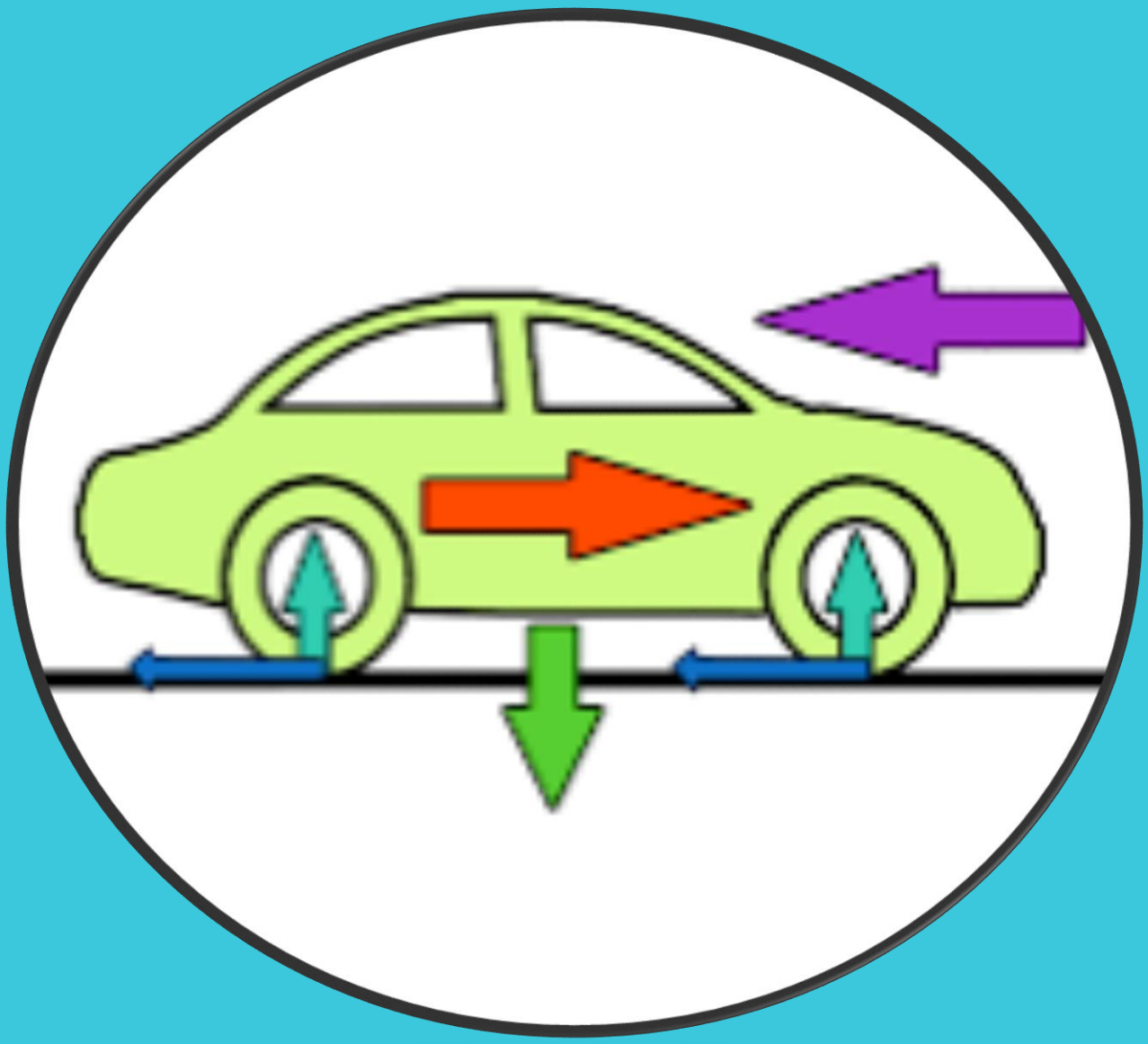


# Motion in Physics

## Key Stage 4 Revision Programme

Pupil Name

Handbook Designed by

## Timetable – Tutorials

| Tutorial | Date | Time | Location |
|---|---|---|---|
| 1 (Baseline assessment) | 21st November 2019 | 15.30 | Room 166 |
| 2 | 28th November 2019 | 15.30 | Room 166 |
| 3 | 5th December 2019 | 15.30 | Room 166 |
| 4 | 12th December 2019 | 15.30 | Room 166 |
| 5 | 9th January 2020 | 15.30 | Room 166 |
| 6 (Final assessment) | 16th January 2020 | 15.30 | Room 166 |
| 7 (Feedback) | 23rd January 2020 | 15.30 | Room 166 |

## Timetable – Homework Assignments

| | | |
|---|---|---|
| Tutorial 1 | | |
| Tutorial 2 | | |
| Tutorial 3 | | |
| Tutorial 4 | | |
| Tutorial 5 | | |

# Contents


| | |
|---|---|
| Course Rationale | P4 |
| Glossary of Keywords | P5 |
| Tutorial 1- baseline assessment | P6 |
| Tutorial 2- scalars and vectors | P7 |
| Tutorial 3- rearranging equation | P12 |
| Tutorial 4- distance-time graph | P16 |
| Tutorial 5- acceleration | P20 |
| Tutorial 6- final assessment | P23 |
| Tutorial 7- feedback | P24 |

# Course Rationale

**Motion**, in physics, change with time of the position or orientation of a body. Motion along a line or a curve is called translation. Motion that changes the orientation of a body is called rotation. In both cases, all points in the body have the same velocity (directed speed) and the same acceleration (time rate of change of velocity). The most general kind of motion combines both translation and rotation.

