Physics GCSE Unit 1 Summary

Energy

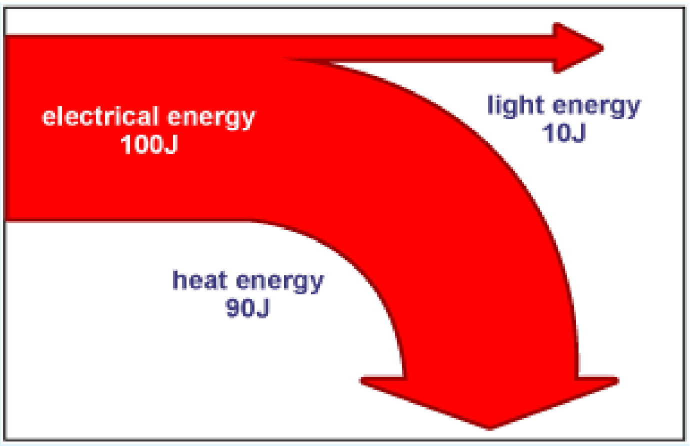
There are 9 different forms of energy:

Light Heat Chemical Kinetic (movement) Electrical
Elastic (Gravitational) potential Nuclear Sound

Energy is never created or destroyed! Energy is transferred from one form to another form. Not all of the energy transferred by a device is useful energy. Potential energy is stored energy. All energy will eventually spread out to the surroundings as heat.

Sankey diagrams are ways of representing the different energy transformations that take place in different electrical devices. The start of the Sankey diagram shows the total energy going into the device. The diagram then splits off into different sized arrows to represent the other energy transfers that take place, the bigger the arrow the larger the energy. The energy entering the device must equal the energy leaving the device.

To know how good a device is at transferring energy you need to be able to calculate the efficiency. To do that you need to use the following equation (which will be given in the exam)



Sample Sankey diagram for a light bulb

$$Efficiency = \frac{Useful\ energy\ out}{Total\ energy\ in}$$

OR

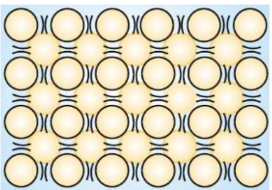
$$Efficiency = \frac{Useful\ power\ out}{Total\ power\ in}$$

So for the above example the answer would be

$$Efficiency = \frac{10}{100} = 0.1$$

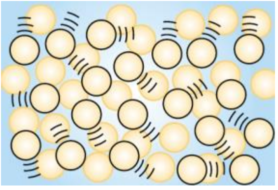
The closer the efficiency is to 1 the more useful energy the device is transferring. So for the light bulb example we got an efficiency of 0.1, so the light bulb isn't very good and transferring useful energy.

Kinetic theory



Most matter or substances can be classed as being solids, liquids or gases.

Solids: They have the least amount of energy are arranged in a pattern. They vibrate around fixed positions

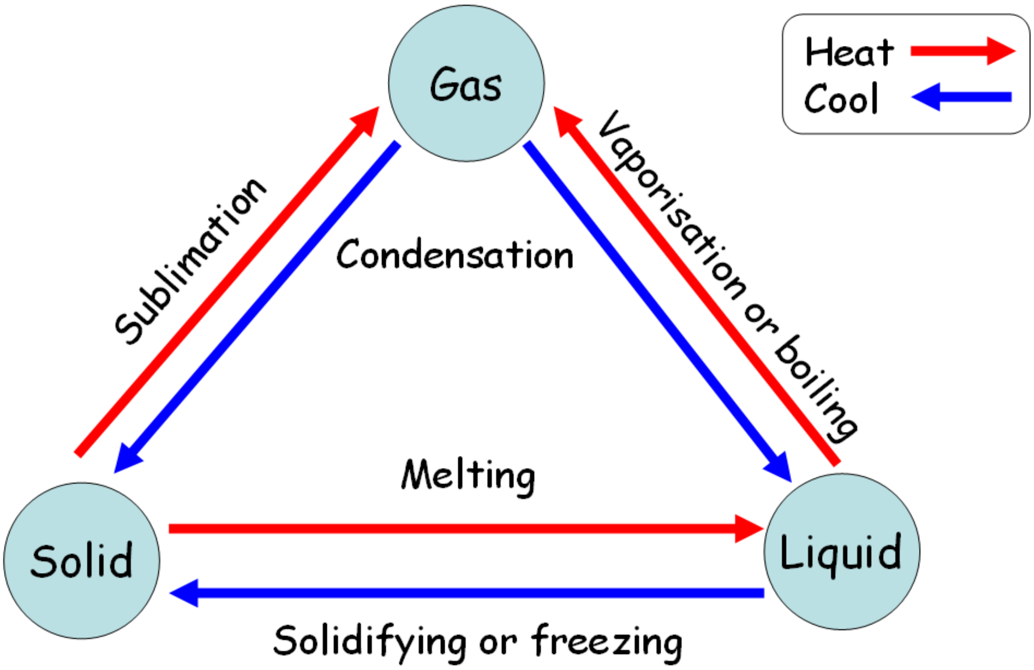


Liquids: The particles are closely packed together but can move about freely over one another.

Gases: They have the most amount of energy and move around at high speeds and can collide with one another.

	Flow	Shape	Volume	Density
Solid	no	fixed	fixed	much higher than a gas
Liquid	yes	fits container shape	fixed	much higher than a gas
Gas	yes	fills container	can be changed	low compared with a solid or liquid

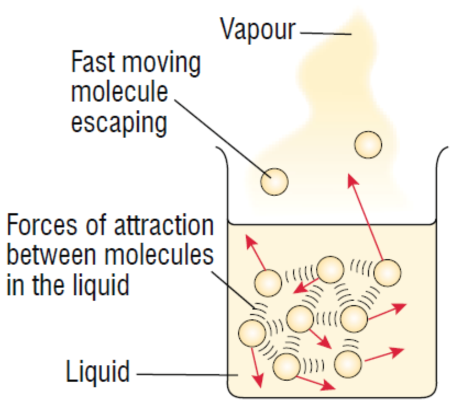
Matter can also change from one state to another e.g. ice to water to water vapour.



Evaporation and condensation

There are 3 things that can cause evaporation to happen quicker

- **A larger temperature**
- **A larger surface area**
- **A draught of air moving over the surface**



Evaporation has a cooling effect

There are attractive forces between the particles in the liquid. Evaporation happens when the liquid particles that have the most kinetic energy break away from the attractive forces. These particles escape from the surface of the liquid and enter the air. This makes the average kinetic energy of the remaining particles less and the temperature goes down.

Condensation is when a liquid turns to a gas, like water forming on a cold window. The rate of condensation can be increased by 2 things

- **Bigger surface area**
  - **Reducing the surface temperature**

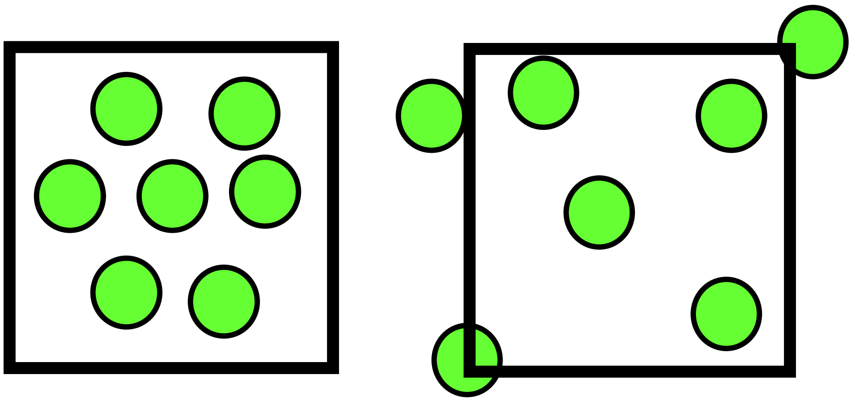
Heat transfer

Heat can be transferred quicker if the temperature difference between the substance and surroundings is greater.

Heat can be transfer by 3 methods

Conduction: Occurs in solids and felt by direct physical contact. The heat travels by the vibration of the atoms. In metals, the heat also moves by the movement of free electrons or ions. Heat flows from the warm area to the cold area.

Convection: Occurs in liquids and gases. This happens because when an area gets hotter the particles move further apart, i.e. that area expands. This makes that area less dense and lighter than the surroundings so it rises. When it then starts to cool that particles move closer together again and it will fall. In short the hotter section expands and rises, the cool part falls. This motion is called convection currents.



Before being heated After being heated

Radiation: All objects do it. It can travel through empty space (vacuum) and travels in waves. This heat radiation is called infrared radiation. Black matt objects are good absorbers and emitters of radiation but light reflective surfaces are bad absorbers and emitters of radiation. Large surface areas radiate heat quicker

Insulation

You can prevent heat loss from objects by using insulation. Air and other gases are bad conductors of heat but make good insulators. For convection you must stop the heat from rising e.g. using a lid.

Trapped air helps to prevent heat loss by conduction and convection. A vacuum (empty space with no particles) also stops conduction and convection as those methods need particles to transfer heat

Radiation can be reduced by using light reflective surfaces.

House insulation: There are different types of insulation for the home e.g. loft insulation, double glazing, cavity wall insulation etc. House insulation is given a rating to determine how good it is at insulating.

This rating is called the **U-Value**; the **lower** the u-value, the **better** it is at insulating.

For example: If 2 types of double glazing windows have U-values of 2.8 and 1.6, the better type to choose is the U-value of 1.6 as it is a better insulator

Pay back time: This is the amount of time it takes you to save back on your energy bills the money spent on the insulation

$$Pay\ back\ time = \frac{Cost\ of\ insulation}{Energy\ bill\ saving}$$

For example: if double glazing costs £150 but you save £50 per year on your energy bill then the pay back time is 3 years

$$Pay\ back\ time = \frac{£150}{£50} = 3\ years$$

Specific heat capacity

Specific heat capacity is the amount of energy needed to raise the temperature of a 1 kilogram substance by 1°C. If an object has a low specific heat capacity then it is quick to heat up, if it has a large specific heat capacity then it will take longer to heat up as it needed more energy.

$$Energy\ (J) = mass\ (kg) \times specific\ heat\ capacity\ (J / kg\,°C) \times temperature\ change\ (°C)$$

Example: If 10kg water is heated from 20°C to 30°C, how much energy has it gained if the specific heat capacity is 4200 J/kg °C ?

Temperature change = 30 – 20 = 10°C

Mass = 10kg

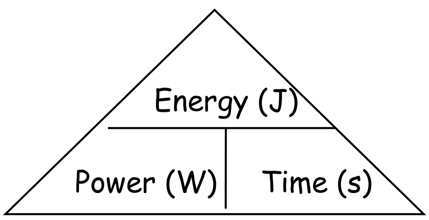
$$Energy = 10 \times 4200 \times 10$$

$$Energy = 420\,000 J$$

Power and electricity bills

Power is measured in watts (W) and it is the amount of energy transferred in one second. So a 60W bulb transfers 60 Joules of energy every second.

$$Power\ (W) = \frac{Energy\ (J)}{Time\ (s)}$$



To know how much electrical energy you have used, you need to multiple the power of the device by the number of hours it has been on for. So if the bulb has been on for 5 hours then it has use 300 Watt-hours of energy. However, the electricity companies use kilowatt-hours (kWh) to work out your bill.

$$Units\ of\ electricity\ used\ (kWh) = Power\ (kW) \times time\ (hours)$$

$1\ kilowatt.hour = 1000\ Watt.hours$ $\qquad$ $1\ Watt.hour = \frac{1}{1000} kilowatt.hour$

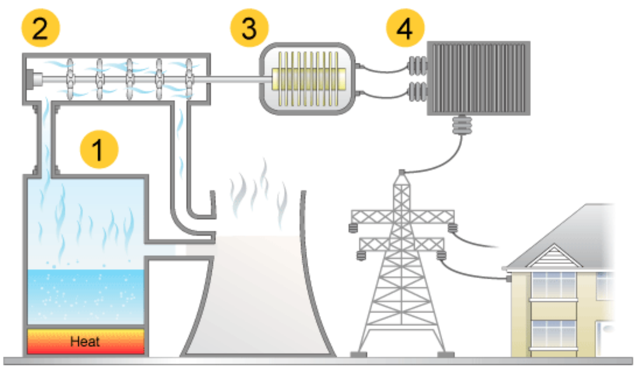
So the bulb would then have used 0.3 kilowatt-hours of electrical energy.
Electricity companies charge you for every kilowatt-hour of electricity you use.

$$Cost = Electrical\ energy\ used\ (kilowatt.hours) \times cost\ per\ kilowatt.hour$$

So, for example, if an electricity company changes you 10p per kilowatt-hour of electricity used then the bulb has cost you:

$$Cost\ of\ electricity = 0.3\ kilowatt.hours\ \times 10p = 3p$$

Generating Electricity



The way electricity is generated is by burning fuels to heat water. This water then turns to steam (1). The steam then spins the turbine (2) which is connected to a generator (3). The generator creates electricity and travels to a transformer where the voltage is "stepped up" or increased (4). The electricity then travels down the electrical lines and then gets stepped down by another transformer and enters the home.

