velocity of the train.

(b) Calculate the deceleration of the train, and explain how your answer shows the train is slowing down.

Answer:

Part (a)

Step 1: List the known quantities

- Initial velocity, $u = 50 \text{ m/s}$

- Final velocity, $v = 42 \text{ m/s}$

Step 2: Write down the relevant equation

change in velocity = final velocity – initial velocity

$$\Delta v = v - u$$

Step 3: Substitute values for final and initial velocity

$$\Delta v = 42 - 50 = -8 \text{ m/s}$$

- The velocity of the train **decreases** by 8 m/s

Part (b)

Step 1: List the known quantities

- Change in velocity, $\Delta v = -8 \text{ m/s}$
- Time taken, $t = 30 \text{ s}$

Step 2: Write down the relevant equation

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

$$a = \frac{\Delta v}{t}$$

Step 3: Substitute the values for change in velocity and time

$$a = \frac{-8}{30} = -0.27 \text{ m/s}^2$$

Step 4: Interpret the value for deceleration

- The answer is **negative**, which indicates the train is **slowing down**

Examiner Tips and Tricks

Remember the units for acceleration are **metres per second squared**, m/s^2

In other words, acceleration measures how much the velocity (in m/s) changes every second, m/s/s.

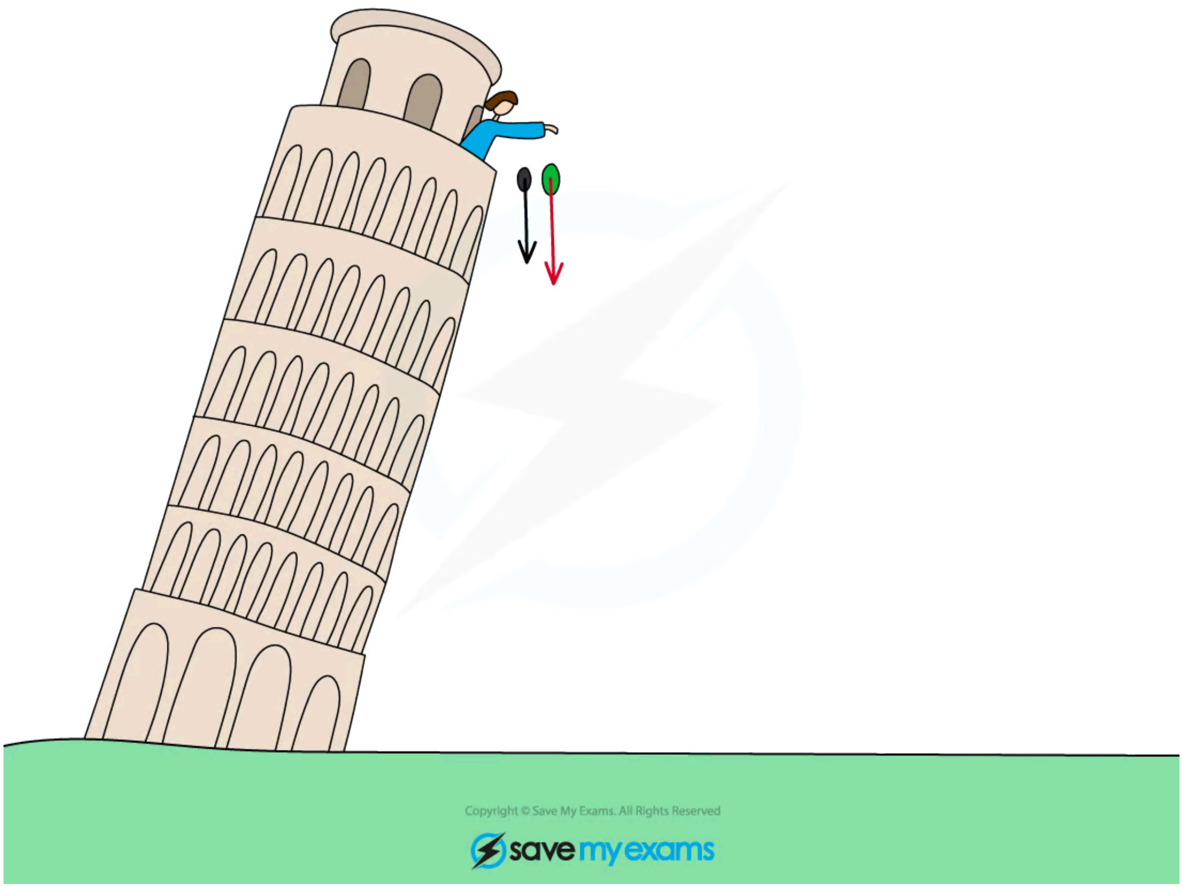
Freefall

Your notes

Your notes

- In the absence of **air resistance**, all objects fall with the **same acceleration**
- This is called the **acceleration due to gravity:**

$$g = \text{acceleration due to gravity} = 10\ \text{m/s}^2$$



In the absence of air resistance, Galileo discovered that all objects (near Earth's surface) fall with an acceleration of about 10 m/s²

- This means that for every second an object falls, its velocity will increase by 10 m/s

Estimating Accelerations

- The **acceleration** of an object is a measure of **how quickly its velocity changes**
- A typical family car, for example, takes around 10 seconds to go from 0 m/s to 27 m/s (roughly 60 mph)
  - This is an acceleration of about 2.7 m/s^2

Your notes

- The table below gives some other **typical accelerations**:

Typical Accelerations Table

Example	Typical Acceleration (m/s^2)
Family car	2 – 3
Falling object	10
Rocket	30
Formula 1 car	50
Fighter jet	90 – 120

Examiner Tips and Tricks

You should be able to **estimate** the magnitude of everyday accelerations. Memorise the examples given in the table to develop a sense of the **magnitude** of different accelerating objects.