Working out various aspects of motion-related issues requires a mathematical skill. To change the subject of a formula, or rearrange a formula, items in the formula need to be rearranged so a different variable is a subject. Knowledge of solving equations and inverse operations is very useful. Believe it or not, there are many good reasons to develop your ability to rearrange equations that are important in mathematical physics. It can save time, help you with units and save some brain space!

This workbook will help to develop your equation manipulation skills. For Higher *Physics* learn the uses of equations and graphs of *motion*. Understand their use in determining other aspects of the *motion* of objects. The motion of objects can be analysed using equations and graphs. These tools allow other aspects of motion such as acceleration and displacement to be determined or modelled.

Learn how the average speed of an object is calculated and how distance-time graphs work with your Uni pathways course.

# Subject Vocabulary

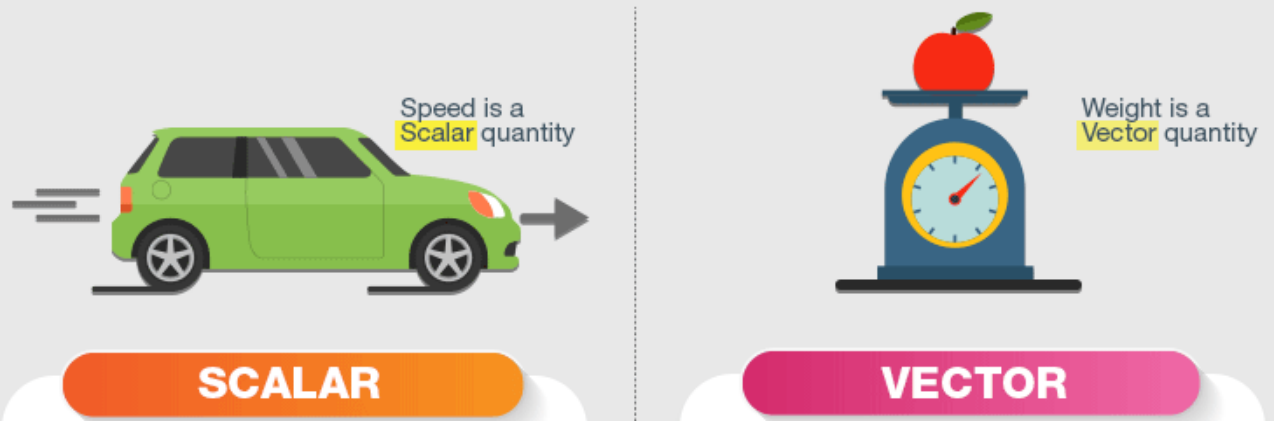
| Word | Definition | In a sentence |
|---|---|---|
| Scalar | A quantity having only magnitude, not direction. | A scalar is usually said to be a physical quantity that only has magnitude and no other characteristics. |
| Vector | A quantity having both magnitude and direction. | A vector is a quantity or phenomenon that has two independent properties: magnitude and direction. |
| Speed | Speed is the distance travelled per unit of time. | we turned on to the runway and began to gather speed. Higher speed means an object is moving faster. |
| Velocity | Velocity is a measure of how fast something moves in a particular direction. | To define it needs both magnitude and direction. If an object moves east at 9 metres per second (9m/s), then its velocity is 9 m/s to the east. |
| Acceleration | Acceleration is the change in speed or velocity of an object over a certain time. | To accelerate an object is to change its velocity, which is accomplished by altering either its speed or direction (like in case of uniform circular motion) in relation to time. |

# Tutorial 1 – Baseline assessment

## The Purpose of Tutorial 1

A. students' backgrounds knowledge on the essential elements of motion

# Tutorial 2 – scalars and vectors



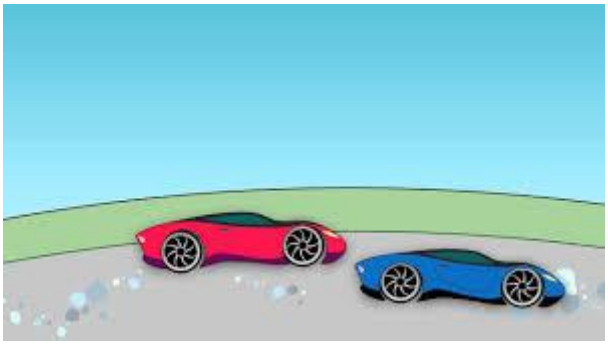

## Topic:

scalars and vectors

## Objectives:

(a) Defining and differentiating scalars and vectors.
(b) Remembering the definitions and units of velocity, speed and average speed.
(c) Recall and use the equation related to speed, time and distance.

