# GCSE Physics
# Revision notes 2020/2021

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# Static and Current Electricity

## Static Electricity

### Static Charge

**Static charge is a charge that can't move. There are two kinds positive (+) and negative (-).**

All **atoms** contain positive particles (protons) and negative particles (electrons) but because they contain the same number of protons and electrons they have no overall charge.

Static electricity is caused by an atom having too many or too few electrons (e-).

A **Van de Graaff generator** is a machine that generates huge amounts of static charge, by rubbing electrons off a roller and depositing them on the metal dome.

### Induction and Earthing

The basic rule you need to know is that **Like charges repel** and **Opposite charges attract.**

**Induction** - This is the effect caused when a charged object causes **electrons** in another object to move. This causes the uncharged object to become attracted to the charged object.

**Earthing** - If enough charge builds up on an insulator, the charge can leap the gap, causing a spark. This can be prevented by **discharging** the object, gradually. This is called **earthing.**

### Useful Static

Static electricity is used in many useful machines like photocopiers and smoke stacks (to remove pollution from the smoke).

### Nasty Static

If clouds get charged up enough, you get **lightning**, the biggest spark of all. Static can also be dangerous when refuelling aircraft. The fuel rubs against the side of the hose and lots of charge builds up. If the plane isn't earthed, the spark can blow the plane up.

## Basic Circuits

### Current, Voltage and Resistances

**Current** - This is a measure of the flow of electrons around a circuit (measured in Amperes or Amps).

**Voltage** - This is a measure of how much energy the electrons are carrying around the circuit (measured in Volts).

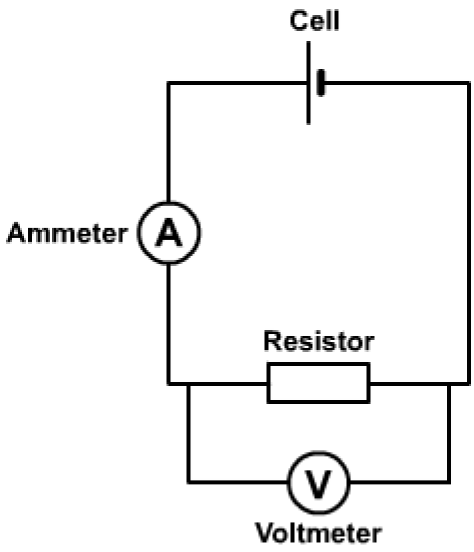
**Resistance** - This is a measure of how hard it is for the purple to travel through a part of the circuit (measured in Ohms).

**Direction Problem!**

Current flows from the **positive (+ve)** terminal of the battery to the **negative (-ve)**. This is called **conventional current flow.** The problem is, electrons are negatively charged, so they want to get away from the **-ve** and go to the **+ve**. So if electrons are going left to right, you say that the current is going right to left.

## Circuits

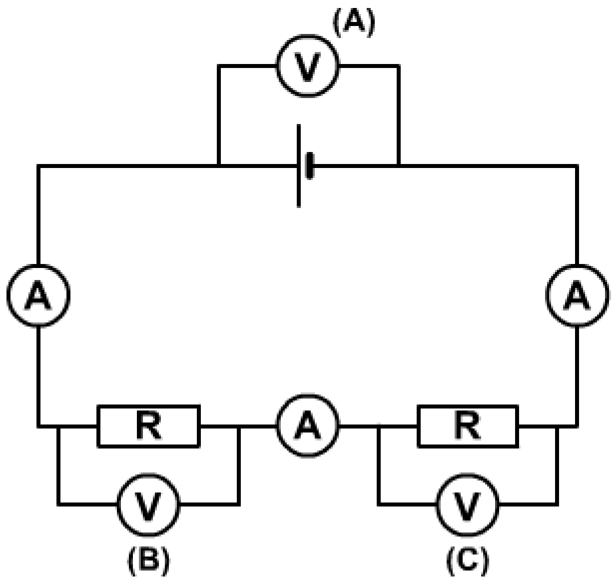
**Simple Measurement Circuit**




An ammeter needs to measure the flow of charge, so it is in **series**. This means that all the charge has to flow through it and can be counted. It also means that an ammeter needs to have a very low resistance.

A voltmeter measures **voltage** across a component, which you may have heard as **potential difference.** This means it is in **parallel** and it also needs a high resistance (otherwise all the current would flow through the meter instead of the component).