Your notes

Calculating Uniform Acceleration

Calculating Uniform Acceleration

- The following equation of motion applies to objects moving with **uniform (constant) acceleration**:

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

$$v^2 - u^2 = 2 \times a \times x$$

- Where:
  - x = distance travelled in metres (m)
  - u = initial speed in metres per second (m/s)
  - v = final speed in metres per second (m/s)
  - a = acceleration in metres per second squared (m/s^2)
- This equation is used to calculate quantities such as **initial or final speed**, **acceleration**, or **distance travelled** in cases where the **time taken** is **not known**

Worked Example

A car accelerates steadily from rest at a rate of 2.5 m/s^2 up to a speed of 16 m/s. Calculate how far the car moves during this period of acceleration.

Answer:

Step 1: Identify and write down the equation to use

- The question says that the car '**accelerates steadily**' - so the equation for **uniform acceleration** can be used:

$$v^2 - u^2 = 2 \times a \times x$$

Step 2: List the known quantities

- Initial speed, u = 0 m/s (the car starts **from rest**)
- Final speed, v = 16 m/s
- Acceleration, a = 2.5 m/s^2
- Distance, x = ? (this needs to be calculated)

Step 3: Substitute known quantities into the equation and simplify where possible

$$16^2 - 0^2 = (2 \times 2.5 \times x)$$

- This can be simplified to:

$$256 = 5 \times x$$

Step 4: Rearrange the equation to work out the distance travelled

$$x = 256 \div 5$$

$$x = \mathbf{51.2\ m}$$

Your notes

Examiner Tips and Tricks

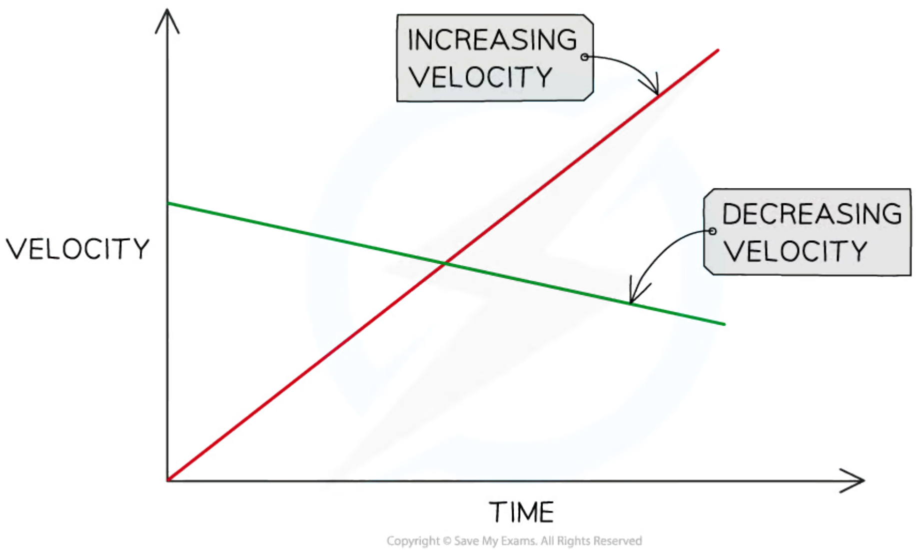
Writing out your **list of known quantities**, and labelling the quantity you need to calculate, is really good exam technique. It helps you determine the correct equation to use, and sometimes examiners award credit for showing this working.

Velocity-Time Graphs

Your notes

Velocity-Time Graphs

- A velocity-time graph shows how the velocity of a moving object varies with time
  - The red line represents an object with **increasing** velocity
  - The green line represents an object with **decreasing** velocity