## Starter:



A red and a blue car started racing from the leaf at the same time. The picture shows their position after five seconds. Look at the picture and answer the following questions:

(i) Which way the cars are moving?
(ii) Which one has travelled far after five seconds?
(iii) What does the blue car have more compare to the red car?

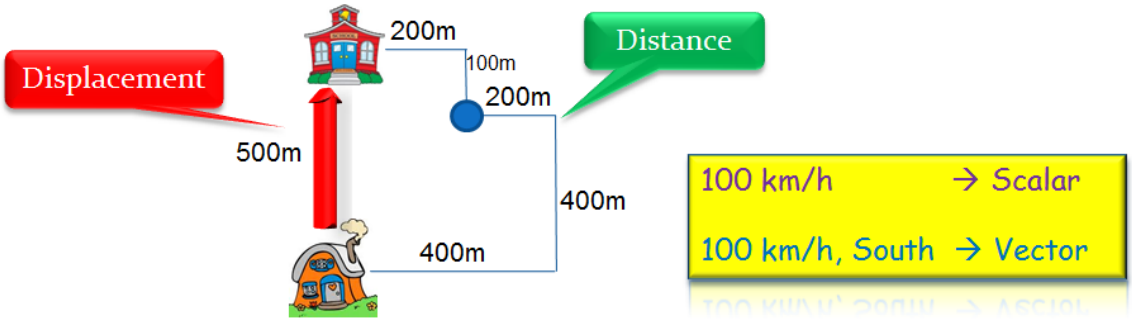
Objective A: learning scalar and vector quantity

**Scalar** → **Quantity that has size**

**Vector** → **Quantity that has size and direction**

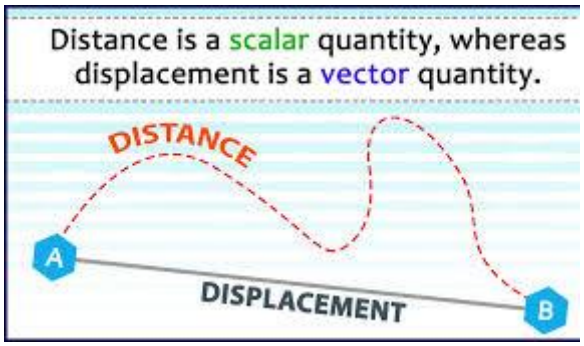
The **length** of the arrow in a drawing shows its **size**.
The **head** shows the **direction** of the vector.

Example of **Scalar**: **Distance**, **Mass** , **Speed**
Example of **Vector**: **Displacement**, **Weight** , **Velocity**




100 km/h → Scalar

100 km/h, South → Vector




Practice A: Defining scalars and vectors

1) What does a vector have that a scalar does not?

2) Write the scalars and the vectors quantities in the right column of the table.

velocity, acceleration, displacement, mass, force, distance, speed, energy, time, weight

| Scalars | Vectors |
|---|---|
| | |
| | |
| | |
| | |
| | |

**Assessment A:** Recall the key concepts of scalars and vectors.
**Use the words from the table and fill in the gaps**

| | | | | | |
|---|---|---|---|---|---|
| vector | displacement | direction | distance | scalar | size |

a) Magnitude means .....
b) A ..... quantity has magnitude only.
c) A vector quantity has magnitude and .....
d) .....is how far an object has moved. It is a scalar.
e) ..... is how far an object has moved measured in a straight line from the starting point *and* the direction of the line.
f) Displacement is a .....

**Objective B:** Recall the key concepts velocity, speed and average speed including definitions and units.

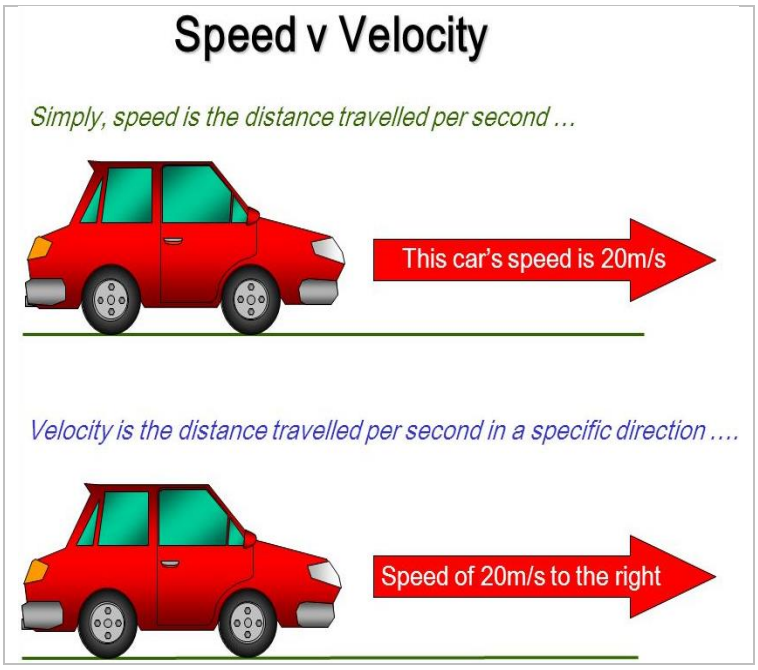



Figure X: speed and velocity

1. Speed tells us how much distance an object travels each second.
The SI **unit** is **metres per second** or m/s

$$\boldsymbol{speed\ (m/s) = \frac{distance\ (m)}{time\ (s)}}$$

2. Average speed
The speed of an object is rarely constant, for instance a car will change its speed a lot as it travels across a town. We can still work out the **average** speed however...