Transformers: When electricity travels down the power lines some of the energy is lost as heat because of friction. If the current was increased then even more energy would be lost as heat (think about when you rub your hands together really fast). So step up transformers are used to increase the voltage (not the current) before it travels down the line, it then gets stepped down at the other end.

Energy resources

Electricity can be generated from several different resources such as wind, water, fossil fuels, light, biomass and nuclear. Some are renewable (can be used again) and other are non-renewable.
Fossil fuels are fuels which were made from plants and animals that lived millions of years ago. Examples of these fuels are coal, oil and gas.

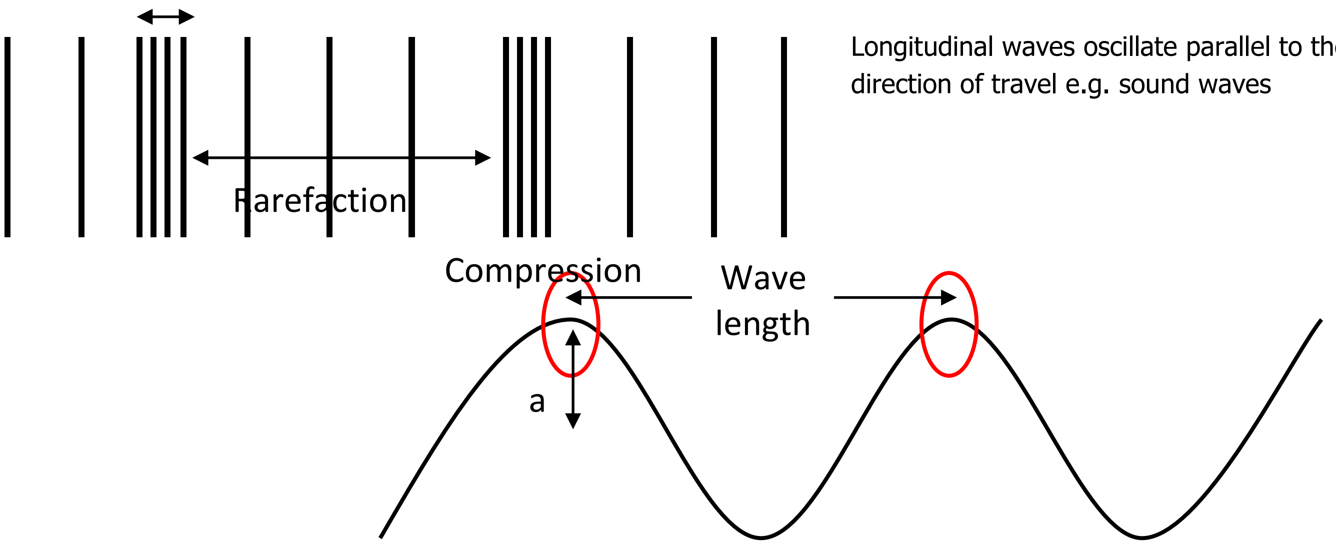
Fossil fuels need to be burned in order to be used to generate electricity. This is also true for biomass. The other energy resources don't require combustion to work but they do involve making a turbine spin except for solar. For solar energy the light gets converted directly into electricity.

Energy type	Renewable	Causes acid rain	Causes global warming	Reliable (will always work)	Other info
Wind	**YES**	NO	NO	NO	Free energy source

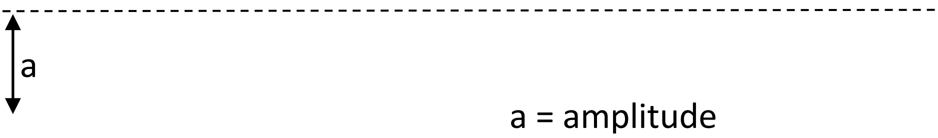
Wave	**YES**	NO	NO	NO	Free energy source
Solar	**YES**	NO	NO	NO	Free energy source
Geothermal	**YES**	NO	NO	NO	Free energy source, Creates steam
Fossil fuels	NO	**YES**	**YES**	**YES**	Needs burning
Nuclear-fuel is uranium/plutonium	NO	NO	NO	**YES**	High decommissioning (dismantle and remove radioactive waste) costs, produces radioactive waste, no other pollution
Hydroelectric	**YES**	NO	NO	**YES**	Free energy source, Good for sudden electricity demand
Biomass	**YES**	NO	**YES**	**YES**	Free energy source
Tidal	**YES**	NO	NO	**YES**	Free energy source

Waves and their properties

Waves can be classed as either **longitudinal** or **transverse** waves.



Longitudinal waves oscillate parallel to the direction of travel e.g. sound waves



a = amplitude

Transverse waves oscillate perpendicular (right angles) to the direction of travel e.g. all EM waves

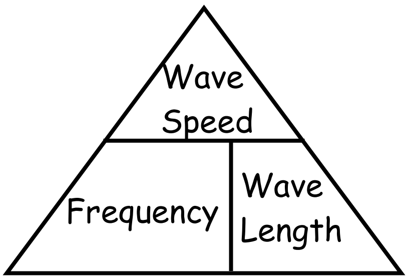
The frequency is the number of waves that occur every second. The frequency is measured in Hertz (Hz). In the case of sound, the frequency determines the pitch.

Amplitude is how ‘tall the wave is and in the case of sound a large amplitude means a loud sound, a small amplitude means a quite sound

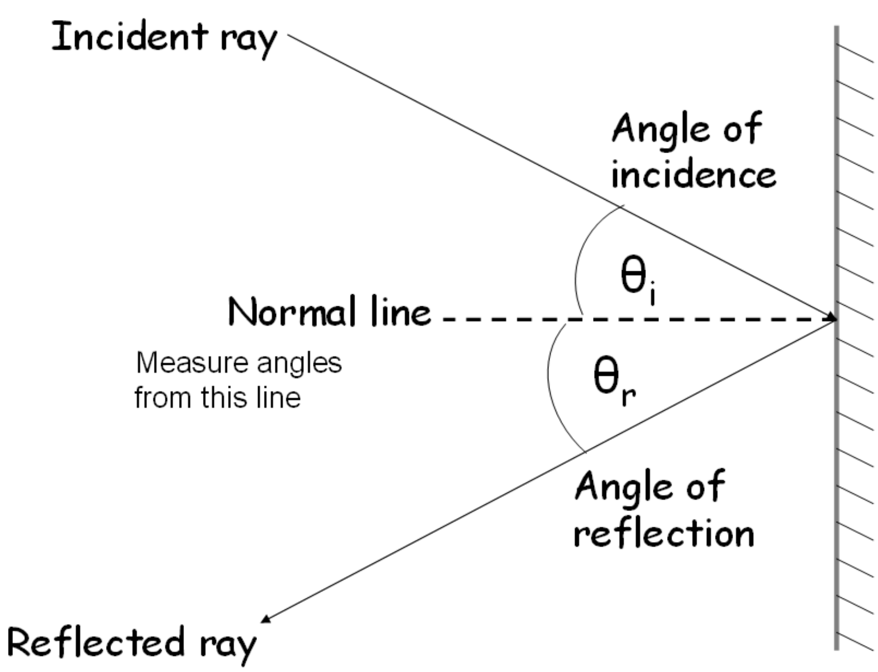
The wavelength the distance between one point on the wave to the next corresponding point, measured in metres (m). The easiest way to think of it is the distance between one peak and the next peak OR one compression to the next compression, this is one complete wave.

You can calculate the speed of a wave (measured in metres per second [m/s]) if you know the frequency and the wavelength.

$$Wave\ speed\ (m/s) = Frequency\ (Hz) \times Wavelength\ (m)$$



Waves can be reflected, refracted and diffracted



<u>Reflection:</u> This can happen when waves strike a smooth flat surface.

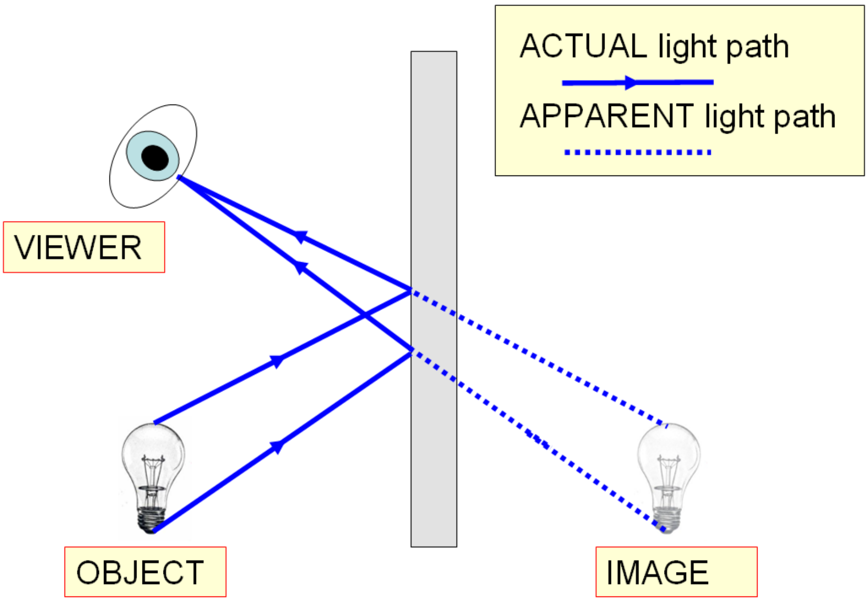
When light hits a plane (flat) mirror we measure the incoming incident ray from the normal. This is a line that comes out perpendicular (right angles) to the surface of the mirror. For any reflected ray, the angle of incidence is equal to the angle of reflection.

Forming images

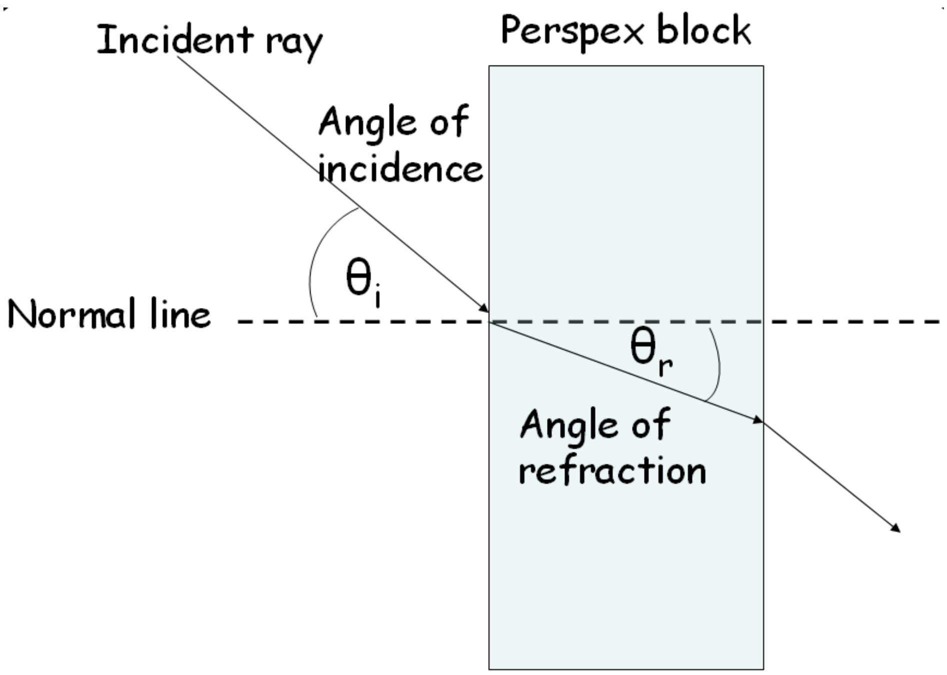
Images formed in a plane mirror are

- Same size as object
- Upright
- Same distance behind the mirror as the object is in front
- Laterally inverted (left is right, right is left)
- virtual

A Virtual image is one that is not made from real light rays. Virtual images cannot be projected onto a screen.



