A-level Physics
Transition from GCSE

First of all, we're looking forward to seeing you in A-level Physics next year!

You will probably be taking a well-earned rest over the holidays, but you may wish to look at this booklet before the beginning of your Year 12 so you can give yourself the best start to the Physics course.

The content in this booklet is a recap of some of the key knowledge you learned during GCSE, which you'll build on when you further your understanding through the A-level. It focuses on the topics you'll study in the autumn term.

There are three sections:

>   1: Equations, Prefixes and Unit Conversions
>   2: Motion
>   3: Electricity

Each section has some reminder notes, and then some questions and problems for you to try. Sections 2 and 3 recommend some online videos you may find useful.

You are not expected to be an expert on all of the content in this booklet before the term starts! We will cover this content again, and build further knowledge on top.

You may not be able to complete all the questions; don't worry, you'll have the opportunity to learn the skills you need during the course.

However, working through this booklet to remind yourself of some of the Physics you covered during GCSE will put you in the best position to make the most of the time you will spend with us.

1: Equations, Prefixes and Unit Conversions

Physics and maths are very closely linked; maths is often called the 'language of physics'. Our A-level course doesn't require advanced maths, but it does make regular use of some maths skills, including working with prefixes, unit conversions and rearranging equations.

Equations

Equations are efficient ways of stating some of the key laws of physics, and allow us to work out how quantities that we know or want to predict are related to each other.

We meet lots of equations in A-level Physics, but there are very few you have to memorise (they are <u>almost</u> all given on a formula sheet). However, you will need to become used to working with the equations and rearranging them.

At GCSE many of the equations are similar to

$$A = B \times C \quad \text{or} \quad X = Y \div Z$$

which you may have manipulated using equation triangles. Many of the A-level Physics equations can't be worked using equation triangles, but they <u>can</u> all be controlled using the standard rules about rearranging that you learned in GCSE Maths.

The following section uses the following three formulas you will have met at GCSE:

$$
\begin{array}{ll}
\text{average speed} = \text{distance} \div \text{time} & v = s / t \\
\text{force} = \text{mass} \times \text{acceleration} & F = m \times a \\
\text{wave speed} = \text{frequency} \times \text{wavelength} & v = f \times \lambda
\end{array}
$$

Below you will be asked a number of questions, and in each case will need to select which formula to use.

Write out your answers in the way shown below in the example question. You may have your own way of working questions out, but for this exercise use the following approach. Show all your working, and follow these steps each time:

1. Read the question and identify out which two quantities you have been given, and which one you are being asked to work out
2. Choose the formula that links those three quantities
3. Write out the symbol formula in the format given above on the first line

4. Write another line with the values you have been given substituted into the formula – you should be left with one unknown quantity (just use the symbol to represent it)
5. (If needed) Rearrange the formula so you have an equation for the unknown quantity.
6. Evaluate the unknown quantity – work it out with a calculator and give it in a decimal form. Don't leave it as a fraction if division is involved.

Example question:

A cheetah travels a distance of 120 m in 5.5 seconds. What speed did it run at?

The three quantities are <u>distance</u>, <u>time</u> and <u>speed</u>, so you know which equation to use

$$v = s / t \qquad \text{(write out the symbol equation first!)}$$

$$v = 120 / 5.5 \qquad \text{(substitute in the given values)}$$

$$v = 21.8 \, m/s \qquad \text{(no rearrangement needed, so evaluate)}$$

Practice questions:

Q1.1: What is the <u>speed</u> of sound wave with a <u>frequency</u> of 200 Hz and a <u>wavelength</u> of 1.65 m?

(Remember: identify the three quantities involved, choose a formula, write it out in its symbol form, then substitute, rearrange if needed, and then evaluate)

Q1.2: A motorbike with a mass of 160 kg must accelerate at 1.2 m/s^2 to win a time trial. What force is required to produce this acceleration?

Q1.3: What is the speed of a surveillance drone that moves a distance of 330 metres in 15 seconds?

Q1.4: A student on a beach watches a wave on the surface of the sea. She estimates the speed of the wave at 3 m/s, and that it had a wavelength of 5 m. What is the frequency of the wave?

Q1.5: A bee takes 3.2 seconds to fly between two flowers, moving at a speed of 2.5 m/s. How far did it fly?

Q1.6: The arm of a manufacturing robot accelerates at 1.22 m/s^2 when a force of 350 N is applied to it. What is the mass of the arm?