$$\boldsymbol{average\ speed = \frac{total\ distance}{total\ time}}$$

3. Typical Speed ('~' means approximately)

| | | | |
|---|---|---|---|
| Walking: | ~1.5 m/s | A gentle breeze: | ~4 m/s |
| Running: | ~3 m/s | Cycling: | ~6 m/s |
| Strong wind: | ~15 m/s | A car at 60 mph: | ~27 m/s |
| High speed train: | ~56 m/s | Passenger jet: | ~250 m/s |
| Sound: | 330 m/s | Military jet: | ~690 m/s |

- Speed is the distance travelled each second e.g. 4 m/s. It is a scalar quantity as it only has magnitude.
- **Velocity** tells us the speed and the direction e.g. 4 m/s going upwards. It is a vector quantity as it has magnitude and direction.

**Practice B:** Recall the key concepts velocity, speed and average speed including definitions and units

1 What is the definition of speed?
2 What is the SI unit for speed?
3 What is average speed?
4 What is the difference between speed and velocity?

**Assessment B:** Recall the key concepts velocity, speed and average speed including definitions and units.

(a) Distance is how ..... an object has moved.
(b) Displacement is how ..... An object has moved from its position.
(c) Distance is ..... quantity and displacement is a .....quantity.
(d) Velocity is the .....in a specific .....

**Objective C:** Recall and use the equation related to speed, time and distance.

**Worked example 1:** A bear walks a distance of 40 metres in 8 seconds. What is its speed?

$$speed = \frac{distance}{time}$$

$$speed = \frac{40}{8}$$

$$speed = 5\ m/s$$

**Worked example 2:** A tiger runs at a speed of 20 m/s for 12 seconds. What distance does it travel?

$$distance = speed \times time$$

$$distance = 20 \times 12$$

$$distance = 240\ m$$

**Worked example 3:** How long does it take an eagle to fly 500 metres at a speed of 25 m/s?

$$time = \frac{distance}{speed}$$

$$time = \frac{500}{25}$$

$$time = 20\ s$$

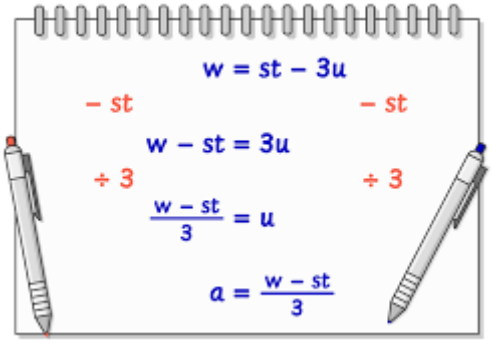
**Practice C:** Recall and use the equation related to speed, time and distance.

1) Distance = 50 m. Time = 10 s. What is the speed?
2) Speed = 4 m/s. Time = 8s. What is the distance?
3) Distance = 100 m. Speed = 10 m/s. What is the time?

**Assessment C:** Recall and use the equation related to speed, time and distance.

1) A bullet takes 2 seconds to reach its target. Target is 600 m away from the gun. How fast did the bullet travel?
2) A car travels at 30 m/s for 8 seconds. What distance does it travel?
3) A tennis balls travels 20 m at a speed of 40 m/s. How long does this take?
4) John drove for 3 hours at a rate of 50 miles per hour and for 2 hours at 60 miles per hour. What was his average speed for the whole journey?

# Tutorial 3 – Rearranging equation




## Objectives:

(a) Rearrange equation: dealing with equal sign.
(b) Rearrange equation: cancelling out.
(c) Rearrange equation: swapping the left and right over
(d) Rearrange equation: how to change the subject of an equation

**Objective A:** Rearrange equation: dealing with equal sign.

**Practice A**: Rearrange equation for different subjects.

<u>Dividing in algebra</u>
We don't use the share sign '÷'.
We replace the share sign with a fraction. We call 'sharing' dividing and write the variable that is being divided under the variable that is dividing it.
In the equation speed = $\frac{\text{distance}}{\text{time}}$ the distance is divided by the time.

Re-write each of these equations by replacing the share sign with a fraction.

1. $s = d \div t$
2. $a = F \div m$
3. $F = W \div s$
4. $v = s \div t$
5. $m = p \div v$

The equals sign '='

The equals sign tells us that the left side of an equation has the same value as the right. To keep this true if we do something to one side of an equation we have to do the same to the other. We call this rearranging.

When we are rearranging we sometimes want to multiply or divide by a variable. When we do this to one side the equals sign reminds us that we must also do it to the other.

$s = \frac{d}{t}$ × by t

$s \times t = \frac{d}{t} \times t$

| | |
|---|---|
| 1. $P = \frac{E}{t}$ | multiply by t |
| 2. $R = \frac{V}{I}$ | multiply by I |
| 3. $E = Q \times V$ | divide by Q |
| 4. $a = \frac{\Delta v}{t}$ | multiply by t |
| 5. $Q = I \times t$ | divide by I |

**Objective B:** Rearrange equation: cancelling out.

If there is the same variable on the top and bottom of a fraction we cancel both out. This is because if we divide something by itself its equal to one. In an equation if we multiply or divide by one it doesn't change it.