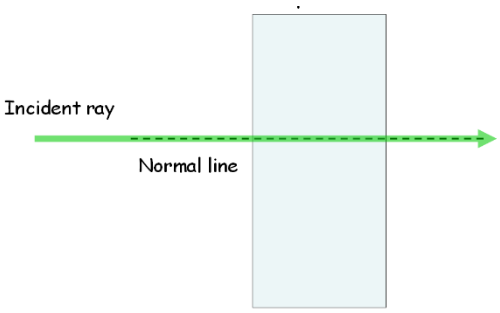
Refraction



Refraction is when a wave changed direction when entering a more/less dense medium.

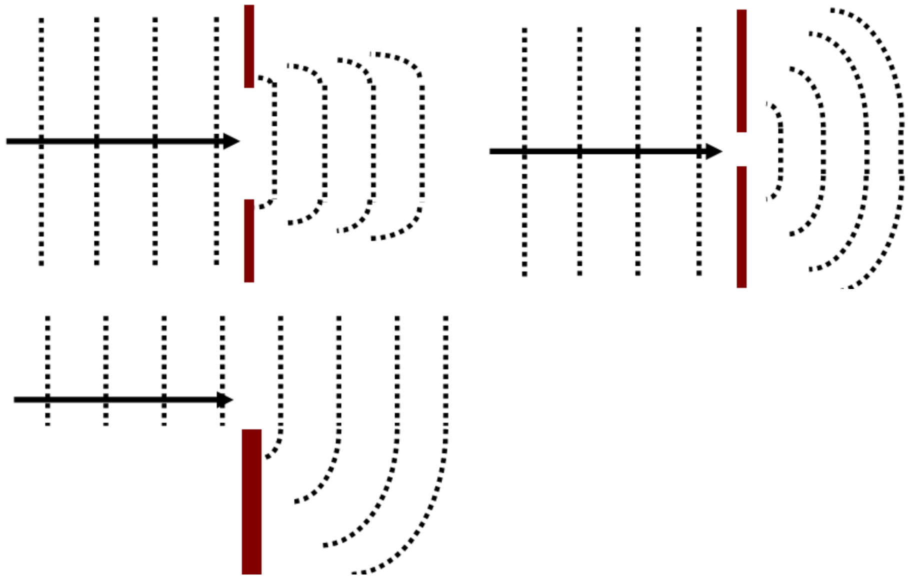
Using the example of light, when the ray enters the Perspex block from air it gets slowed down as Perspex is denser. This also causes the ray to change direction (bends towards normal). When the light is leaving the block it speeds up as air is less dense. The ray will then bend away from the normal line.

If the light enters along the normal line i.e. perpendicular to the surface of the material then no refraction occurs. The light will still be slowed down as it is travelling through a denser material but the light will not change direction.

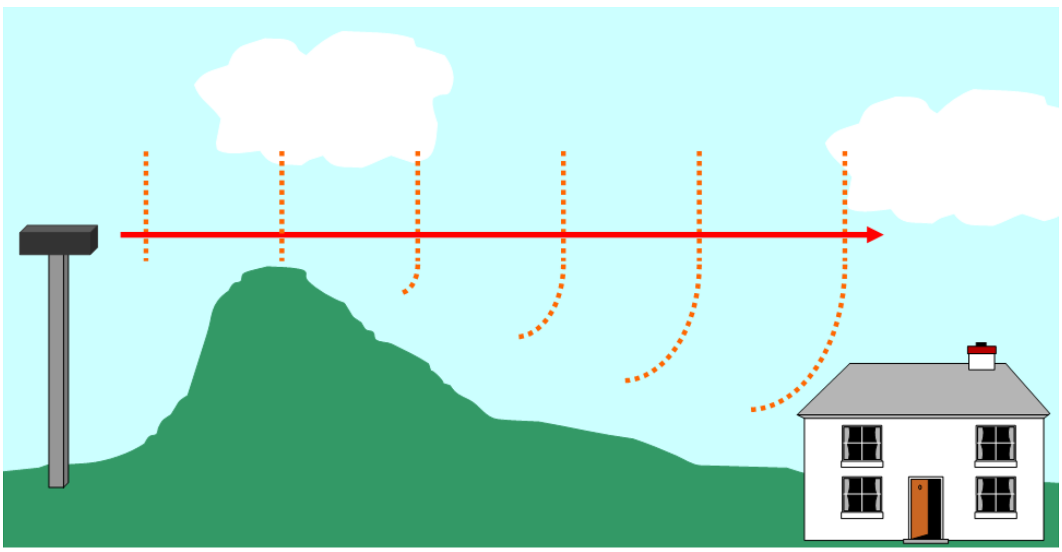


Diffraction

This is when a wave gets spread out when passing through a gap or round an obstacle

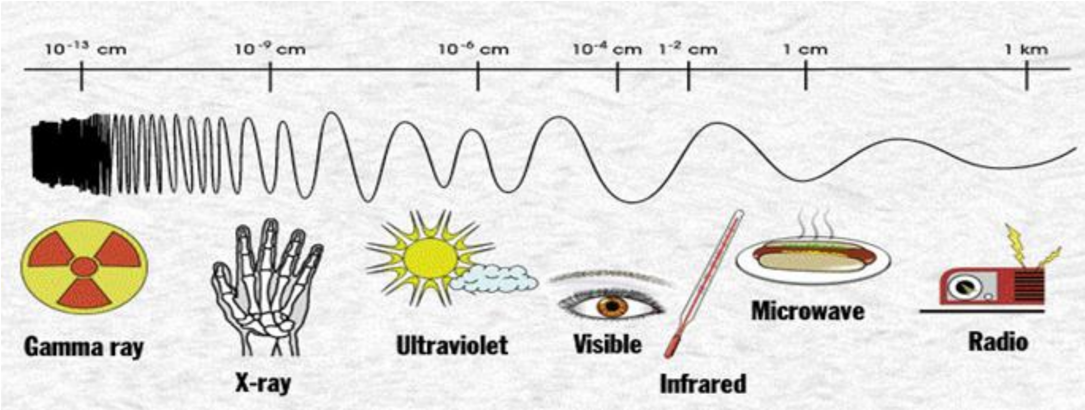


More diffraction occurs if the size of the gap/obstacle is of a similar size to the wavelength



If you live in a hilly or mountainous area then certain TV signals may be poor if they aren't diffracted enough by the obstacle.

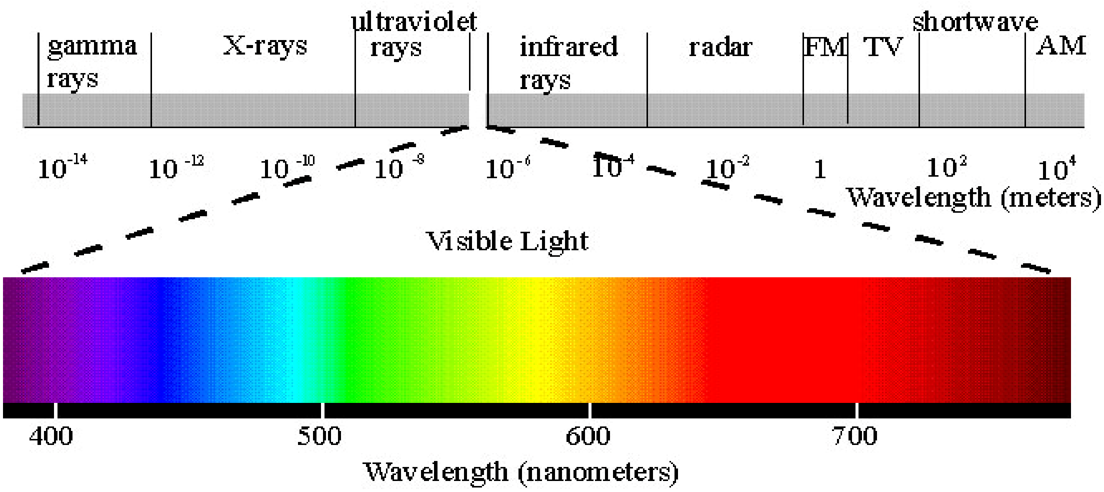
Electromagnetic spectrum



Part of the spectrum	Frequency (Hz)	Wavelength (m)
Gamma	Highest	Shortest
X-ray	↓	↓
Ultraviolet		
Visible		
Infrared		
Microwave		
Radio	Lowest	Longest

The electromagnetic spectrum is energy that travels by waves. The only part of the spectrum that we can see is visible light. The electromagnetic spectrum has different properties, namely frequency and wavelength. All electromagnetic waves travel at the same speed in a vacuum (empty space).

The visible part of the spectrum can be separated into the colours that compose white light. This can be done by passing light through a prism.

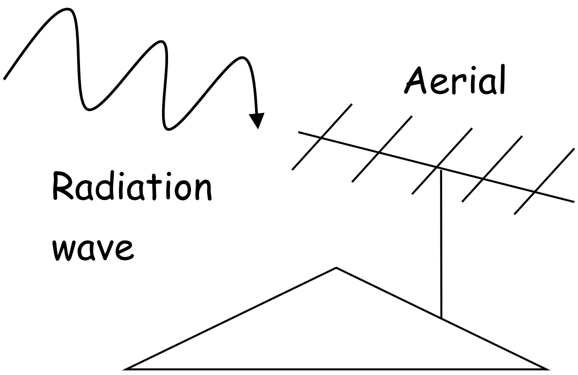


Violet Indigo Blue Green Yellow Orange Red

Part of the spectrum	Advantages	Disadvantages
Gamma	• To sterilise surgical instruments • To kill cancer cells	• High doses can kill cells • Low doses can cause cancer
X-ray	• To see bones • To kill cancer cells	• High doses can kill cells • Low doses can cause cancer
Ultraviolet	• In sun beds to give a tan • Identifying forgeries in money	• High doses can kill cells • Low doses can cause cancer (skin)
Visible	• For seeing and communication – photography	• Blindness
Infrared	• Communication e.g. Broadband and remote control for TV • For cooking e.g. toaster	• Absorbed by skin and felt as heat • Excessive amounts cause burns
Microwave	• For communication in mobile phones and with satellites • Cooking food	• Absorbed by water in the cells, releasing heat, this can damage or kill the cells
Radio	• For communication without the use of satellites, TV and radio	• High levels can lead to tissue damage, particularly the ears • Large doses can cause cancer and leukaemia

Communication

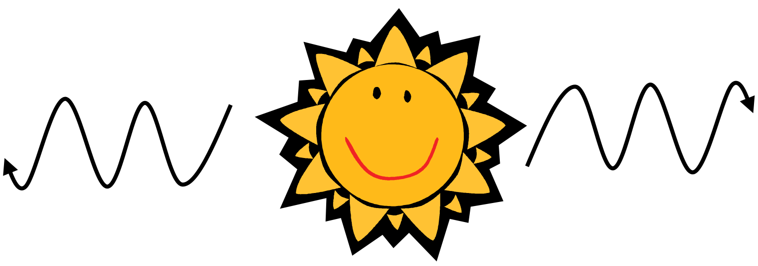
The most common waves used for communication are radiowaves, microwaves, infared and visible light.



When radiation is absorbed the energy that it carries will cause the material to heat up. It can create an alternating current in the metal which will have the same frequency as the radiation itself.

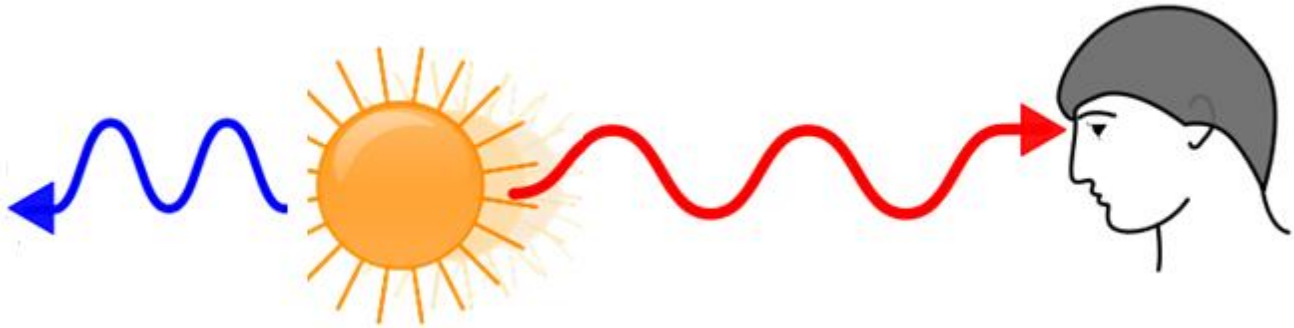
Space

Everything thing in the universe began 14 billion years ago with what is called the **Big Bang**. The universe began as a small hot dense point and then began to rapidly expand.