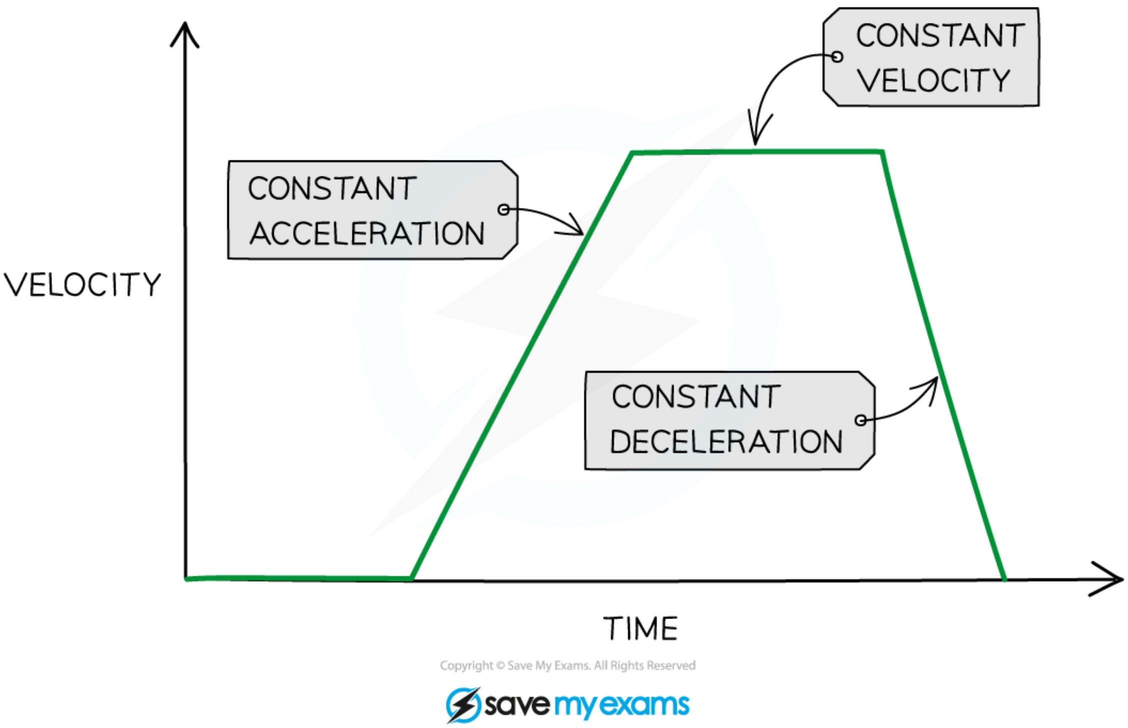


Increasing and decreasing velocity represented on a velocity-time graph

Acceleration on a Velocity-Time Graph

- Velocity-time graphs also show the following information:
  - If the object is moving with a **constant acceleration/deceleration**
  - The **magnitude** of the acceleration/deceleration
- A **straight line** represents **constant acceleration**
- The **slope** of the line represents the **magnitude** of acceleration
  - A **steep** slope means **large acceleration** (or deceleration) - i.e. the object's speed changes very **quickly**

- A **gentle** slope means **small acceleration** (or deceleration) - i.e. the object's speed changes very **gradually**
- A **flat line** means the acceleration is **zero** - i.e. the object is moving with a **constant velocity**



Interpreting the slope of a velocity-time graph

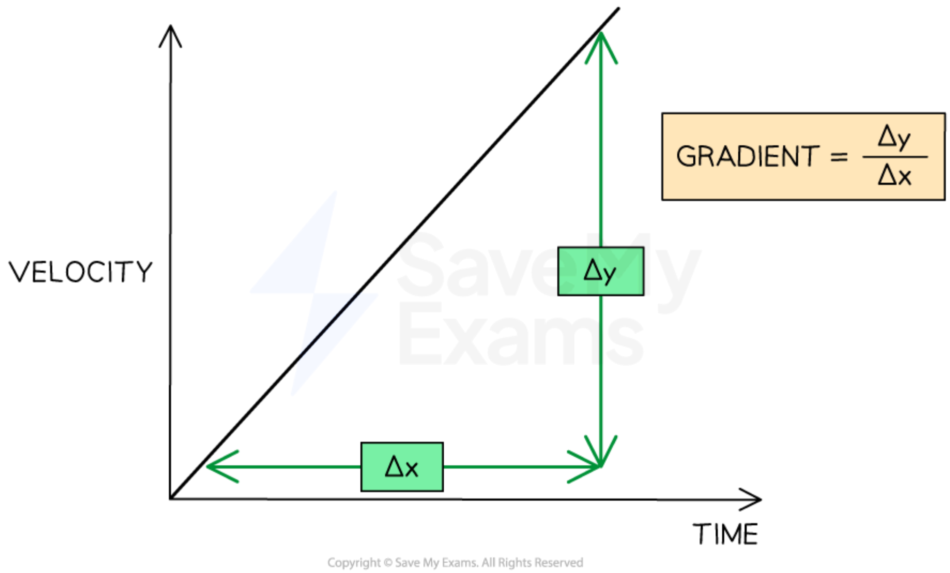
Gradient of a Velocity-Time Graph

- The **acceleration** of an object can be calculated from the **gradient** of a velocity-time graph