Example

$\frac{d}{t} = \frac{s \times t}{t}$ This equation has t on the top and bottom of the right hand side.

We can cancel the 'ts' out by putting a line through them…

$\frac{d}{t} = \frac{s \times \cancel{t}}{\cancel{t}}$ We can now remove the crossed out ts…

$\frac{d}{t} = s$

**Assessment B:** Complete the cancelling out in each of these questions and then rewrite each one…

1. $\frac{m \times a}{m} = \frac{f}{m}$
2. $\frac{F \times m}{m} = a \times m$
3. $\frac{s \times t}{t} = \frac{d}{t}$
4. $\frac{F \times s}{s} = \frac{W}{s}$
5. $\frac{I \times t}{I} = \frac{Q}{I}$

**Objective C:** Rearrange equation: Swapping the left and right over

It is absolutely fine to swap all of the variables on the left with those on the right. Equations are normally written with a single variable on the left…

$$\frac{d}{t} = s \quad \text{so} \quad s = \frac{d}{t}$$

**Assessment C:** Swap each of these over so the single variable is on the left hand side…

1. $m \times a = f$
2. $\frac{F}{m} = a$
3. $s \times t = d$
4. $F \times s = W$
5. $I \times t = Q$

<u>Objective D: How to change the subject of an equation</u>

<u>Inverse functions</u>

Every mathematical function has an inverse function. The inverse function does the opposite thing to the function.

| Function | Inverse function |
|---|---|
| Multiply × | Divide / |
| Divide / | Multiply × |
| Add + | Subtract - |
| Subtract - | Add + |

Write your answers to the following questions

| |
|---|
| 1. What is the inverse function of 'multiply'? |
| 2. What is the inverse function of 'divide'? |
| 3. What is the inverse function of 'add'? |
| 4. What is the inverse function of 'divide'? |

We are given the equation V = I × R. We have values for V and I are but we want to know what R is. We need to make 'R' the subject. To do this we need to 'rearrange for R'. This means that we need the answer to start with 'R ='.
When we look 'V = I × R' we need to get the 'R' on its own. The 'R' is being multiplied by the 'I'. We need to use the inverse function of multiply to remove the 'I'. The inverse function of multiply is divide, so we need to divide by 'I'.
The equals sign reminds us that what we do to one side we need to do the other.

$V = I \times R$ Divide by I

$$\frac{V}{I} = \frac{I \times R}{I}$$

On the right hand side we have 'I' on the top and bottom, it is ready to cancel out.

$$\frac{V}{I} = \frac{\cancel{I} \times R}{\cancel{I}}$$ Cancel out I

$$\frac{V}{I} = R$$

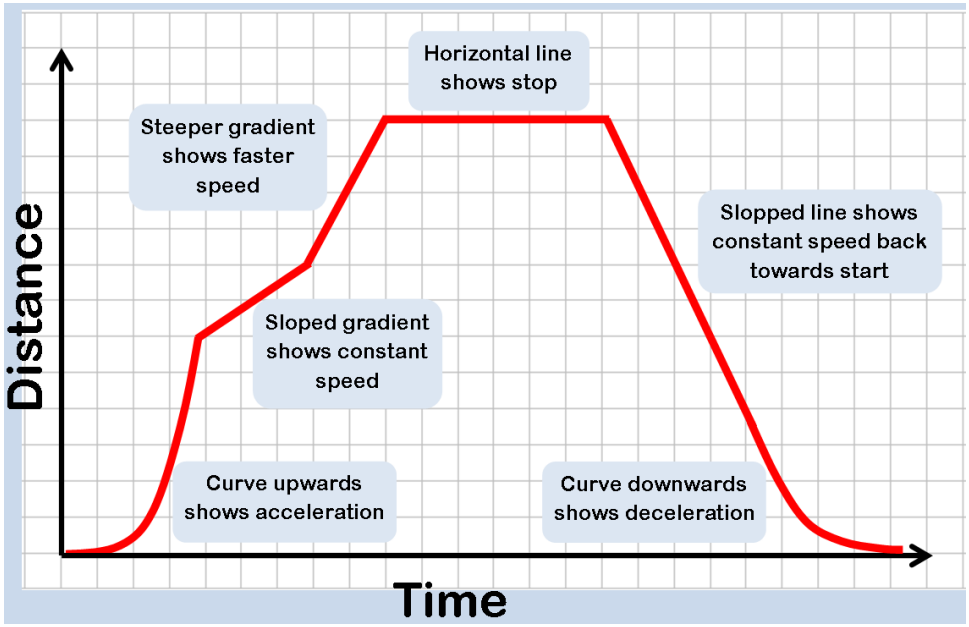
We now have 'R' on its own, but an equation should be written with the subject on the left. We now swap both sides over…

$$R = \frac{V}{I}$$

Assessment D: Rearrange equation for different subjects. Now complete these questions…

| | |
|---|---|
| 1. s = v × t | rearrange for v |
| 2. s = v × t | rearrange for t |
| 3. V = I × R | rearrange for I |
| 4. V = I × R | rearrange for R |
| 5. Q = I × t | rearrange for I |

# Tutorial 4 – distance-time graph




## The Purpose of Tutorial 3

A. Drawing graphs from using distance and time data
B. Analyse distance/time graphs including determination of speed from the gradient.