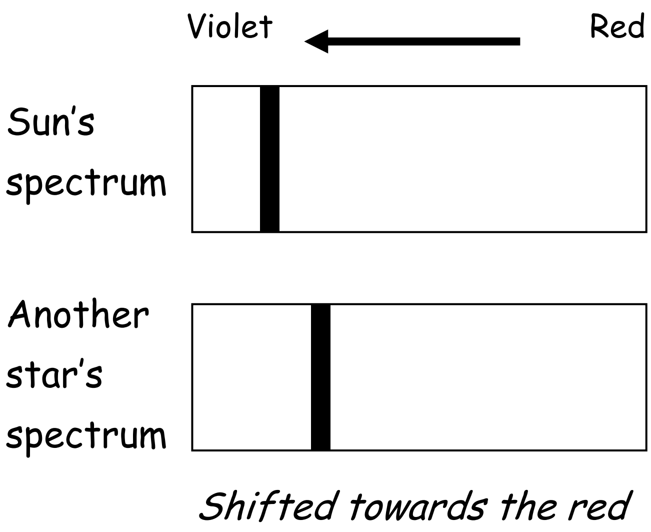
There is evidence for this. When an object which emits light is stationary then the light it emits will be the same in all directions.

However, if an object is moving away from us the light waves get spread out which decreases the frequency. This makes the light appear red, we call this **red shift.** The bigger the red shift the further away the object is.



If an object was moving towards us it would appear blue because frequency would be increased.

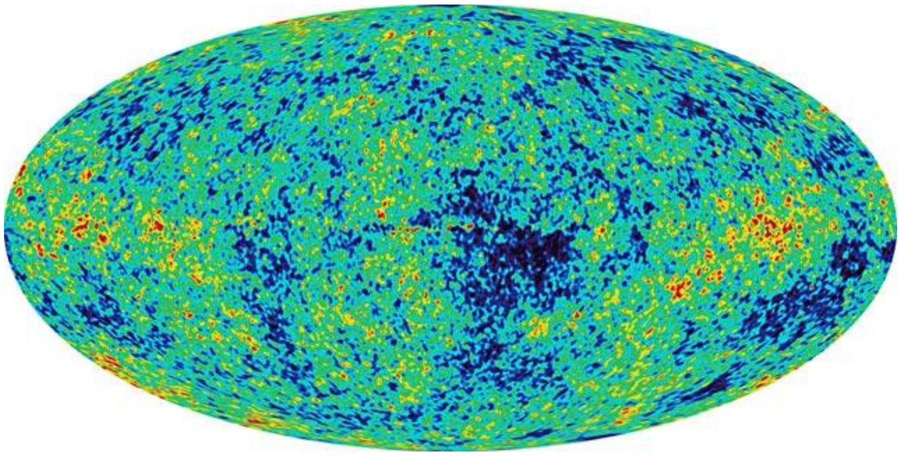
The way we can observe red shift more effectively is by looking at the spectrum of light given off by astronomical objects.



The spectrum from stars for example will have dark line appearing in them. These dark lines indicate what elements the star is composed of e.g. Hydrogen. So, since the Sun is so close to use we can consider it to be stationary. So we can compare the dark lines from other objects to the sun's spectrum and if these dark lines are more towards the red end of the spectrum, then the object is moving away from us. If it is towards the violet end then it is moving towards us.

Cosmic microwave background

The cosmic microwave background radiation is radiation left over from the big bang. This is radiation that is distributed throughout the universe and is evidence that the big bang happened

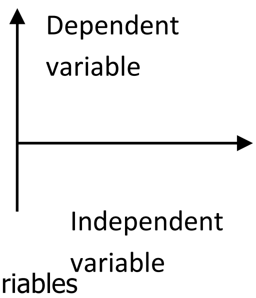


How science works

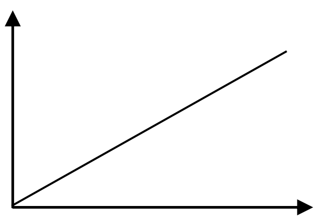
When carrying out experiments and answering questions based on interpreting experiments you need to know the following.

The independent variable is what is changed during an experiment
Remembering Tip: Independent starts with I so it is the variable that I change
The dependent variable is what you measure in the experiment i.e. the results
The control variables are the things you want to keep the same during an experiment.

When plotting a graph for your results you generally plot the dependent variable along the y-axis and the independent variable along the x-axis
Your independent/dependent variable can either be continuous or categoric.

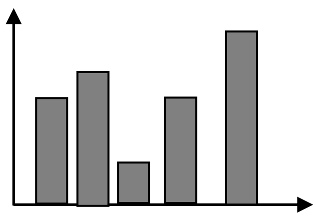


Continuous variables can be any number 5, 1.2, 5.76, 3.0, 7, 94 etc



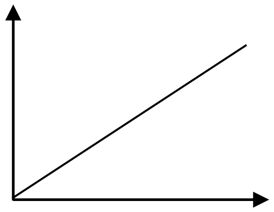
- You plot a line graph for continuous variables

Categoric variables are things such as colours e.g. red, blue, green.



- You plot a bar graph for categoric variables

Describing results



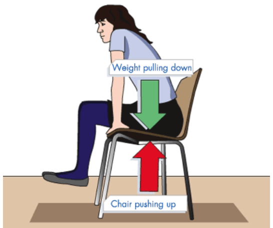
- This graph is showing a positive correlation, i.e. as one variable increases so does the other and the line goes up.
- A negative correlation is when one variable goes up the other goes down, the line would go downwards.

Experimental procedure

Prediction: What you think will happen
Plan: How you are going to carry out your experiment
Conclusion: What you have found out from the experiment
Fair test: When you make sure each experiment is set up the same way
Repeatable: In experiments you usually repeat measurements and take a mean (average). This is to ensure you are getting the same results.
Reproducible: If another experimenter can get the same results as you using their equipment then your finding are correct

Physics GCSE Unit 2

<u>Forces</u>

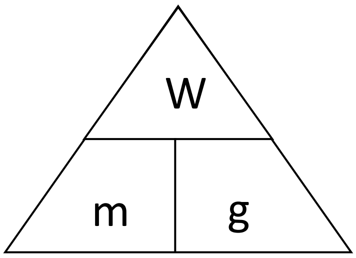


Forced act in pairs. When 2 forces interact they are equal and opposite in direction e.g. a person exerts a force on the chair but the chair applies an equal force upwards on the person, a **reaction force**.

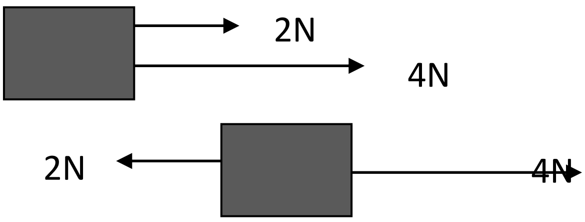
Weight is also a force measured in newtons. Don't confuse mass and weight as mass is actually the amount of 'stuff' that makes up an object measured in kilograms. Weight is the force calculated by

Weight (N) = Mass (kg) x Gravitational field strength (N/kg)

The gravitational field strength on Earth is taken as 10N/kg.



A resultant force is the sum of forces acting on an object.

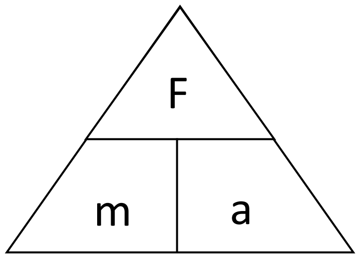


Resultant force = 2N + 4N = 6N to the right

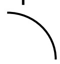
Resultant force = 4N - 2N = 2N to the right

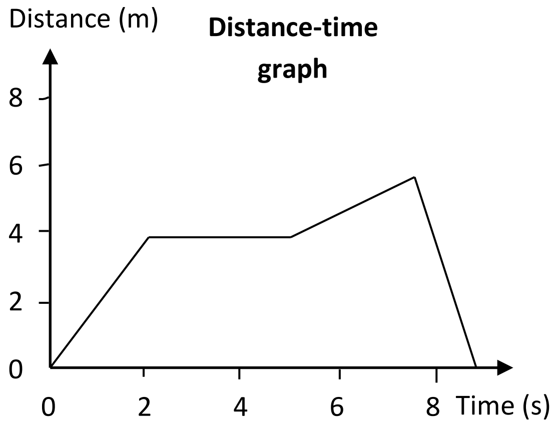
Balanced forces occur when an object is stationary or moving at a constant speed. The faster an object is moving the bigger the frictional forces acting on it.

Resultant Force (N) = Mass (kg) x Acceleration (m/s²)

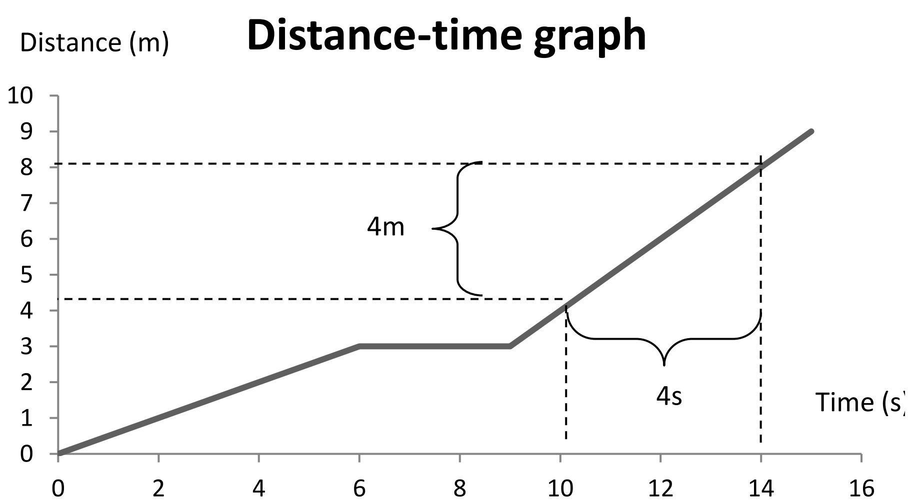


Distance-time and velocity-time graphs

Distance-time graphs tell you how an objects distance is changing over time. If there is a smooth slope on your graph then the object is moving at a constant speed. If there is a flat line then there is no movement. A steeper slope means a faster speed. If the slope is downwards the object is returning to the starting position. If there is an upwards curve () on a distance time graph then the object is accelerating, a downward curve () means it is decelerating.



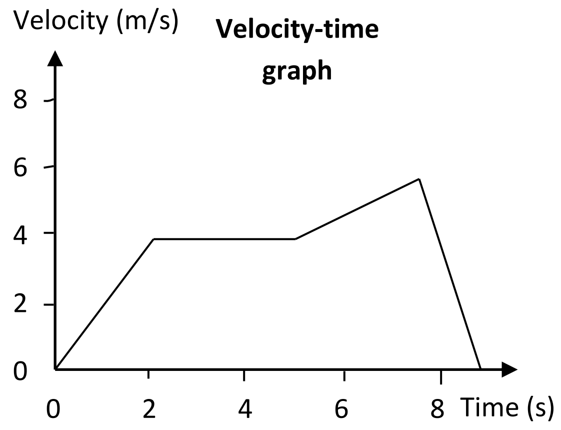
In order to work out the speed from the slope you choose a section of the slope and determine what size it is relative to the axis. Since speed is distance ÷ time you then use those values from the slope. So in this case



Speed = 4m ÷ 4s = 1m/s

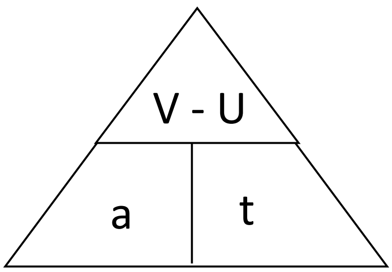
Speed is how fast you are travelling and velocity is your speed in a given direction.