$$\text{acceleration} = \text{gradient} = \frac{\Delta x}{\Delta y}$$

Your notes

Your notes



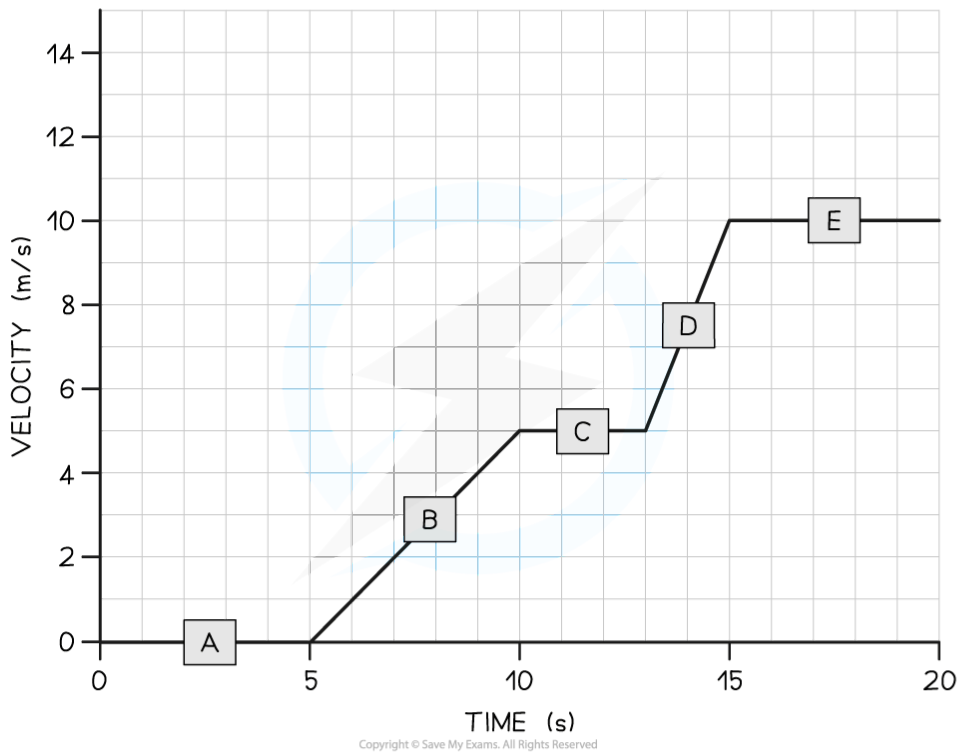
The gradient of a velocity-time graph can be found by dividing the change in velocity by the change in time

Worked Example

A cyclist is training for a cycling tournament.

The velocity-time graph below shows the cyclist's motion as they cycle along a flat, straight road.

Your notes



(a) In which section (A, B, C, D, or E) of the velocity-time graph is the cyclist's acceleration the largest?

(b) Calculate the cyclist's acceleration between 5 and 10 seconds.

Answer:

Part (a)

Step 1: Recall that the slope of a velocity-time graph represents the magnitude of acceleration

- The slope of a velocity-time graph indicates the magnitude of acceleration

  Therefore, the only sections of the graph where the cyclist is accelerating are sections B and D
- Sections A, C, and E are flat; in other words, the cyclist is moving at a constant velocity (therefore, not accelerating)

Step 2: Identify the section with the steepest slope

- Section D of the graph has the steepest slope
- Hence, the largest acceleration is shown in section D

Part (b)

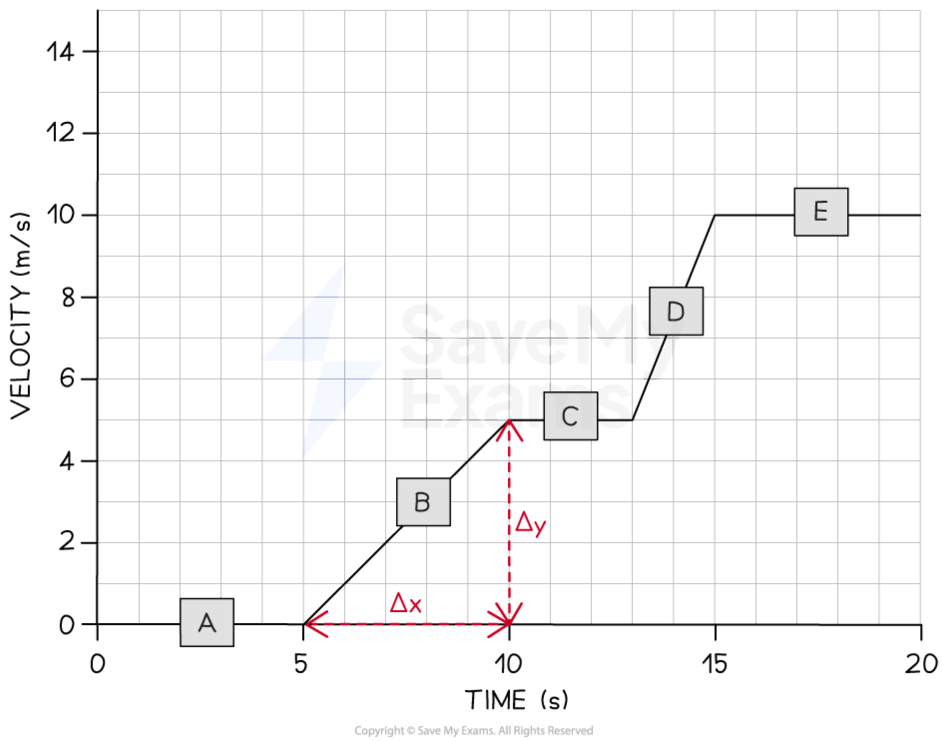
Step 1: Recall that the gradient of a velocity-time graph gives the acceleration

Your notes

- Calculating the gradient of a slope on a velocity-time graph gives the acceleration for that time period

Step 2: Draw a large gradient triangle at the appropriate section of the graph

- A gradient triangle is drawn for the time period between 5 and 10 seconds



Step 3: Calculate the size of the gradient and state this as the acceleration

- The acceleration is given by the gradient, which can be calculated using:

$$a = \frac{\Delta y}{\Delta x}$$

$$a = \frac{5}{5}$$

$$a = 1 \text{ m/s}^2$$

- Therefore, the cyclist accelerated at 1 m/s^2 between 5 and 10 seconds

Examiner Tips and Tricks

Use the **entire slope**, where possible, to calculate the gradient. Examiners tend to award credit if they see a **large gradient triangle** used.