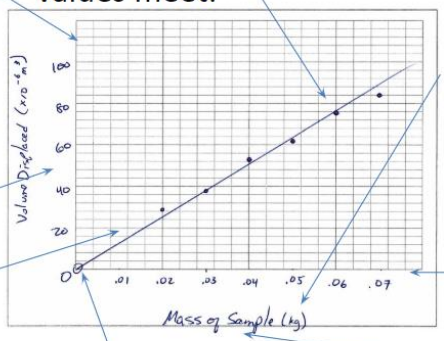
## Line Graphs

1. **Y-axis**: The vertical axis.

2. **scale**: A number line going up in even steps from zero or the lowest value to the highest value.

3. **best fit line**: A curve or straight line plotted so that it has the same number of points either side of it.

4. **points**: dots or crosses placed where a pair of values meet.




5. **origin**: The point on the graph where both variables are equal to zero.

6. **axis**: An axis is a straight line that the scale is written on.

7. **unit**: placed in brackets after the variable.

8. **X-axis**: The horizontal axis.

9. **variable**: There is one variable on the X-axis and another variable is on the Y-axis.

**Practice A:** Drawing graphs from using distance and time data

(i) Use the data to draw a graph

| Time (S) | Temperature (°C) |
|---|---|
| 0 | 125 |
| 1 | 100 |
| 2 | 70 |
| 7 | 37 |
| 9 | 33 |
| 11 | 30 |
| 12 | 28 |
| 17 | 24 |
| 18 | 23 |

**Assessment A:** Drawing graphs from using distance and time data

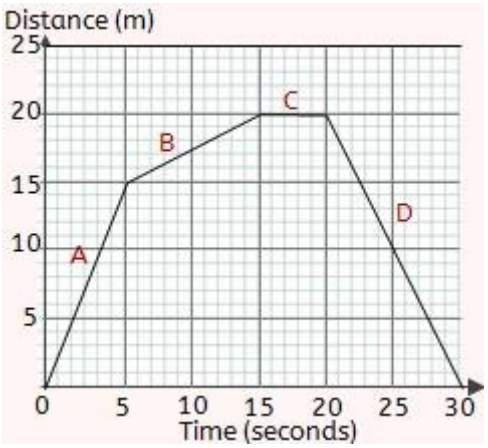
1. Which axis on a graph is vertical?

2. Which axis on a graph is horizontal?

3. A curve or straight line plotted so that it has the same number of points either side of it.

4. Which two things are used to label each axis on a graph?

**Objective B:** Analyse distance/time graphs including determination of speed from the gradient.




1. It is useful to display the movement of an object on a **distance-time graph**.

2. Section A is a straight line, the object moves at a constant speed. It covers a distance of 15 m in 4 s so its speed is

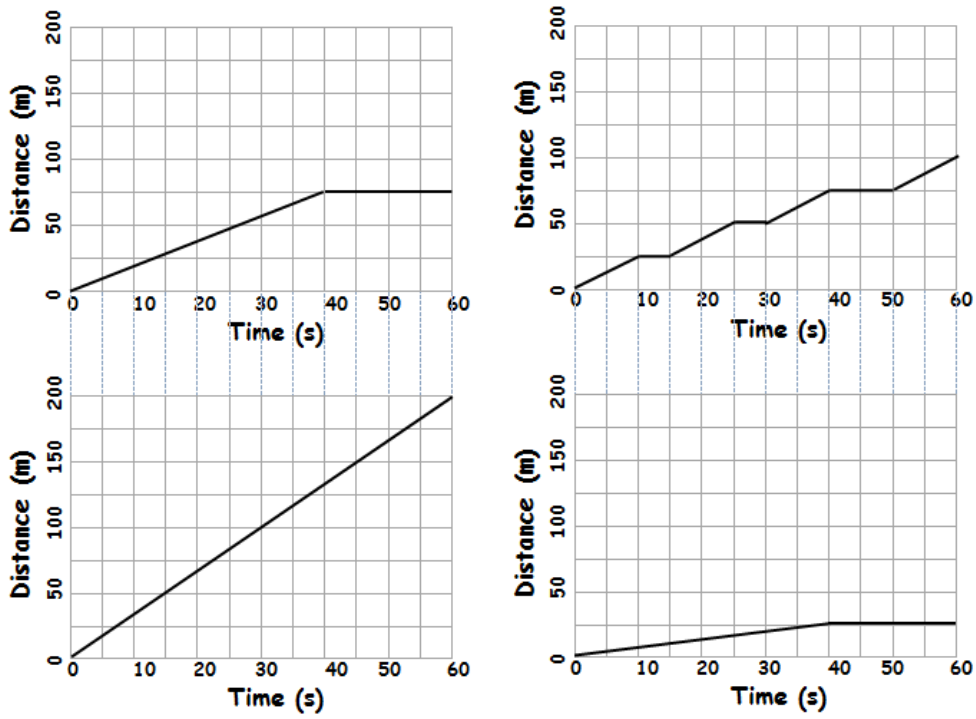
$v = \frac{s}{t} = \frac{15}{4} = 3.75$ m/s