Velocity-time graphs tell you how an objects velocity is changing over time. If there is a smooth slope on your graph then the object is accelerating. If there is a flat line then the object is moving at a constant speed. A steeper slope means a larger acceleration. If there is a downwards slope then the object is decelerating. The area under the velocity time graphs tells you the distance travelled. To work out the acceleration from a section of the slope you use the same method as above for the distance-time graph.



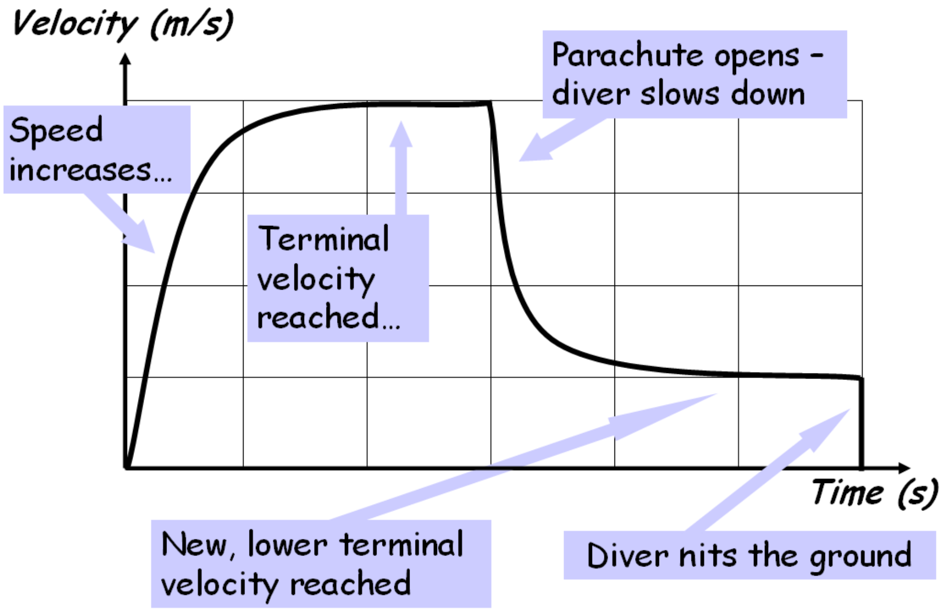
A velocity-time graph tells you how an objects velocity changes over a certain time. This is the acceleration.

$$Acceleration\ (m/s^2) = \frac{Final\ velocity\ (m/s) - initial\ velocity\ (m/s)}{time\ taken\ (s)}$$



Terminal velocity

An object falling through a fluid or gas will initially accelerate due to the force of gravity. Eventually the force of gravity will be balanced by the up thrust of the liquid/gas; this makes the resultant force zero and the object will move at its **terminal velocity** (steady speed).
The faster the object falls the greater the frictional force that acts.



To the left is a velocity time graph for a sky diver who jumped out of a plane.

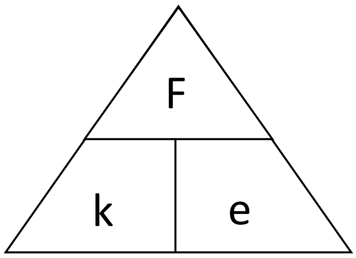
Hooke's Law

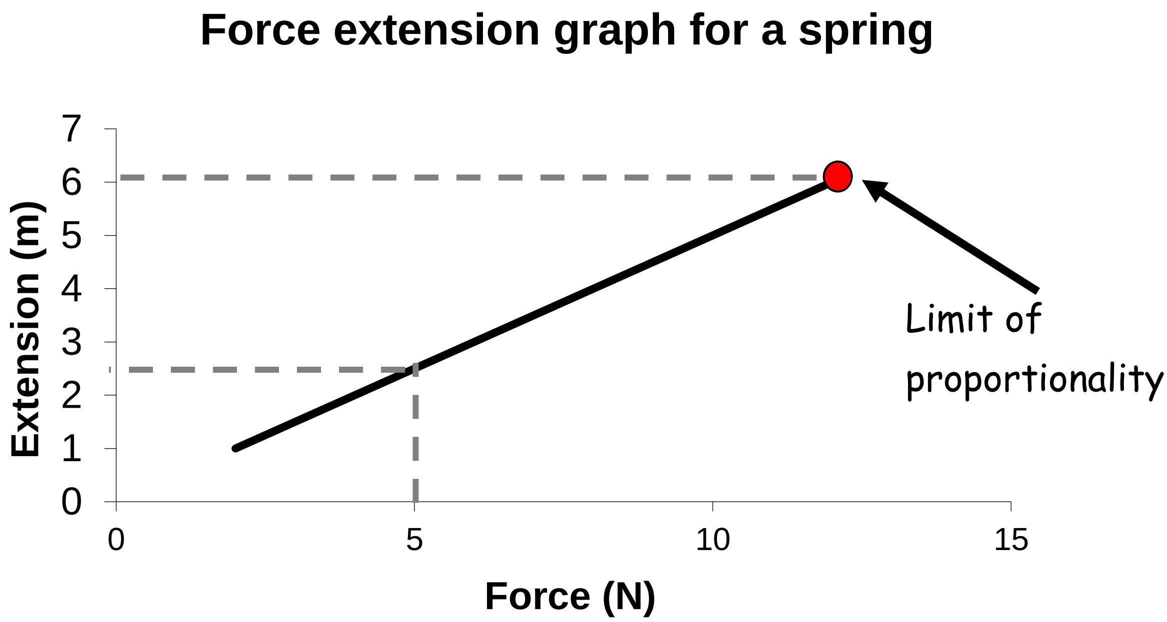
When a weight (force) is applied to a spring it extends. The amount it extends is proportional to the force added. It is governed by the equation:

Force (N) = spring constant (N/m) x extension (m)

(F = k x e)

The spring constant can be determined from the gradient (slope of the line) on a force extension graph.





Choose a section of the line and measure the amount of force and the extension. Then divide the force by the extension

For example: In the sample graph the section of the line chosen if for a force of 6N and an extension of 3m.

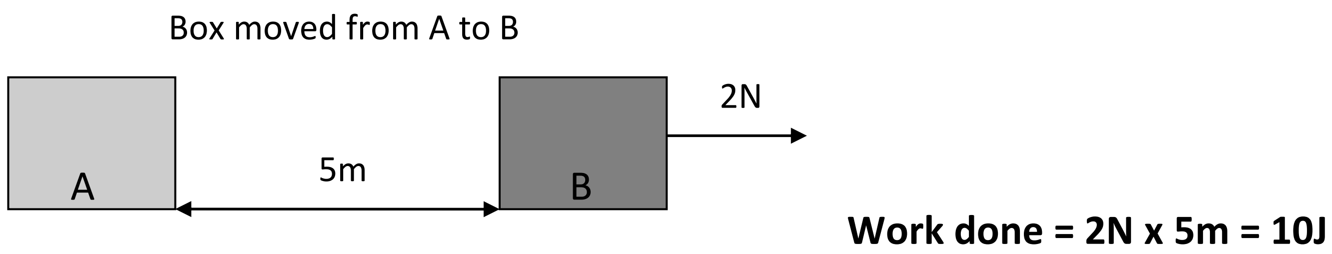
$k = F \div e$ $k = 6 \div 3 = 2$ N/m

Also marked on the graph is the **limit of proportionality**. This is the point at which the spring can still return to its original length. Beyond this point the spring can never go back to its original length/shape.

Force and energy

When a force acts upon an object causing it to move a through a distance energy is transferred and work is done. The amount of work done is equal to the amount of energy transferred. The amount of work done is calculated by:

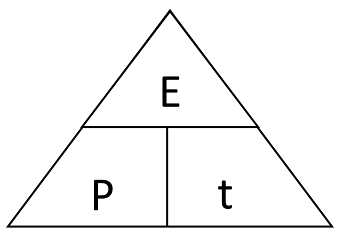
Work done (Joules, J) = Force applied (N) x distance moved (m)



If you try to do work against a surface with friction then most of the energy gets transformed into heat.

Power is the amount of work done (energy transferred) every second and is calculated using the following equation

$$Power\ (W) = \frac{Energy\ transformed\ (J)}{time\ (s)}$$



Work can also be done on other objects. If you change the shape of an object then the energy gets stored in the object, e.g. an elastic band. This is elastic potential energy. Remember, potential energy is stored energy that is 'waiting' to be used, kinetic energy is movement energy.

Gravitational potential energy is the amount of energy an object has when it is held above the ground. It is calculated using the following equation

$$Gravitational\ \ potential\ \ energy\ (J) = mass(kg) \times gravitional\ \ field\ (N/kg) \times height(m)$$

Example: A book of mass 0.5kg is on a shelf 2 metres off the ground. What is its gravitational potential energy if the gravitational field strength is 10N/kg.

Answer: GPE = m x g x h

GPE = 0.5 x 10 x 2 = 10J

To work out the kinetic energy a body has you need to know it's mass and it's velocity;

$$Kinetic\ energy\ (J) = \frac{1}{2} \times mass\ (kg) \times velocity^2\ (m/s)^2$$

Mass

2000kg

Velocity

60m/s

Kinetic Energy = $\frac{1}{2}$ x 2000kg x $(50m/s)^2$

= $\frac{1}{2}$ x 2000kg x $2500(m/s)^2$

= 2500000J OR 2500kJ

<u>Momentum</u>

Momentum (has the symbol p) describes how much motion an object has. It is measured in kilogram metre per second (kg m/s). Like velocity, momentum has magnitude acting in a certain direction.

Momentum (kg m/s) = Mass (kg) x Velocity (m/s)

Mass = 0.1kg

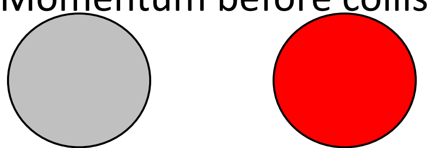
Velocity = 50m/s

Momentum = 0.1kg x 50m/s

= 5kg m/s

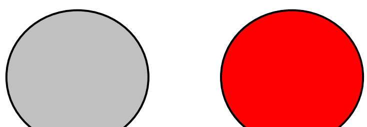
In all situations, momentum is conserved, providing there are no external forces acting. For collisions, the momentum before the collision is equal to the momentum after the collision e.g. snooker balls

Momentum before collision



EQUALS

Momentum after collision

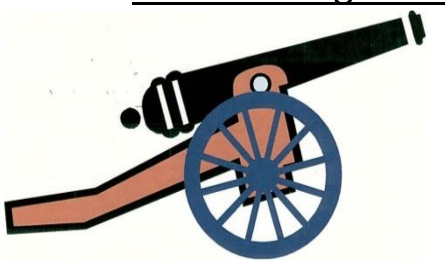


$p=mv$ → $p=0$ $p=0$ $p=mv$ →

Another example is cannon before being fired and after being fired. Before the cannon is fired the momentum is zero, after it is fired the cannon ball moves forward and the cannon moves back. The momentum of the cannon ball is the same as the momentum of the cannon moving backwards.

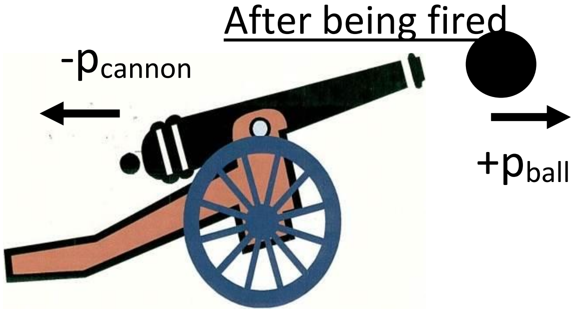
In this sort of example you should choose one direction to be positive and the other direction to be negative. The example below illustrates this point. I will choose the right to be positive and the left to be negative.

<u>Before being fired</u>



$p = 0$

<u>After being fired</u>



$p_{ball} - p_{cannon} = 0$

Static electricity

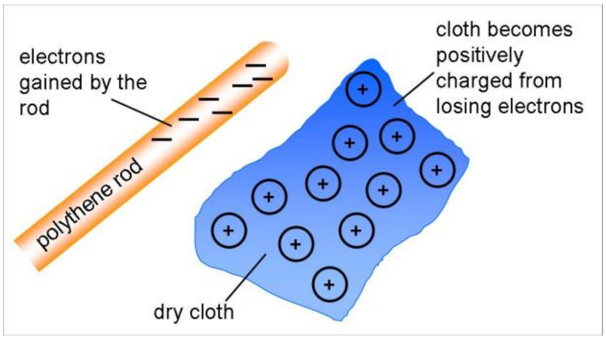
In static electricity when two objects are rubbed together the electrons move from one object to another. This causes one object to have an overall positive charge and the other object to have an overall negative charge.