Remember to actually draw the lines directly on the graph itself, particularly when the question asks you to **use the graph** to calculate the acceleration.

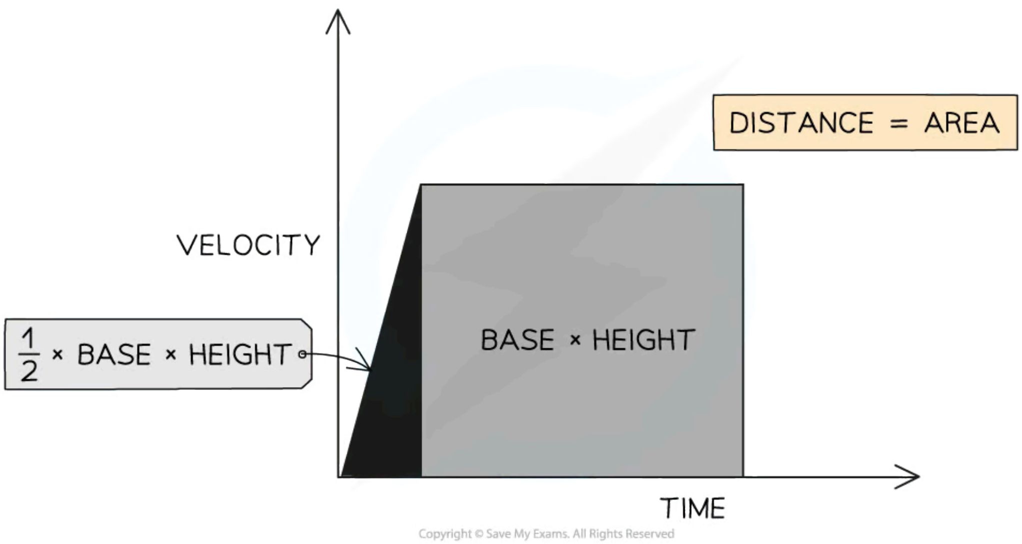
Your notes

Your notes

Area under a Velocity-Time Graph

Area under a Velocity-Time Graph

- The area under a **velocity-time graph** represents the **displacement** (or **distance travelled**) by an object



The displacement, or distance travelled, is represented by the area beneath the graph

- If the area beneath the graph forms a **triangle** (i.e. the object is **accelerating** or **decelerating**), then the area can be determined by using the following formula:

Area = ½ × Base × Height

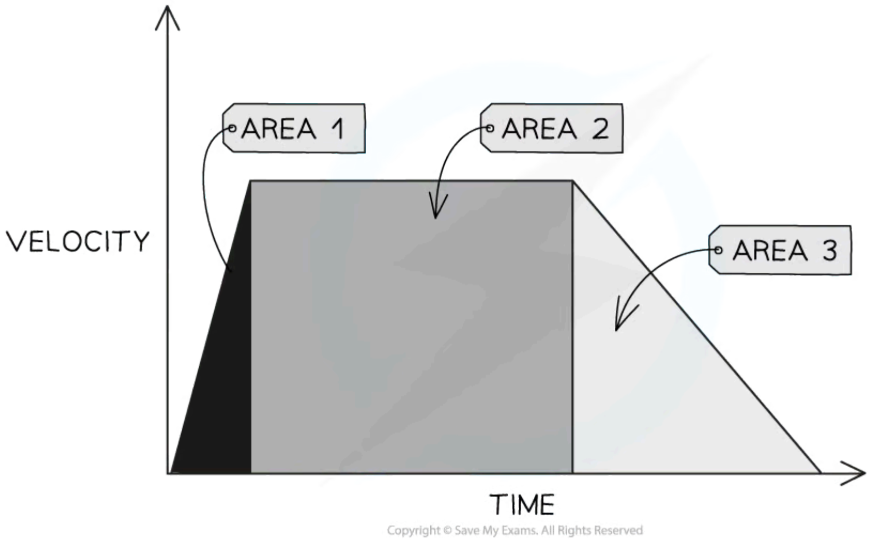
- If the area beneath the graph forms a **rectangle** (i.e. the object is moving at a **constant velocity**), then the area can be determined by using the following formula:

Area = Base × Height

Determining Distance from a Velocity-Time Graph

- **Enclosed** areas under velocity-time graphs represent **total displacement** (or **total distance travelled**)