Q1.7: What is the frequency of a sound wave with a wavelength of 0.2 m (sound moves at a speed of 340 m/s in air)?

Prefixes & Unit conversions

Quantities in physics can range from the very small (e.g. diameter of an electron) to the very large (e.g. the mass of a galaxy). One of the ways we deal with this range is by using prefixes.

We also use prefixes in everyday life. For instance, journey distances are often given in kilometres (km) rather than metres, as the resulting number is smaller; it is easier to say that the distance from London to Paris is 343 km, rather than 343,000 m!

In the same way we use the prefixes centi- and milli- in everyday life when talking about smaller lengths. A typical mobile phone is around 12 centimetres (cm) long (which is easier to remember than 0.12m), and around 8 millimetres (mm) thick (0.008m).

However, we usually 'remove' these prefixes before we put a quantity into an equation. We convert km to metres, cm to metres, mm to metres, and then put the resulting number of metres into our calculators.

It is quite easy to remember that a factor of 1000 is involved when converting km to m, or mm to m, but sometimes it can be hard to decide if a quantity must be *multiplied* or *divided* by 1000.

This skill will come with practice, but until it does ask yourself the question "Am I expecting to get a bigger or smaller number when I've done the conversion?". If you expect a bigger number then multiply, if you expect a smaller number then divide.

Example 1

Q: Convert 13.2 km to metres.

"Am I expecting the number of metres to be bigger or smaller than 13.2?"

The answer is bigger, so we know we have to multiply.
13.2km = 13.2 × 1000 = 13200 m

Example 2

Q: Convert 55.1 mm to metres.

"Am I expecting the number of metres to be bigger or smaller than 55.1?"

The answer is smaller, so we know we must divide. 55.1mm = 0.0551 m

Q1.8: Use that approach to complete the following table, converting between km, m and mm

km	m	mm
65	*65000*	
14.4		
		32
		8.6
	1.2	
	1500	
0.01		

The same rules apply when converting between kilohertz and hertz. The highest frequency humans can hear is around 20 kHz. What is 20 kHz in Hz?

These rules apply to all the other units you have met in GCSE and will meet in A-level; kilojoules, mJ, kilonewtons, millitesla, millifarads, kNm…

The same rules can be used to convert from the other prefixes that you will have met once or twice at GCSE, but we use a lot in A-level (nano-, micro-, mega-, giga-). Once you have the skill about deciding to multiply or divide, then you'll be able to use these prefixes with no problem.

There are a couple of special cases that we have to remember for units, however.

Units for mass

When working with masses in equations we have to convert to kilograms, not to grams.

Why is this? It is the convention that we are stuck with due to scientific history, and it will be easier for us to work with it than to try to convince every scientist in the world to change!

You can still use the same rules to convert between kg, g and mg, but remember that you convert to kilograms (kg) before you put your number into an equation, not to grams (g).

Units for time

We do meet time quantities measure in milliseconds, microseconds and nanoseconds (used for measuring smaller lengths of time), but we don't use kiloseconds, megaseconds etc.

Instead, we use minutes, hours, days, years for longer time intervals. These have to be converted to seconds before they are put into an equation. Remember that there are 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day and 365 days in a year (sometimes we say there are 365.25 days in a year to account for leap-days).

Using your knowledge about prefixes and unit conversions, answer the following three equation questions.

Practice questions:

Q1.9: An F14 jet travels a distance of 22 km in 35 seconds. What is its speed (in m/s)?

Q1.10: A cheetah has a mass of 41 kg. When it starts to run its legs can exert a force of 0.39 kN. What will the resulting acceleration be?

(Hint: remember to leave the mass in kg!)

Q1.11: A seismic wave moves at a speed of 200 km/h. If it has a frequency of 30 Hz, what is its wavelength?

(Hint: work on the speed of the wave first – what is its speed in m/s? You could first work out its speed in km/s, and then work it out in m/s!)

2: Motion (A-level Topic 2)

Scalars and vectors

A 'quantity' in physics is anything that can be measured or calculated. All physical quantities are either scalars or vectors.

Scalar quantities only have size (or 'magnitude'). Mass is a scalar; we can't say that a car has a mass of 500kg to the north; it just has a mass of 500kg. Time is a scalar; we often talk about time 'moving forward', but intervals of time can't be 'upwards' or '45° to the horizontal'. Energy is a scalar quantity. This is obvious for thermal/heat energy, or chemical energy, but it is also true for kinetic energy (the energy in moving objects); the object might be moving in a particular direction, but its kinetic energy doesn't have a direction itself.