**Practice B:** Analyse distance/time graphs including determination of speed from the gradient.

Step 1: Identifying motion from a Distance-Time Graph

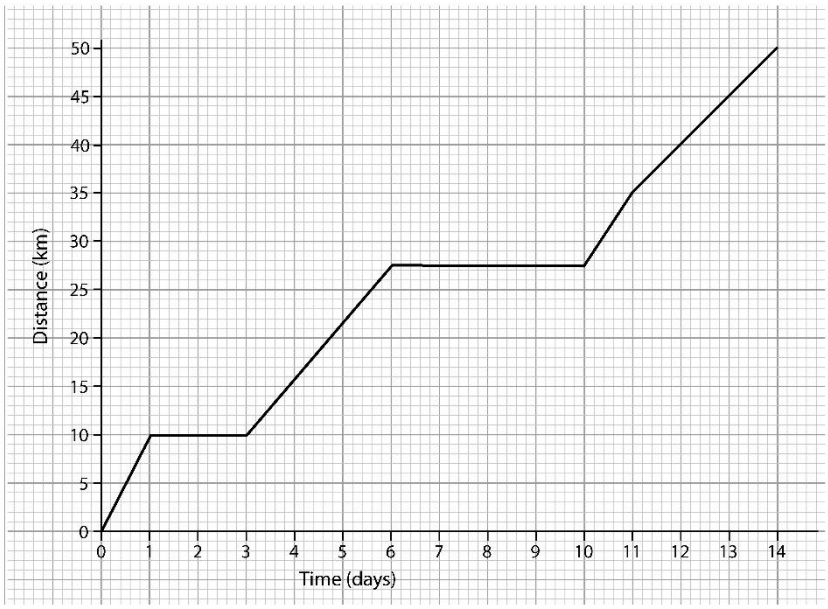
1. Match each description to one of the graphs below.

a) A cheetah stalks his prey, moving slowly, stopping occasionally.
b) A rabbit runs away from a farmer, not stopping for anything!
c) A child runs at a constant speed for 40 s before stopping.
d) A panda moves slowly at a constant speed for 40 s before stopping.




Step 2: Describing motion from a Distance-Time Graph

2. This is a distance time graph for a boat



a) Describe what the distance–time graph shows you for each of the six sections.

_____

_____

_____

_____

_____

_____

b) When is the boat travelling fastest?

_____

c) When is the boat going slowest?

_____

d) How do you know when the boat is not moving?

_____

Assessment B: Analyse distance/time graphs including determination of speed from the gradient.

1. The graph shows Anita's walk on a trail in the country.

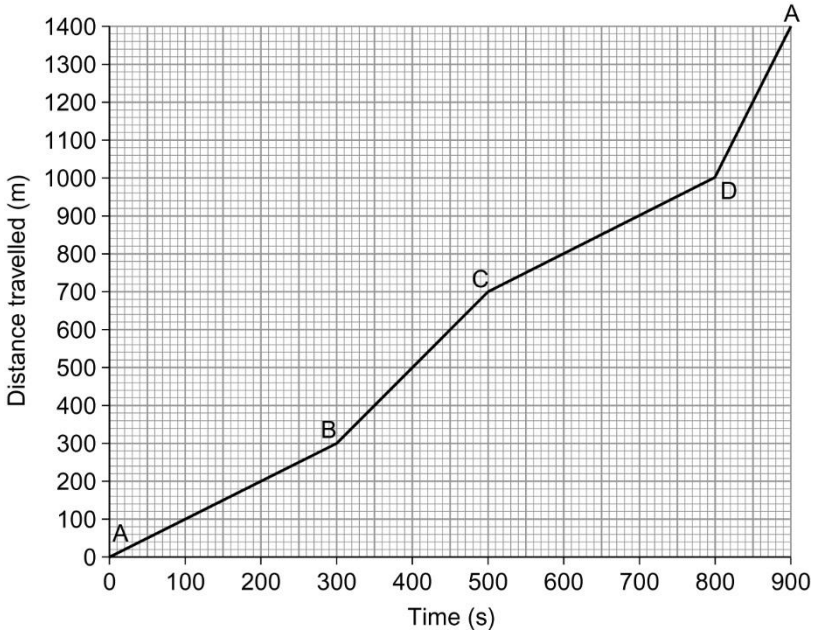
a) Between which two points did Anita travel the fastest? How do you know?

b) Use the graph to find Anita's speed between:

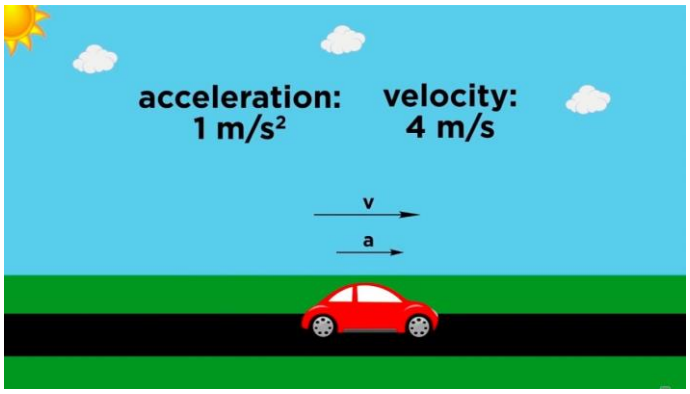
(i) A and B

(ii) B and C

(iii) D and A.