Your notes



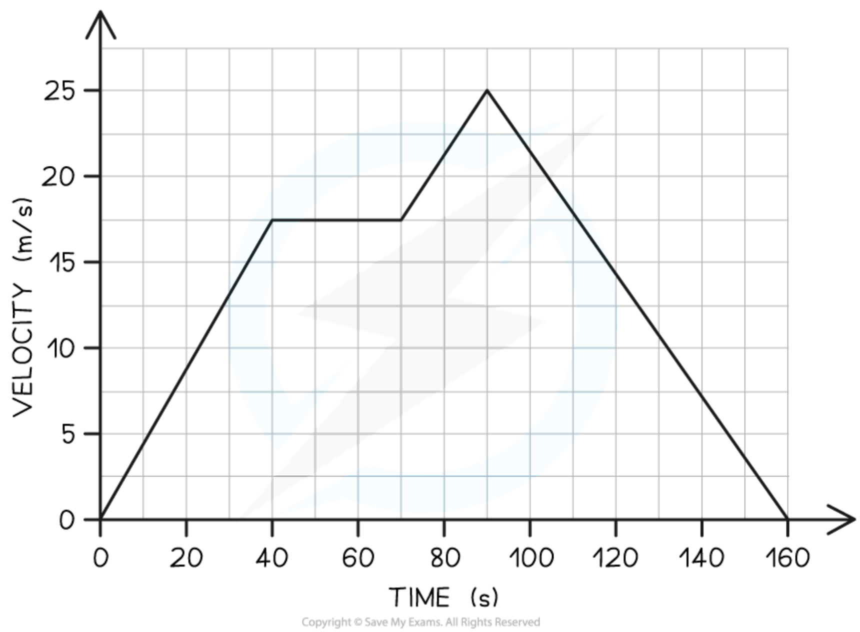
Three enclosed areas (two triangles and one rectangle) under this velocity-time graph represents the total distance travelled

- If an object moves with **constant acceleration**, its velocity-time graph will comprise of **straight lines**
  - In this case, calculate the distance travelled by working out the **area** of **enclosed rectangles and triangles** as in the image above

Worked Example

The velocity-time graph below shows a car journey which lasts for 160 seconds.

Your notes



Calculate the total distance travelled by the car on this journey.

Answer:

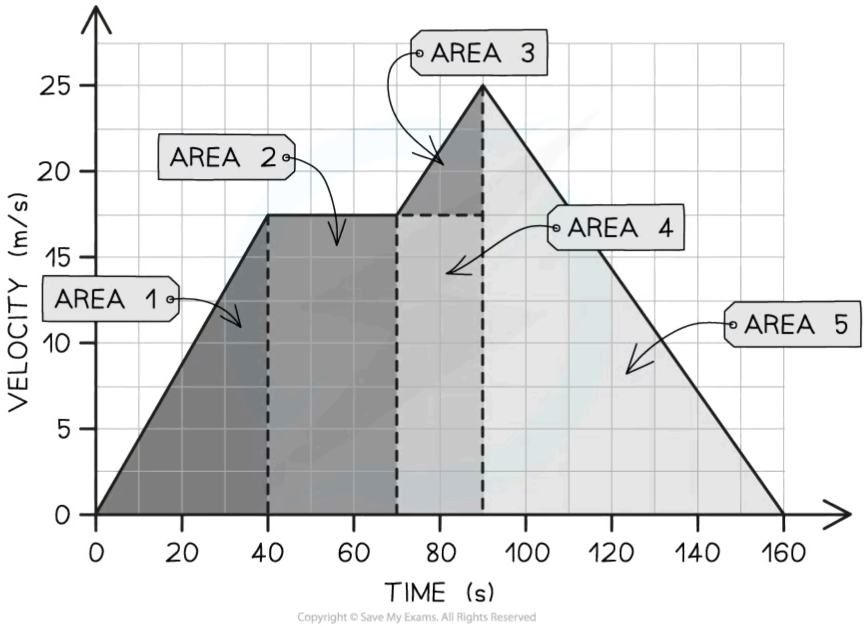
Step 1: Recall that the area under a velocity-time graph represents the distance travelled

- In order to calculate the total distance travelled, the total area underneath the line must be determined

Step 2: Identify each enclosed area

- In this example, there are **five** enclosed areas under the line
- These can be labelled as areas 1, 2, 3, 4 and 5, as shown in the image below:

Your notes



Step 3: Calculate the area of each enclosed shape under the line

- Area 1 = area of a triangle = ½ × base × height = ½ × 40 × 17.5 = **350 m**
- Area 2 = area of a rectangle = base × height = 30 × 17.5 = **525 m**
- Area 3 = area of a triangle = ½ × base × height = ½ × 20 × 7.5 = **75 m**
- Area 4 = area of a rectangle = base × height = 20 × 17.5 = **350 m**
- Area 5 = area of a triangle = ½ × base × height = ½ × 70 × 25 = **875 m**

Step 4: Calculate the total distance travelled by finding the total area under the line

- Add up each of the five areas enclosed:

$$\text{total distance} = 350 + 525 + 75 + 350 + 875$$

$$\text{total distance} = \mathbf{2175\ m}$$

Measuring Speed

Your notes

Typical Speeds

- The table below gives some typical speeds (in m/s) for various everyday scenarios

Typical Speeds Table

Example	Typical Speed (m/s)
Walking	1.5
Running	3
Cycling	6
Car	10 to 30
Passenger aeroplane	200–250
Sound	330–340

- Note that typical speeds of a person walking, running or cycling depends on a variety of factors, such as:
  - Age
  - Terrain
  - Fitness
  - Distance
- Similarly, typical speeds of transportation systems like cars or planes will depend on their:
  - Shape
  - Design
  - Cost

- Purpose

Your notes

Worked Example

A student claims that people typically walk at 6 m/s.

a) State whether or not you agree with this claim and explain your reasoning.

b) Suggest a factor that can affect the typical speeds of a person walking.