Vector quantities have a magnitude <u>and</u> a direction. Forces are vectors; you can push or pull on a door handle, or compress or extend a spring. Weight is just a specific type of force, so weight is also a vector.

There are a number of quantity pairs, where the quantities are very similar but one is a scalar and one is a vector. Speed is a scalar, and velocity is a vector; speed is how fast something is moving in any direction, but when we talk about the velocity of an object we should also say which direction it is moving, e.g. 'the velocity of the rocket is 500 m/s at 5° to the vertical', or 'the snail's velocity is 0.1 m/s backwards'.

Distance (or length) and displacement are a scalar/vector pair. The whale is 53 m long. The whale's displacement over 3 months was 1500 km to the southeast.

Motion basics

One of the key quantities for an object that is moving is how fast it is moving, its speed (or velocity – how fast and in which direction).

The average speed of an object is given by the equation

average speed = distance / time   *or*   v = s / t

This equation is such a fundamental equation that it isn't given on our formula sheets! It is one of the 'suvat equations' that tell us how the following quantities are related for a moving object:

s = distance   u = initial speed   v = final speed   a = acceleration   t = time

Acceleration

If the speed of an object is increasing then the object is accelerating. If the object is slowing down we say it is decelerating (or sometimes we talk about a 'negative acceleration')

There are two equations that tell us how the acceleration of an object changes its speed.

If we know how over much _time_ the acceleration has been happening, we can use the equation

$v = u + a\,t$ (where the symbols have the meanings given above)

If we know how over much _distance_ the acceleration has been happening, we can use the equation

$v^2 - u^2 = 2\,a\,s$

Centripetal acceleration

An object can be accelerating even if its speed isn't changing! An acceleration is actually any change in velocity, so if an object is changing the direction it is moving in while maintaining the same speed it is accelerating.

This is a very common situation when objects are moving at a constant speed in a circle. For instance, a telecommunications satellite orbits the Earth at the same speed, but its direction is constantly changing. It is being accelerated (by the force of gravity).

A motorbike could be travelling at the same speed around a circular track. In this case friction force (between the tyres and the track) would be causing the acceleration.

Any situation in which an object is being accelerated to maintain a circular motion is called 'centripetal acceleration'.

As acceleration is any change in velocity it is also a vector quantity, so it has a size and a direction.
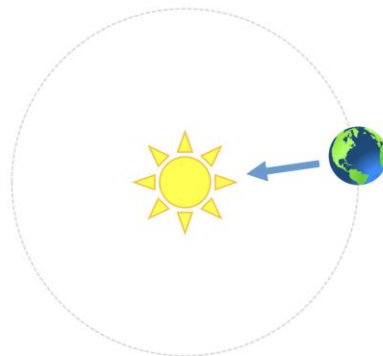
Gravitational attraction to the Sun causes the centripetal acceleration keeping the Earth on its orbit

Distance-time graphs

How objects move over time can be efficiently displayed on graphs.

Distance-time graph (distance on the y-axis, time on the x-axis) show how far an object has moved from a starting position.

On a distance-time graph:

- a flat, horizontal section shows the object not moving
- a positive gradient shows an object moving away from the starting position
- a negative gradient shows an object moving towards the starting position
- a constant gradient (linear section) shows the object moving at a constant speed/velocity
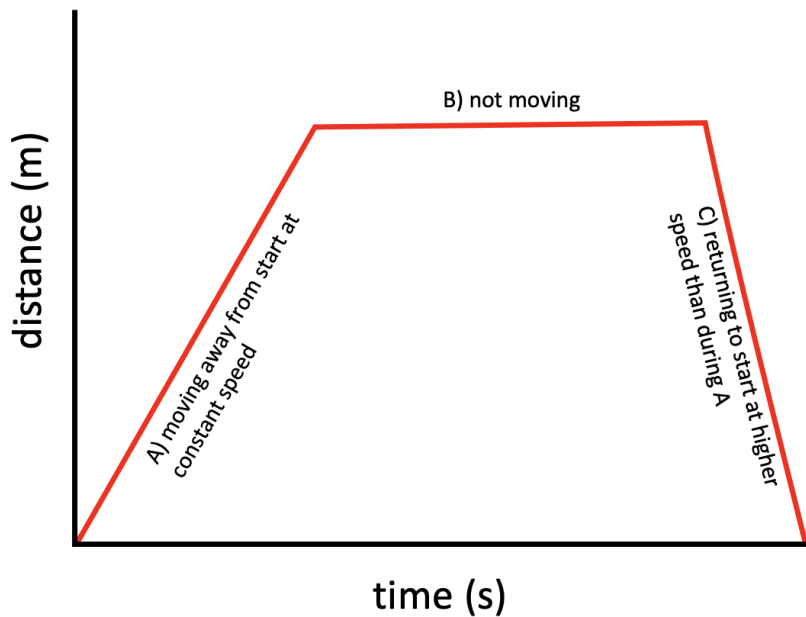
Velocity-time graphs

Velocity-time graph (velocity on the y-axis, time on the x-axis) show the velocity an object has at any moment.