# Tutorial 5 – Acceleration




## The Purpose of Tutorial 4

A. Learning definition, equation and unit of acceleration
B. Calculating the magnitude of everyday accelerations

**Objective A:** Learning the definition, the equation and the unit of acceleration

1. **Acceleration** tells us how quickly **velocity** changes.

2. acceleration = $\frac{\text{change in velocity}}{\text{time}}$ (m/s) / (s) = (m/s²)

$a = \frac{\Delta v}{t}$ where a = acceleration, t = time, $\Delta v$ = change in velocity

3. Typical Accelerations:

| | | | |
|---|---|---|---|
| Family car: | 3 m/s² | Usain Bolt: | 3.1 m/s² |
| Gravity: | 10 m/s² | Bugatti Veyron: | 11.59 m/s² |

4. All objects that are falling freely under **gravity** accelerate at 10 m/s² .
5. Usain Bolt can accelerate more quickly than a family car, but this does not mean he can run faster than one. After a couple of seconds Usain will stop accelerating and finish the race, the car will continue accelerating to a much higher speed.
6. If an acceleration is **negative** it means it is slowing down. The initial velocity is greater than the final velocity. A negative acceleration is sometimes called a '**deceleration**'.

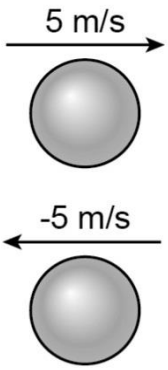
**Practice A:** Learning the definition, the equation and the unit of acceleration

Complete the following sentences using words from the box. You can use each word once, more than once or not at all.

Speed is a _____ quantity and velocity is a _____ quantity.

_____ quantities have both a size and a _____. The two objects on the right both have the same _____. They have different

_____, because one is moving in the opposite direction to the other. This is shown by the ___ sign. Acceleration is a change in _____, so it is also a ____ quantity. An acceleration in the same direction as an object is moving will make a moving object ___. An acceleration in the opposite direction to the movement of an object will make the object __ (_____). An acceleration of _____will not change the velocity of an object.




| | | | | | |
|---|---|---|---|---|---|
| decelerate | direction | magnitude | minus | scalar | slow down |
| speed up | vector | velocities | velocity | zero | |

**Assessment A:** Learning the definition, the equation and the unit of acceleration

1. What does acceleration mean?
2. What are the units for acceleration?
3. In the acceleration equation, what does u stand for?
4. In the acceleration equation, what does v stand for?
5. What is the equation for calculating acceleration?
6. What is the acceleration due to gravity?

**Objective B:** Calculating the magnitude of everyday accelerations

**Worked example 1:** Change in speed = 14 m/s; time taken = 2 seconds. Calculate the acceleration.

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

$= \frac{14}{2}$

$= 7 \text{ m/s}^2$

**Worked example 2:** A car accelerates from rest (zero speed) up to a speed of 30 m/s in 12 seconds. Calculate the acceleration.

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

$= \frac{30}{12}$

$= 2.5 \text{ m/s}^2$

**Practice B:** Calculating the magnitude of everyday accelerations

1. A rocket accelerates upwards from rest to a speed of 12 km/s in 8 seconds. Calculate the acceleration.
2. A driver slams on her brakes and her velocity decreases from 15 to 10 m/s in 2 seconds. Calculate her acceleration.
3. A moped can increase its speed by 2m/s each second. Starting from a standstill, how fast would it be travelling after 8 seconds?
4. A car decelerates in 5 s from 35 m/s to 25 m/s. Calculate its deceleration.

**Assessment B:** If a car increases in velocity from +5 m/s to +15 m/s in three seconds, what is its acceleration?

(i) 33.3 $m/s^2$
(ii) 3.3 $m/s^2$
(iii) 10 $m/s^2$

# Tutorial 6 – Final assessment

# Tutorial 7 – Feedback

## What is the Purpose of Tutorial 7?

C. To receive feedback on final assessments.
D. To share examples of best practice with the other pupils in your group.
E. To write targets for improvement in school lessons.
F. To reflect on the programme including what was enjoyed and what was challenging.

## Final assessment feedback

| What I did well… | What I could have improved on… |
|---|---|
| • | • |
| • | • |
| • | • |

| My target for future work is… |
|---|
| |

## Reflecting on Uni Pathways

| What did you most enjoy about Uni Pathways? |
| --- |
| • <br>• <br>• |

| What did you find challenging about the programme? | How did you overcome these challenges? |
| --- | --- |
| • <br>• <br>• | • <br>• <br>• |

# Notes

# Notes

# Notes

# Motion in Physics

## Key Stage 4 Programme

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