Answer:

Part (a)

- The student's claim is incorrect because 6 m/s is **too fast**
- The typical speed that people walk at is about **1.5 m/s**

Part (b)

- Some factors that can affect the typical speeds of a person walking are:
  - The **terrain** might be wet, rocky or steep
  - The **age** of the person
  - The **fitness** of the person
  - The **length** of the walk or journey

Examiner Tips and Tricks

You may be asked to recall typical values of speed for a person walking, running or cycling, or comment on typical values of speed for different types of transportation system - so **learn the values in this table** and have an idea about how they compare to each other.

Measuring Speed

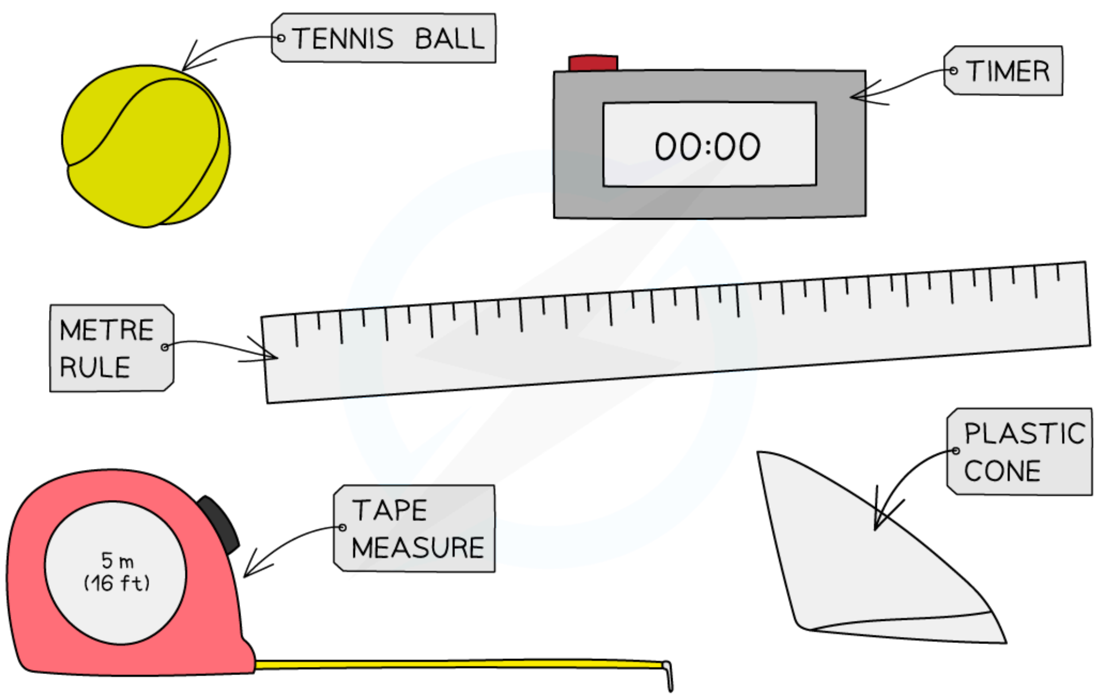
- Speed is the distance travelled by an object every second
- The simplest way to measure the speed of an object, is to time **how long** it takes to travel a **known distance** and use the equation:

Your notes

$$\text{AVERAGE SPEED} = \frac{\text{DISTANCE MOVED}}{\text{TIME TAKEN}}$$

Choosing Equipment

- To ensure a result for speed is as accurate as possible, choose the appropriate equipment to measure the distance and time

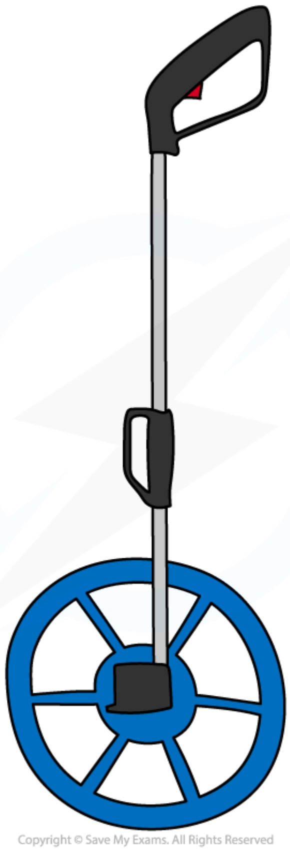


Some simple equipment that can be used to measure distance travelled and time taken for objects like a tennis ball and plastic cone

- To compare the average falling speed of a tennis ball to a plastic cone, for example:
  - A **metre rule** could be used to measure the distance they fall from
  - A **timer** could be used to measure how long they take to reach the ground
- It would not be practical to use a metre rule to measure the length of an athletics track though