On a velocity-time graph:

- a flat, horizontal section shows the object moving at a constant speed/velocity; if the line is above the x-axis the velocity is positive, if it is below the x-axis the velocity is negative
- the gradient shows the acceleration – a positive gradient shows an increase in speed, a negative gradient shows a deceleration
- a constant gradient (linear section) shows a constant acceleration/deceleration
- the area under the line on a velocity-time graph shows the distance moved by the object.
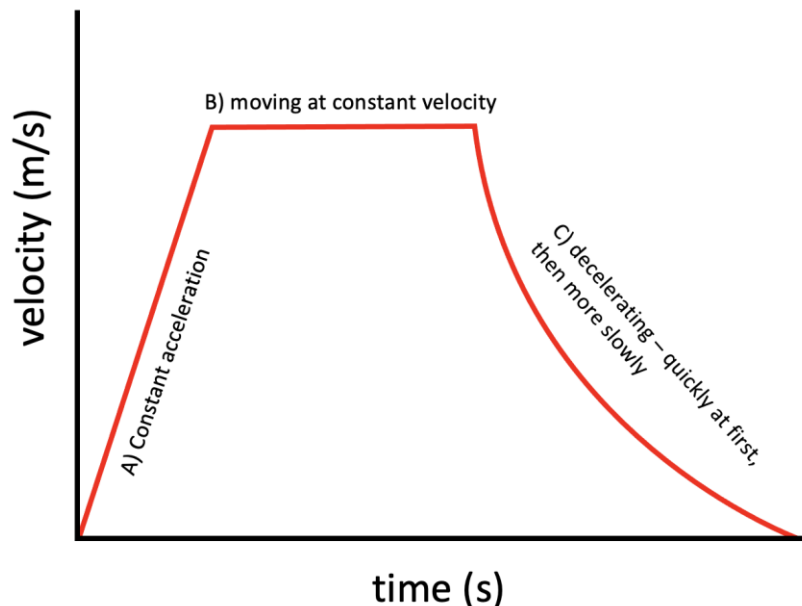
B) moving at constant velocity

velocity (m/s)

A) Constant acceleration

C) decelerating – quickly at first, then more slowly

time (s)

Useful videos

You may find the following short YouTube videos useful (put the names given below into a search engine to find the video).

- Cognito GCSE Physics Scalar and vector quantities
- Cognito GCSE Physics Acceleration
- Cognito GCSE Physics Distance time graphs
- Cognito GCSE Physics Velocity time graphs

Motion: Knowledge questions

Use the notes on the previous pages to answer these questions

Q2.1: What is the difference between vector and scalar quantities?

. . . .

. . . .

Q2.2: Give an example of a scalar/vector pair of quantities, stating which one is the scalar and which one is the vector.

. . . .

. . . .

Q2.3: Is acceleration a scalar or a vector? Can you explain why?

. . . .

. . . .

Q2.4: Give an example of a situation where the speed of an object is constant, but its velocity is changing.

. . . .

. . . .

Q2.5: What are the two formulas that link initial speed (u), final speed (v) and acceleration (a)? How can you decide which of the formulas to use to answer a question about acceleration?

. . . .

. . . .

. . . .

. . . .

Q2.6: On a distance-time graph, how do you:

a) find the velocity of an object

. . . .

b) identify when the object is stationary

. . . .

c) identify when the object is moving away from the start

. . . .

d) identify when the object is moving with a constant speed

. . . .

e) identify when the object is accelerating or decelerating (i.e. it is moving with a non-constant speed)

. . . .

Q2.7: On a velocity-time graph, how do you:

a) identify when the object is stationary

. . . .

b) identify when the object is moving with a constant speed

. . . .

c) identify when the object is accelerating or decelerating

. . . .

d) find how far the object has moved in a given time interval

. . . .