Like charges repel

Unlike charges attract

Neutral objects are attracted to both positively and negatively charged objects.

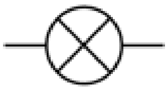
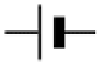
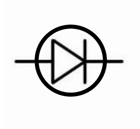
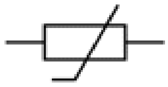
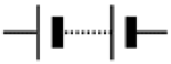
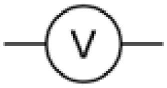
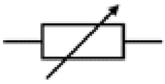
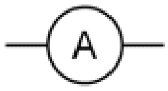
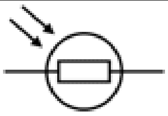
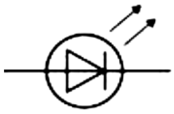
If you wanted to test if an object was charged then you could check if it attracted bits of paper, hair etc. It could attract or repel another charged object.

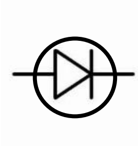
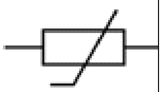
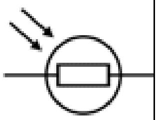
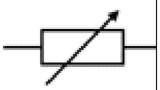
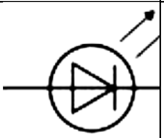


If an object becomes highly charged then the potential difference between then object and the ground increases and the objects will discharge. When a charged object discharges (goes to ground) then a spark might occur. This is the electrons jumping from the object to the earthed conductor.

Current and circuits

We use symbols in circuits and you need to be able to recognise and draw circuits using the following symbols.

 Open Switch	 Closed Switch	 Lamp	 Cell	 Diode	 Thermistor
 Battery	 Voltmeter (connect in parallel)	 Resistor	 Fuse	 Variable resistor	 Ammeter (connect in series)
 Light dependent resistor (LDR)			 Light emitting diode (LED)		

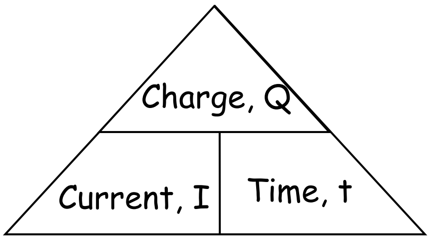
	A diode is a component that only allows current to flow one way in a circuit		This is a temperature resistor. As the temperature increases the resistance decreases
	A LDR is a resistor whose resistance decreases if the light intensity increases (more light shining on it)		This is a resistor whore resistance can be changed. E.g. a dimmer switch
	A light emitting diode (LED) is a component that only allows current to flow one way in a circuit and when the current is flowing that way it gives off light		

Current (symbol I, measured in amperes, A) is the rate of flow of electrical charges (symbol Q) or electrons i.e. The number of charges per second.

Current is the amount of charges (measured in Coulombs) that flow every second, it is represented by the equation:

Current (Ampere, A) = Charge (Coulombs, C) ÷ Time (s)

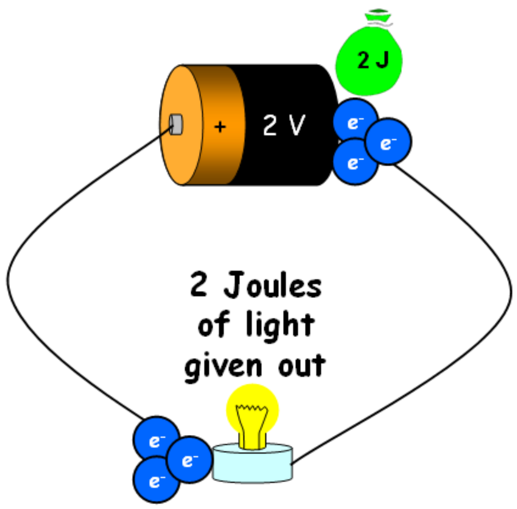
So if a circuit has a current of 2A that means that there are 2 coulombs of charge going around the circuit every second



Quick example: 6 Coulombs of charge go around a circuit every 2 seconds. What is the current?

Answer: $I = Q \div t$ $I = 6C \div 2s = 3A$

Voltage or potential difference (symbol V, measured in volts, v) is the amount of energy transferred by the charges i.e. the amount of energy per charge

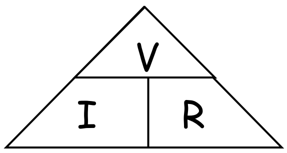


If there is a 2V cell or battery in a circuit then it gives 2 joules of energy to every coulomb of charge. When these charges get to the device in the circuit e.g. a bulb, then the energy gets transferred to the device. To calculated potential difference/voltage you use the following equation.

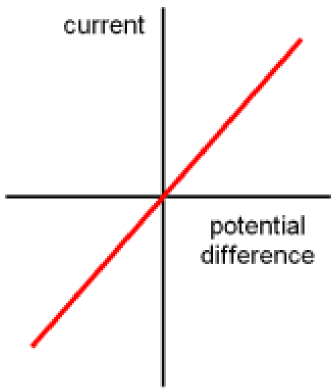
$$Potential\ \ difference\ (V) = \frac{Work\ done\ (J)}{Charge\ (C)}$$

Resistance (symbol R, measured in ohms, Ω) is something that opposes the flow of current.

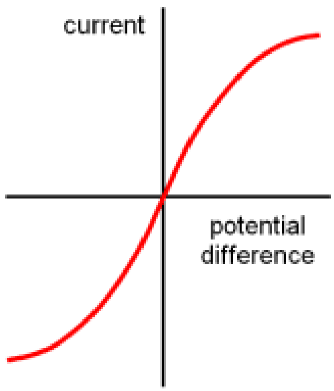
Voltage, current and resistance related by the equation: V = I x R



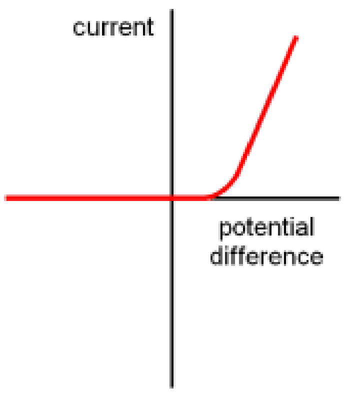
Current- potential difference graphs tell you how the current through a component varies with voltage.



Resistor at a constant temperature



A filament lamp



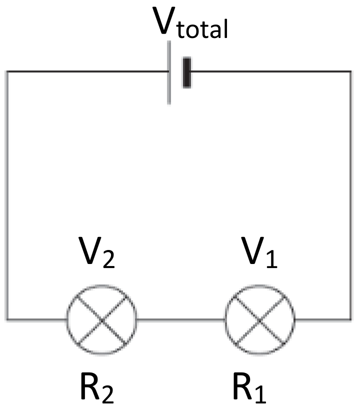
A diode

There are two types of circuits, parallel and series circuits.

In a series circuit

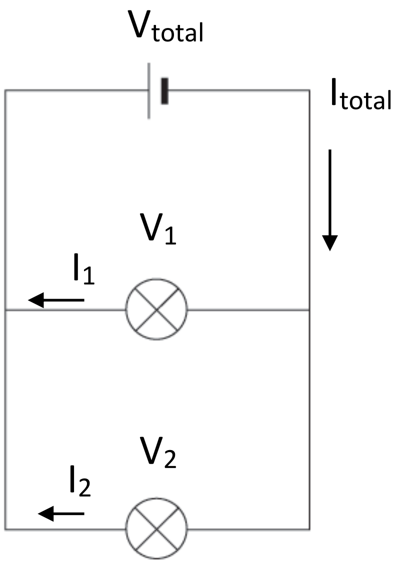
- The total resistance is the sum of the resistance of each component in the circuit
    - Total resistance (R_{total}) = $R_1 + R_2$
- The current is the same at every point in the circuit

- The voltage is shared between each component in the circuit
    - Total voltage (V_{total}) = $V_1 + V_2$



In a parallel circuit

- The voltage is the same across each branch
    - $V_{total} = V_1 = V_2$
- The total current through the circuit is the sum of the current through each component
    - Total current (I_{total})= $I_1 + I_2$



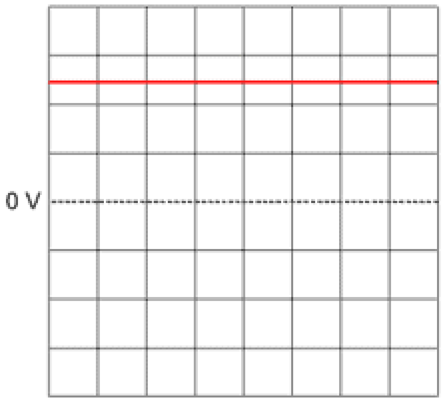
Mains electricity and safety

In circuits which are powered by cells/batteries the current only flows in one direction, this is called **direct current (d.c.)**.

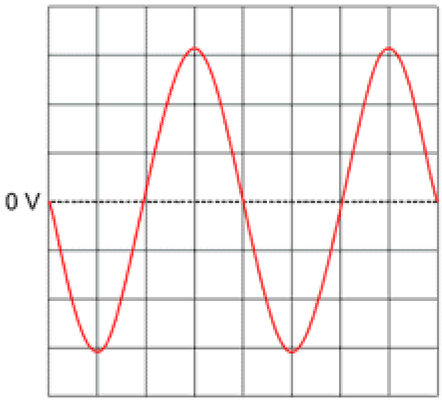
Alternating current (a.c.) is what we receive from power station and what comes out of plug sockets. This current changes direction i.e. the current move back and forth in the circuit. The properties of the UK electrical supply are 230 volts and the frequency is 50 cycles per second (50 Hertz [Hz]).

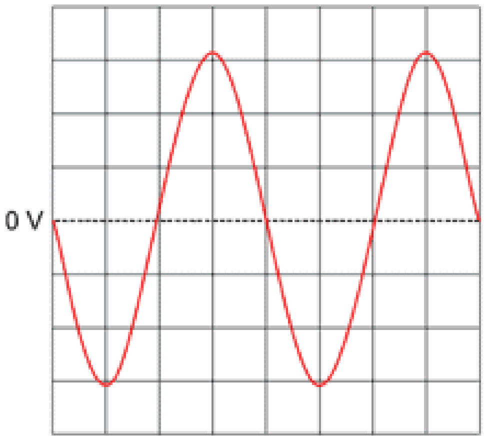
If you were to look at D.C and A.C current on an oscilloscope you can see how the voltage changes over time.

Direct current



Alternating current





From the oscilloscope trace you can determine the period and frequency of the alternating current (A.C.)

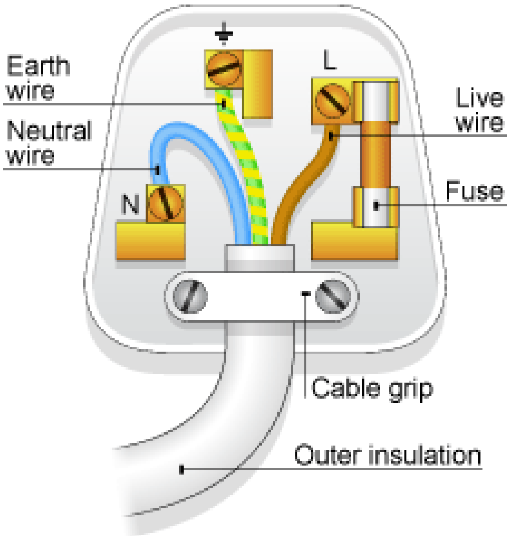
The period is the length of time for one complete wave to pass. In the oscilloscope trace on the left, there are 5 scale divisions for the period. If one scale division is 0.005 seconds then the period is 5 times that.