Your notes

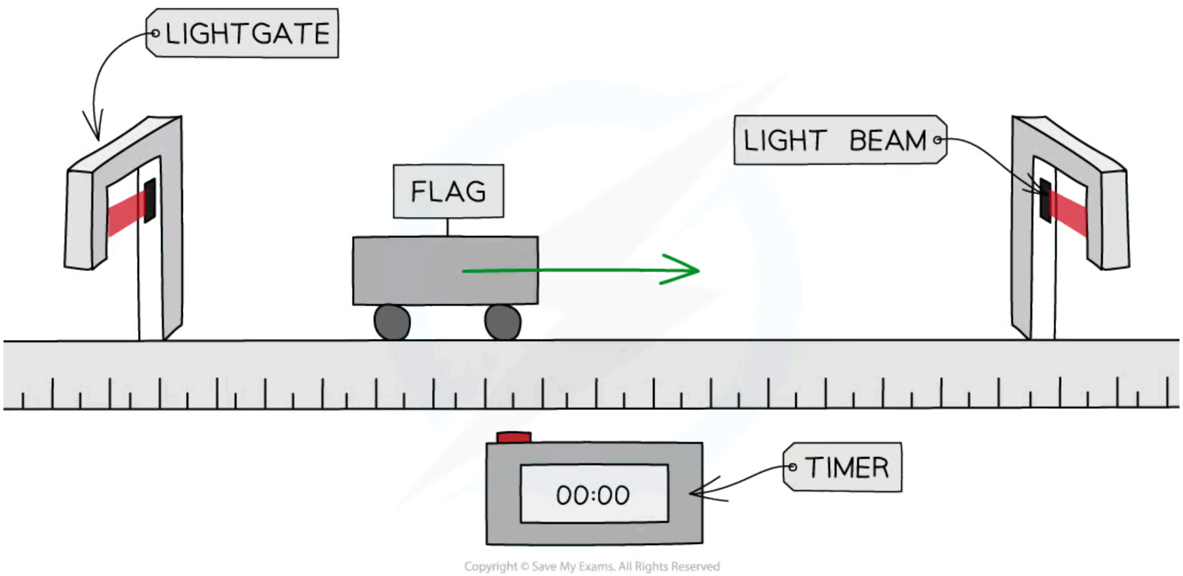
- In this instance, a more appropriate piece of equipment would be a (long!) **tape measure**, or even better, a **trundle wheel**



A trundle wheel is ideal for measuring long distances

Using Lights Gates to Measure Time

- Light gates are pieces of digital equipment that allow **times** to be measured more accurately

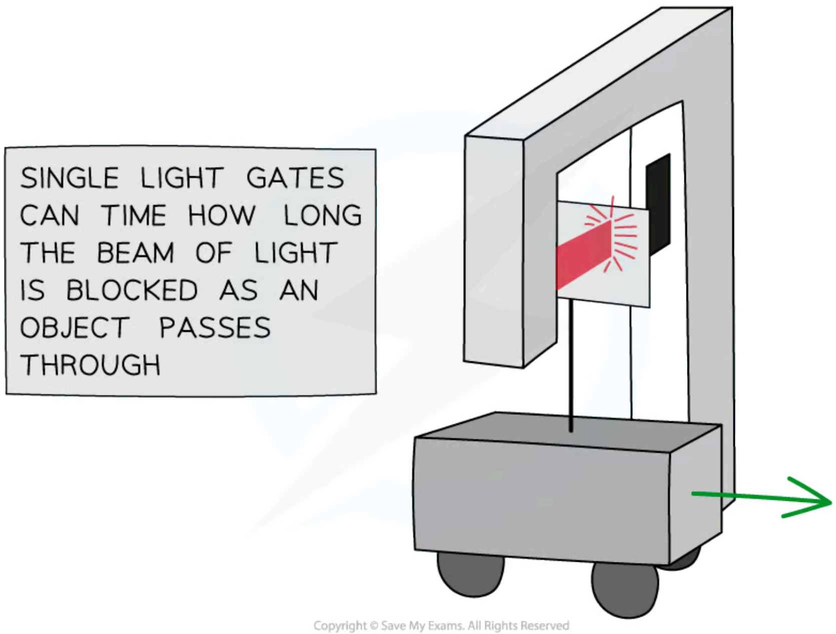


Light gates can be used to accurately time the motion of objects in a laboratory

- A light gate can be used to start a **timer** when an object passes through it
- A **flag** on top of the moving object **blocks** a beam of light as it passes through the light gate, triggering the timer to start
- A second light gate (at some fixed distance away) can be used to **stop** the timer as the object passes through it

Single Light Gates to Measure Speed

- A single light gate can also be used to measure the **speed** of an object as it passes through



Example of using a single light gate to measure speed

- The timer measures how long the light gate is blocked for
- The distance travelled is given by the **length of the flag** passing through the light gate
- The two measurements for **distance travelled** and **time taken** can then be used in the equation for speed

Examiner Tips and Tricks

Whenever you're asked to describe an experiment, if you need to use an **equation** to calculate something, write this down first. The quantities in the equation give you some hints about the variables you might need to measure.