Motion: Practice questions

Q2.8: Identify which of the following quantities are scalars by drawing a circle around them. Identify which are vectors by underlining them.

time   speed   distance

        mass   energy   displacement

                force   weight

Q2.9: A car is travelling up the M1 motorway at a constant speed. The driver presses the accelerator to begin to increase speed in order to overtake a vehicle in front.

The car is initially moving at a speed of 26 m/s. After 8 seconds its speed has increased to 31 m/s.
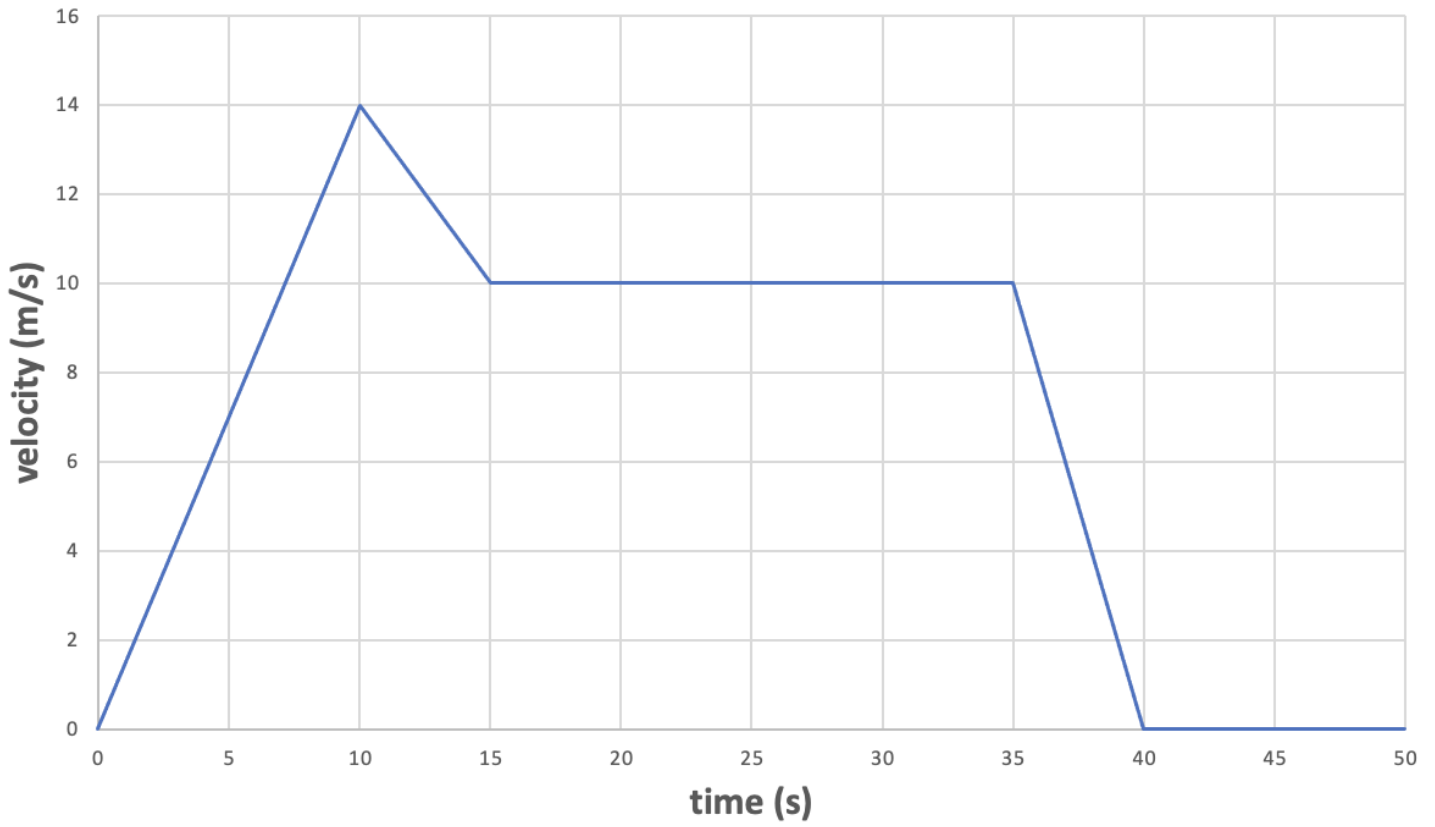
a) What is the average acceleration of the car?

. . . .

. . . .

. . . .

b) How far did the car travel during this acceleration?
   (hint: remember there are two equations for acceleration!)