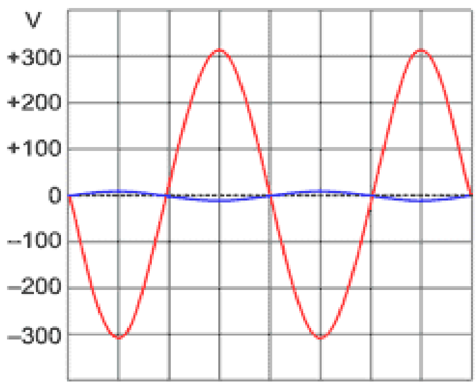
Period = 0.005s x 5 = 0.02seconds

When you know the period you can calculate the frequency (the number of cycles per second)

$$Frequency = \frac{1}{0.02s} = 50Hz$$

Most of your electrical devices are connected to the mains supply by a cable connected to a three pin plug. The electrical cable is composed of a copper wire surrounded by a plastic insulator. The three pin plug consists of 3 separate wires called the Earth wire, Live wire and Neutral wire. The live and neutral wires are responsible for carrying the electrical supply to and from the mains supply.





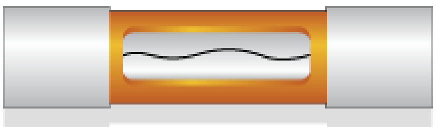
The voltage of the live wire (red line) alternates between positive and negative and the neutral wire (blue line) remains close to zero. The earth pin is used for safety (in particular with devices that have a metal case) in conjunction with the fuse. If the live wire happens to come in contact with the metal case then you could get an electrical shock as the current will pass through you to get to the ground. However, the earth wire and fuse prevents this from happening. The earth wire will take the current from the live wire. This high current then flows through the fuse wire causing it to melt.

Fuses and circuit breakers

Fuses have different current ratings. The fuse will blow if the current exceeds this rating e.g. a 3 amp fuse will blow if the current is equal to or greater than 3 amps. Most common fuse ratings are 3A, 5A and 13A.

To know what rating of fuse to use you need to know the electrical power of the device. Electrical devices use different amounts of power (measured in watts). Power is the amount of energy transformed by the device every second. The way to calculate power other than the one mentioned earlier is:

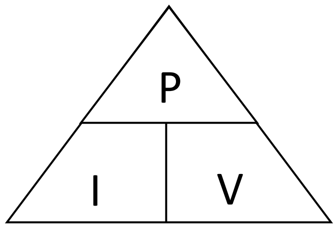
$$Power\ (W) = current\ (A) \times potential\ \ difference\ (V)$$



If an electrical fire has a power rating of 1150W and the voltage used is 230V then what fuse should be used?

Rearranging the equation we get:

I = P ÷ V
I = 1150 ÷ 230 = 5A



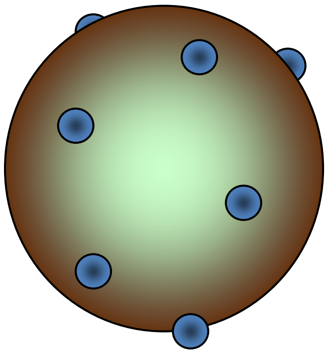
The fuse that should be used is 13A because if a 3A or 5A fuse was used then it would 'blow' even if the device was working correctly.

Another safety device is a circuit breaker which is an electromagnet switch which opens (or 'trips') when there is a fault which stops the current flowing. The electromagnet is connected in series with the live wire and if the current is too large this causes the magnetic field of the electromagnet to big enough to pull the switch contacts apart. The switch will remain open until it is reset. These devices work quicker than fuses

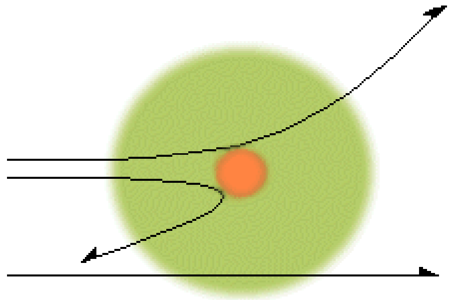
There are also Residual Current Circuit Breaker (RCCB) which, like circuit breakers, but work much faster than circuit breakers and fuses.

Atoms and their properties

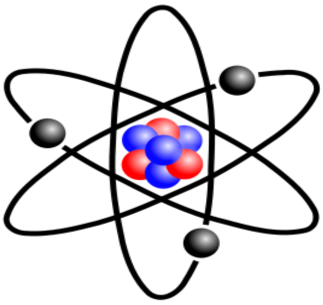
In the early 1900s the model of the atom was called the plum pudding model. It was believed that the atom was a positively charged fluid (the pudding) with electrons dotted inside it (the plums). This model was later disproved by Rutherford and Marsden's scattering experiment.



The way they disproved this was by firing alpha particles (positively charged particles) at a gold leaf and observing that angles at which they got reflected. What they should have seen was the alpha particles passing practically straight through. However, what they discovered was that a number of the particles got deflected at different angles; with some coming straight back on themselves. What they concluded was that most of the atom was empty space with a small positively charged nucleus in the centre with electrons orbiting the outside.



Atoms contain protons, neutrons and electrons. The nucleus is made up of protons and neutrons. All atoms of a particular element have the same number of protons e.g. all carbons have the same number of protons; one carbon atom won't have more protons than another. Atoms of different elements have different numbers of protons e.g. carbons atoms have a different number of protons to an oxygen atom.



The properties of the protons, neutrons and electrons are:

Particle	Relative mass	Relative charge
Proton	1	+1
Neutron	1	0 (no charge)
Electron	Very small (0.0005)	-1

Atoms normally have a no overall charge, due to have equal numbers of electrons and protons. However, atoms can gain or lose electrons and form charged particles called ions. Some forms of radiation can create ions and this radiation is called **ionising radiation.**

Atoms have a mass number which tells you the number of protons and neutrons in an atom. They also have an atomic number which tells you the number of protons in the atom.

In electrically neutral atoms, the number of protons must equal the number of electrons.

Some atoms of the same element can have different mass numbers

$$\begin{matrix} Mass\ number \rightarrow 4 \\ Atomic\ number \rightarrow 2 \end{matrix} He$$

For example: Carbon–12, Carbon–13, Carbon–14

In these atoms the number of protons hasn't changed, but the number of neutrons has e.g. carbon–14 has 2 more neutrons than carbon–12. These are called **isotopes**.

Isotopes which have an unstable nucleus (radio-isotopes) emit radiation or decay. There are 3 forms of radiation they can give out, beta particle, alpha particles and gamma rays.

Alpha decay ($^{4}_{2}\alpha$) is where an alpha particle (a positively charged particle consisting of 2 neutrons and 2 protons i.e. a helium nucleus) is emitted from the nucleus of an atom. Alpha is the most ionising type of radiation.

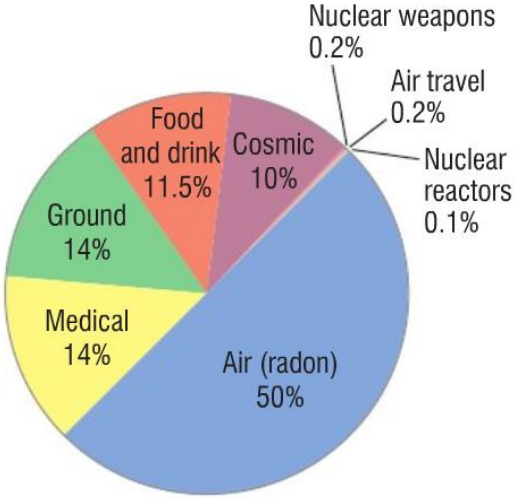
Tip for remembering: Al**p**ha has the letter **p** in it so it is positively charged. Alp**h**a also has the letter **h** in it so it is a helium nucleus.

Beta decay ($^{0}_{-1}\beta$) is when a beta particle (a fast moving electron) is emitted from the nucleus of an atom.

Tip for remembering: b**e**ta has the letter **e** in it so it is an electron.

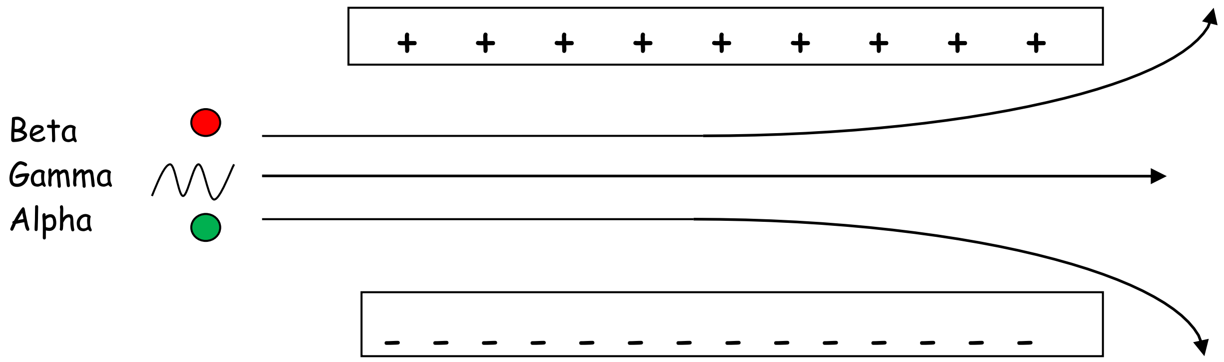
Gamma decay (γ) is where a gamma ray (part of the electromagnetic spectrum) is emitted from the atom. Gamma rays have no charge and no mass. Gamma is the least ionising form of radiation

Tip for remembering: Gamma has 2 m's beside each other which looks like a wave (mm -).

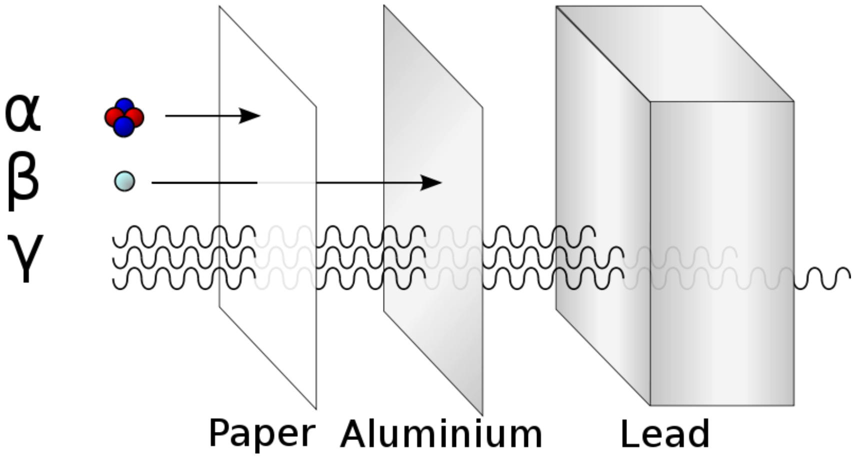


There are different sources that can give out radiation and radiation has been measured by Geiger counters even when there was no known source of radiation around. This called background radiation and some sources are natural and others are manmade.

We can tell what radiation is emitted depending on how it gets deflected in a magnetic and electric field.



As a beta particle has a negative charge it will be repelled by the negatively charged plate and attracted to the positively charged plate. As a gamma ray is part of the electromagnetic spectrum and has no charge it will pass straight through. As an alpha particle has a positive charge it will be repelled by the positively charged plate and attracted to the negatively charged plate.

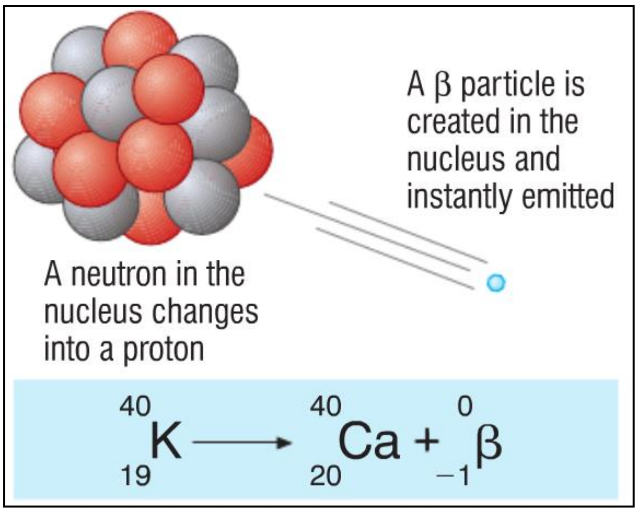


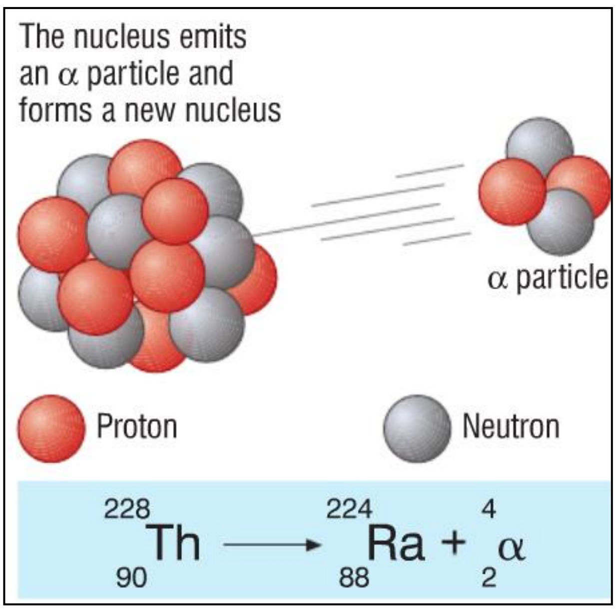
The different types of radiation emitted from isotopes can be stopped by different substances. It depends on how penetrating the radiation is. Alpha particles can be stopped by your skin, paper or even a few centimetres of air. Beta is more penetrating and is stopped by a few centimetres of aluminium. Gamma is the most penetrating as is stopped by lead.