. . . .

. . . .

. . . .

. . . .

Q2.10: Look at this velocity-time graph showing the movement of an object over 45 seconds.

Between what two times was the object:

a) stationary

. . . .

b) moving, with a constant velocity

. . . .

c) accelerating

. . . .

d) changing velocity at the highest rate (either accelerating or decelerating)

. . . .

How far did the object move:

e) Between 0s and 10s?
   (hint: remember the area of a triangle is ½ × base × height)

. . . .

f) Between 10s and 50s?

. . . .

3: Electricity (A-level Topic 3)

Electric Charge

Atoms are made up of three types of sub-atomic particles; electrons, protons and neutrons.

- Protons are found in the nucleus of the atoms, and have positive electric charge.
- Neutrons are found in the nucleus of atoms, but they have no charge.
- Electrons are found in the outer shell of atoms, and have negative electric charge.
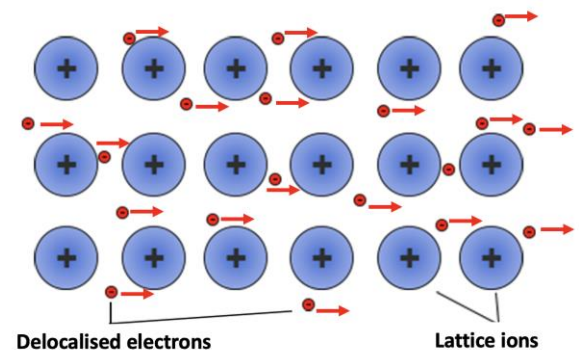
Nucleus

Protons
mass = 1
charge = +1

Neutron
mass = 1
charge = 0

Electron
mass = negligible
charge = -1

* mass and charge numbers are relative to the mass/charge of a proton
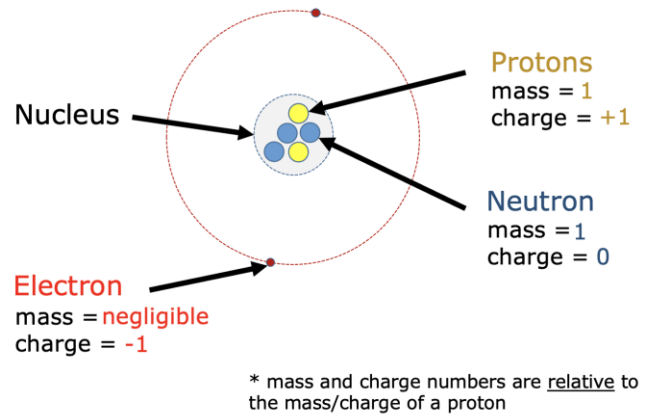
Electric charge is measured in coulombs (C).

Electric Currents

Electric currents are made by a flow of electric charge.

In a metal circuit the electric current is caused by the flow of electrons. The electrons can move because they are found in the outer shells of the atoms.

The current electrons are described as 'delocalised', as they can move between atoms. The rest of the atoms stay in the same place as the electrons move between them; they are called the 'lattice ions'.

Delocalised electrons

Lattice ions

If protons could move in an electric circuit they could cause an electric current (as they have charge as well). However, the protons can't move as they are stuck in the nucleus of the atoms.
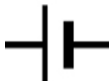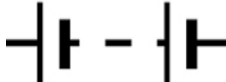
Electric currents are measured in amps (A).

Energy in Electric Circuits

Electric currents in a circuit occur when a power supply causes the electrons to flow.

The amount of energy the power supply <u>gives</u> to the charges is measured in volts (V). A 1V power supply gives each 1 coulomb of charge 1 joule of energy.

The potential difference (p.d.) across a component (e.g. a bulb or a motor) in a circuit is a measure of the amount of energy it is <u>taking</u> from the charge as it flows. If a bulb has a p.d. of 3V across it then it is taking 3 joules of energy from each coulomb of charge that passes through it.

Symbol for a cell

Symbol for a battery (two or more cells)

The size of an electric current in a circuit depends on how much energy the power supply is putting in. The bigger the p.d. of the power supply, the bigger the current in the circuit.
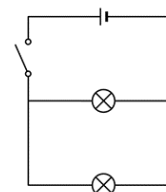
Electric Circuits

The size of an electric current flowing in a circuit is measured using an ammeter. Ammeters are connected in series in a circuit; they have to measure the current <u>flowing through</u> them.

The potential difference across power supplies or components is measured using a voltmeter. Voltmeters are connected across components; they have to measure the <u>difference between two points</u>.
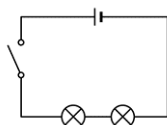
Series circuits have only one path/loop that electrons can take from the negative side of the power supply to the positive side.

Parallel circuits have more than one path/loop electrons can move from the negative side of the power supply to the positive side.

Current rule:

- In a series circuit current is the same at every position.
- In a parallel circuit current splits/joins at the junctions.

Potential difference rule:

- In both types of circuits: around any path/loop the sum of the p.d.s across the components equals the supply voltage.
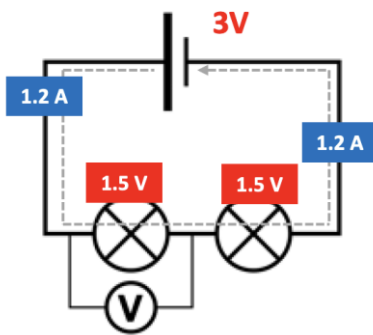
Look at these two circuits. Can you confirm the current and potential difference rules are being followed?
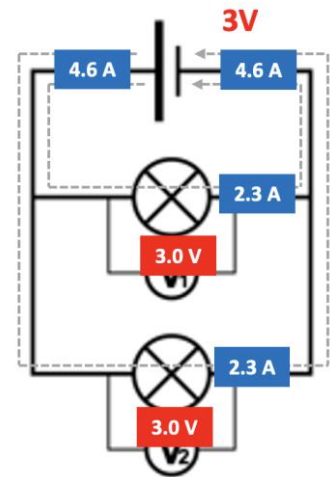
Resistance

Resistance in electric circuits is caused by collisions between current electrons and the rest of the metal atoms (the 'lattice ions'). When the temperature of a metal increases the lattice ions vibrate more, causing more collisions with the current electrons, and so the resistance of the metal increases.

The larger the resistance in a circuit the smaller the current that flows through it. Resistance is measured in ohms (Ω).

If two resistors are placed in series, their total resistance is equal to the sum of their resistances; the same current feels resistance when it passes through each resistor.
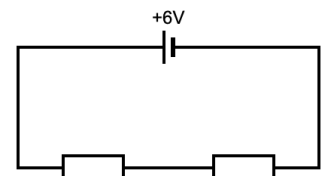
If two resistors are placed in parallel their overall resistance decreases; each branch of the current only passes through one resistor.
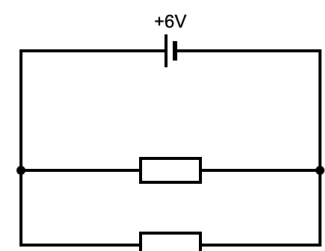
Electricity Equations

The following three equations come up repeatedly when we study electricity. If you know two of the values then you can work out the other value.

Remember that the symbols in the equations here are used to represent the <u>values</u> (either known or unknown) in a question. Different symbols are used as abbreviations for the units.

e.g. in an equation the amount of charge is represented by the symbol **Q** (for historical reasons!). The amount of charge is measured in the unit coulombs, which is abbreviated as C. So we could say any of the following:

- amount of charge = 4 coulombs
- **Q** = 4 coulombs
- Amount of charge = 4 C
- **Q** = 4 C

charge = current × time	$Q = I \times t$
energy = charge × potential difference	$E = Q \times V$
pot. diff. = current × resistance	$V = I \times R$

Useful videos

You may find the following short YouTube videos useful (put the names given below into a search engine to find the video).

- Cognito GCSE Physics Intro to circuits
- Cognito GCSE Physics Charge current and time

Electricity: Knowledge questions

Use the notes on the previous pages to answer these questions

Q3.1: Complete the table about the sub-atomic particles found in an atom

Name	Location in atom	Relative charge	Relative mass
proton			1
	in the outer shells		
neutron		0	

Q3.2: In a metal circuit, why are the electrons able to flow and form an electric current?

. . . .

. . . .

Q3.3: What name is given to the parts of the atom that stay in place and don't flow around the circuit?

. . . .

Q3.4: Current is a measure of how much charge flows through a point in the circuit in one second. What is <u>potential difference</u> a measure of an electric circuit?

. . . .

. . . .

Q3.5: How are voltmeters and ammeters connected in a circuit?

Voltmeters are connected: . . . .

. . . .

Ammeters are connected: . . . .

. . . .

Q3.6: What is the difference between a cell and a battery?

. . . .