Alpha can be the most dangerous to humans as it is more likely to be absorbed by the cells. Beta and gamma are more likely to pass through your cells.

In order to measure how much radiation is given off by a substance we use a Geiger counter. A Geiger counter measures the count rate which is the amount of radiation emitted. The higher the count rate the more radiation is given off.

<u>An example of alpha and beta decay</u>





Radioactive decay is a random process but there is a pattern to it. This pattern is called the **half-life**. Half-life is the amount of time it takes for the radiation count rate to fall by half. So for the graph to the left the count rate starts at 80. The count rate will be half when it reaches 40. The time taken for it to reach 40 is 2 days. Therefore 2 days is the half life. After another 2 days the radiation will fallen by half again and reached 20 counts per minute.

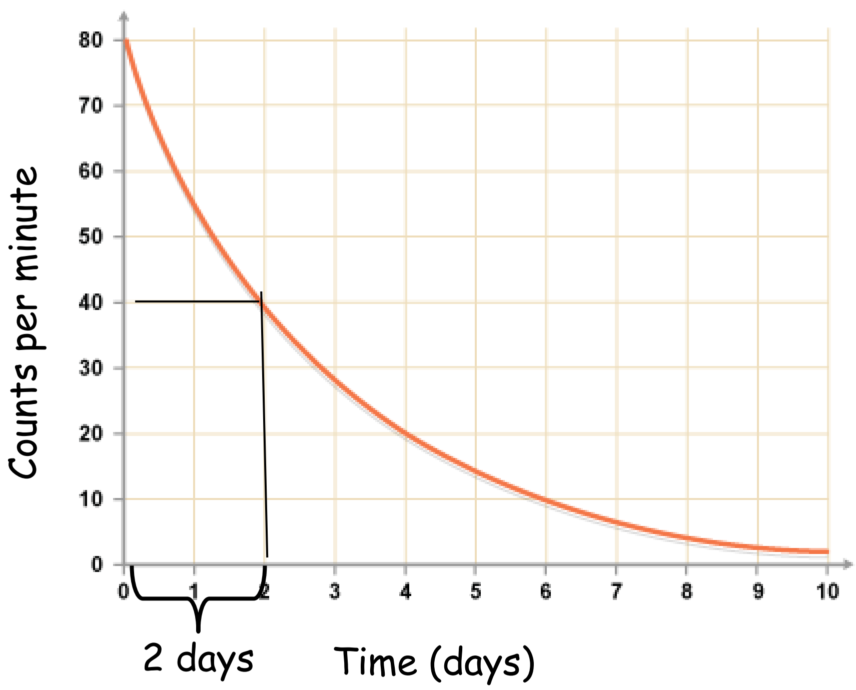
If we have a substance which has a mass of 50g and a half-life of 2 days how would the mass of the substance change?

After 2 days the mass would be 25g (half of 50g). 25 g has radiated away.

After 4 days the mass would be 12.5g (half of 25g). 37.5g has radiated away.

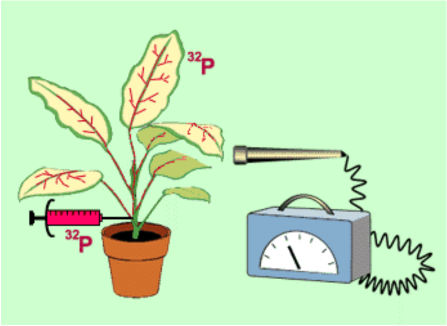
After 6 days the mass would be 6.25g (half of 12.5g). 43.75g has radiated away and so on

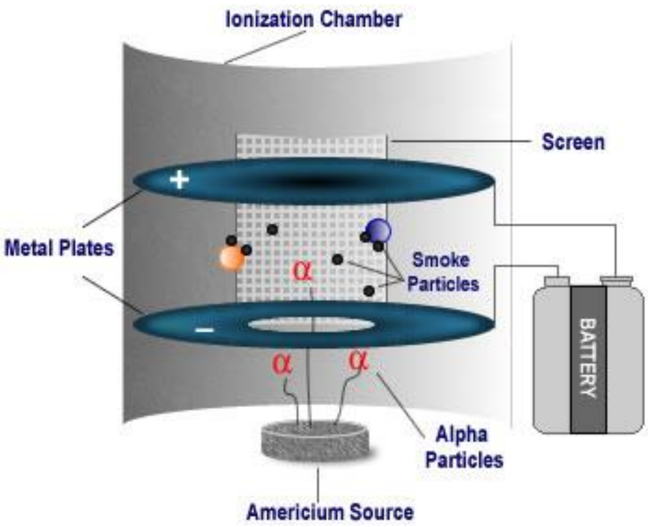
This can be shown on a graph as well…



<u>Uses of radioactive decay</u>

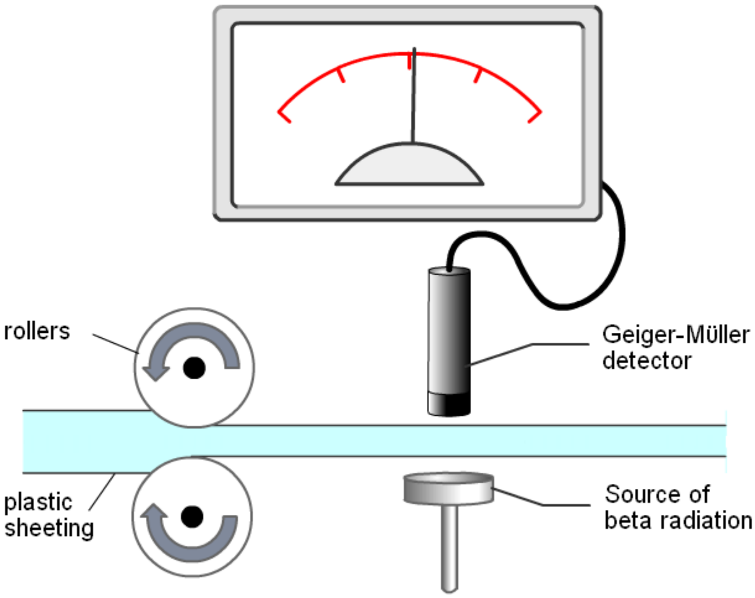
People who work with radioactive source often were special badges. These badges have a special photographic film in them which turns darker the bigger the exposure. Radioactive sources can be used as **tracers**. They can be added to plant fertiliser and you can then check if the plant has taken up the fertiliser. It is also used in the medical industry but doctors must ensure that it has a short half-life so that it doesn't stay in the body very long and cause damage.





Alpha sources are used in smoke detectors. The alpha particles help to create an electric current in the smoke detector by ionising the air. When smoke particles enter the smoke detector the electric current drops, this causes the alarm to go off.

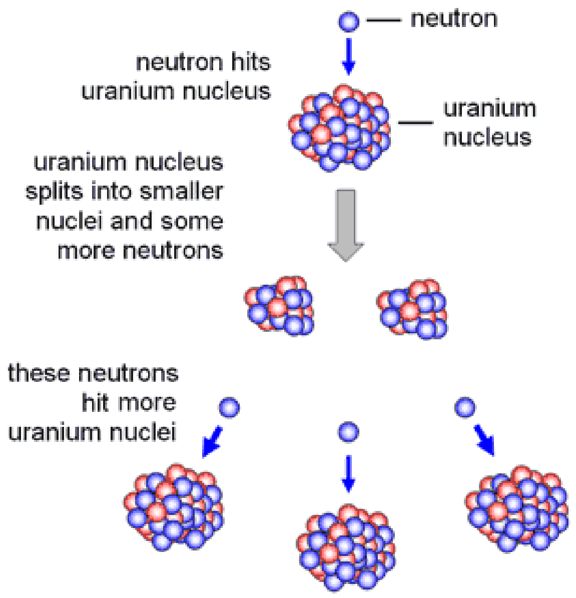
Beta particles are often used to measure the thickness of materials. A Geiger counter measures the amount of radiation passing through the material. If the radiation is too high then the sheet is too thin. If the radiation is too low then the material is too thick.



Nuclear fission and fusion

Fusion is the easiest to remember as it is exactly like it sounds. Fusion is where two atomic nuclei join together to form a larger one. When this occurs energy is released. It is by this process that stars get their energy. For example, two hydrogen atoms can fuse together (and release energy) to create helium.

Fission is the opposite; it is the splitting of an atomic nucleus and it is the process that nuclear power plants use. The two most common fissionable materials are uranium 235 and plutonium 239.



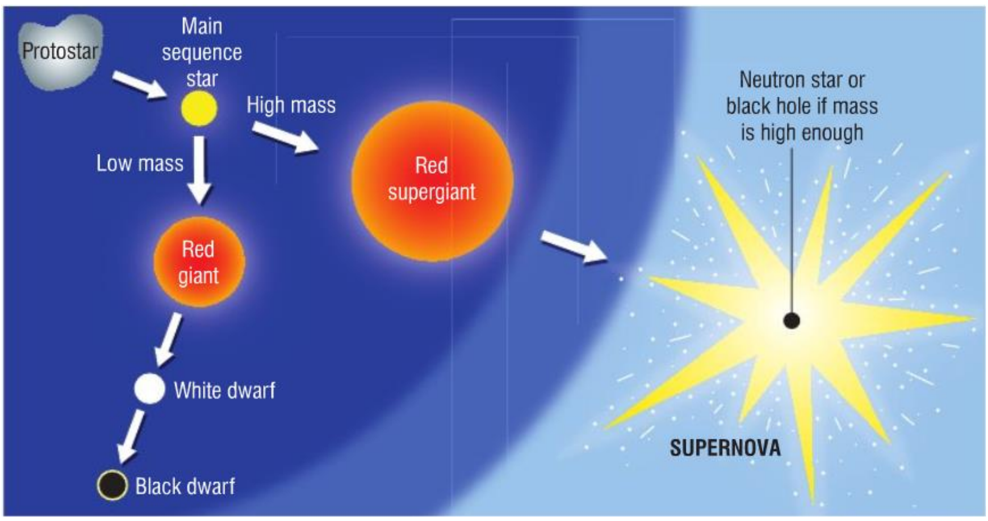
In order for fission to occur the atomic nucleus must absorb a neutron. The neutron is fired at the nucleus and caused the nucleus to spilt, forming two smaller nuclei. When the splitting occurs energy is released along with 2 or 3 more neutrons. These neutrons are then absorbed by other nuclei causing the process to repeat. This is called a **chain reaction**. This reaction is controlled in a nuclear reactor by using control rods. This rods absorb neutrons if the reaction needs to be slowed down.

<u>Life cycle of stars</u>

Planets form when lumps of rock get attracted to each other due to gravity.

Stars form when clouds of gas and dust from space gets pulled together due to the gravitational attraction. The amount of gas build up (gets more concentrated and forms a protostar. When the protostar gets denser and hotter nuclear reactions (i.e. fusion) start which causes hydrogen and other lighter element to fuse together. During fusion energy gets released which is what makes stars hot.

Protostars then become main sequence stars when the forces within the star are balanced (gravitational force and expansion/outward force). Our sun is a main sequence star. After the main sequence star their life cycle can take 2 possible routes depending on their mass.



When the big bang occurred 13 billion years ago the only element in existence was hydrogen. However, due to nuclear fusion in stars all the other elements were created and when stars explode (go supernova) all of those elements are released into the universe. This means that the elements that make up your body, the oxygen that you breathe right now were formed inside stars.