. . . .

Q3.7: What happens to the size of the current in a circuit if the p.d. of the power supply is increased?

. . . .

Q3.8: Write down a rule that allows you to decide if a circuit diagram you are looking at shows a parallel or a series circuit:

. . . .

. . . .

. . . .

Q3.9: What causes resistance in electric circuits?

. . . .

. . . .

Q3.10: What happens to the size of the current around a loop in a circuit if the resistance around the loop is increased?

. . . .

Q3.11: Complete the table about the different <u>units</u> used to measure electrical quantities. Remember, the unit symbol is just an abbreviation (short version) of the unit name – it often is a different symbol to the one used to represent a value in an equation

Quantity	Unit name	Unit symbol
charge		C
current		A
time	seconds	
energy	joules	
potential difference		V
	ohms	Ω

Q3.12: Complete the table about the different <u>equation symbols</u> used to represent a value for the electrical quantities in the electrical equations. Remember, this is often different to the symbol used for the quantity's unit.

Quantity	Equation symbol
charge	Q
current	
time	
energy	
potential difference	
resistance	

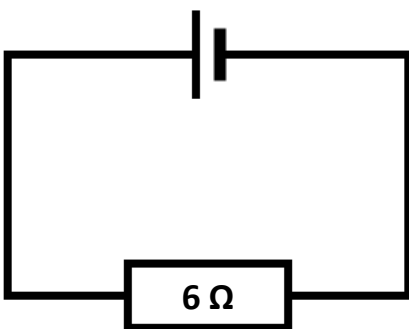Q3.13: What is the symbol version of the equation that links **resistance, p.d.** and **current**?

. . . .

Q3.14: What is the symbol version of the equation that links **time**, **current** and **charge**?

. . . .

Q3.15: Look at the following circuit.

a) What is the equation that links **resistance, p.d.** and **current**? (give it in both its word and symbol forms)

. . . .

b) If the **current** flowing in this circuit is 1.5A, then how big is the supply **p.d.**? (use the equation above)
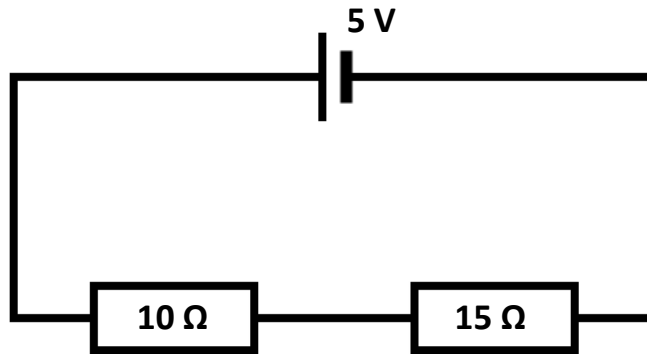
. . . . volts

c) How much **charge** flows around this circuit in 15 seconds? (look for an equation that links **current**, **charge** and **time**)

. . . . C

d) How much **charge** flows around this circuit in 1 minute?

. . . . C

Q3.16: Look at the following circuit.

a) Explain whether this a parallel or series circuit:

. . . .

. . . .

b) What is the overall resistance of the two resistors?
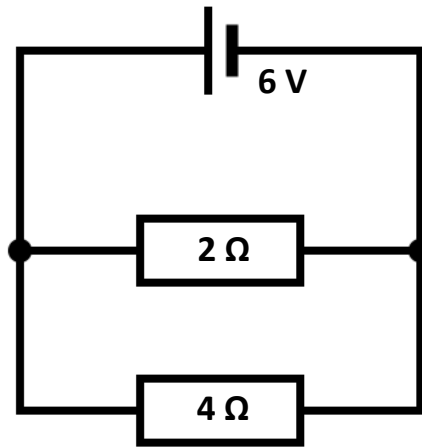
. . . . Ω

c) What current would flow in the circuit? (use the equation for **resistance, p.d.** and **current**, but you'll have to rearrange to work out the current)

. . . . amps (A)

d) If the power supply was replaced with a 10V supply, what current would flow in the circuit?

. . . . A

Q3.17: Look at the following circuit.

a) Explain whether this a parallel or series circuit:

. . . .

. . . .

b) Each of the resistors 'feels' the full supply voltage as they are each connected to both terminals of the supply.

i) How much current flows through the 2Ω resistor?

. . . . A

ii) How much current flows through the 4Ω resistor?

. . . . A

c) What is the total current flowing out of the power supply?

. . . . A