## Series Circuits

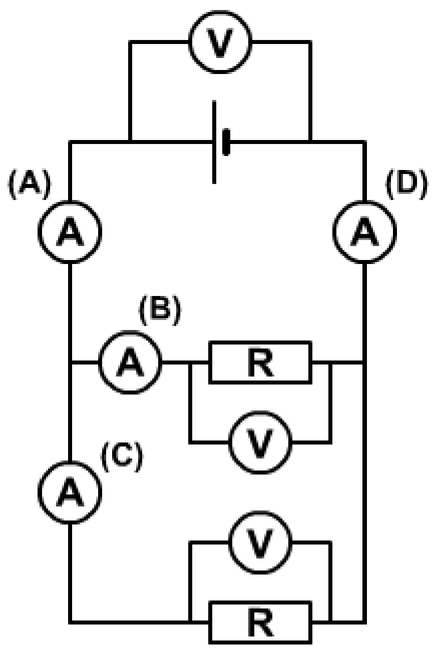



**Current in series:** same all the way round (all the current has to flow through everything).

**Voltage in series:** voltages across each component add up to the total voltage supplied by the battery, as they have to share the voltage between them [(A) = (B) + (C) in the diagram]. Higher resistances will need more of the voltage.

Final point - **resistors in series:** To work out the total resistance of two resistors, just add them together. This is because the current has to go through both of them.

**Parallel Circuits**

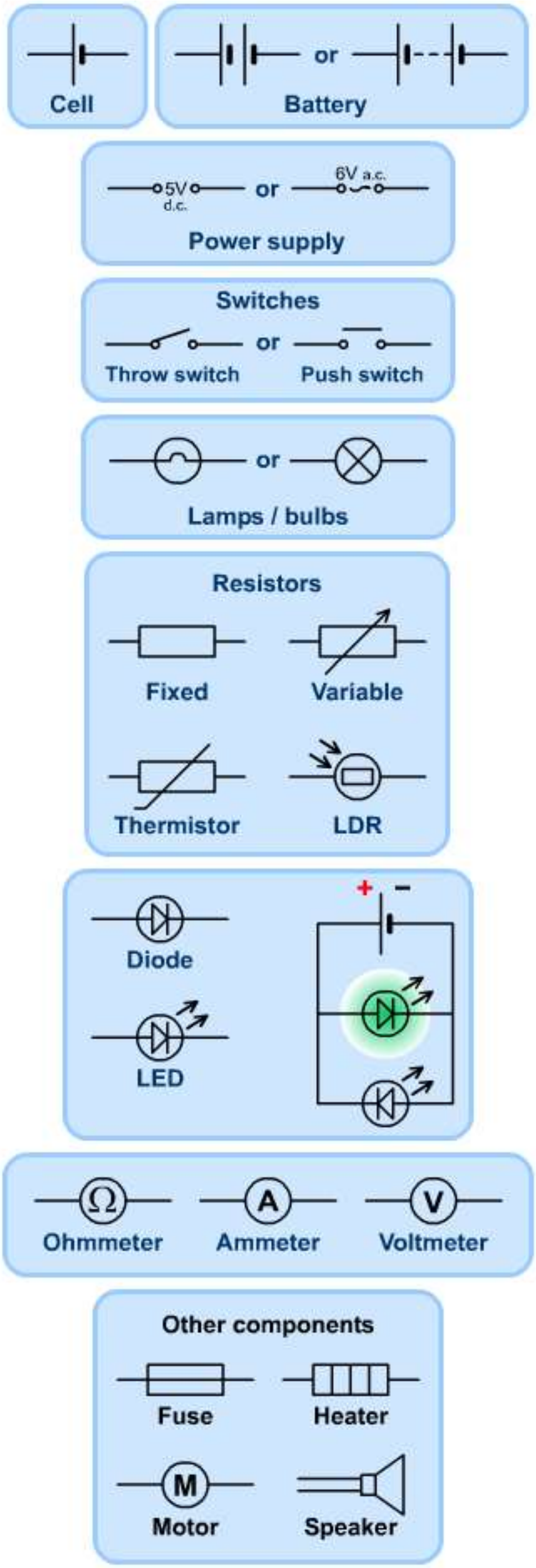


**Voltage in parallel:** all voltages the same.

**Current in parallel:** the current is shared out between the branches, but recombines near the battery. In the diagram (A) = (B) + (C) = (D). How much current each branch gets depends on the individual resistors - **bigger resistance = lower current.**

**Resistance in parallel:** you don't normally have to work out numbers, but the rule of thumb is that the total resistance of two resistors in parallel is **less** than the **lowest** individual resistor.

## Circuit Symbols


Cell
or
Battery
5V
d.c.
or
6V a.c.
Power supply
Switches
or
Throw switch
Push switch
or
Lamps / bulbs
Resistors
Fixed
Variable
Thermistor
LDR
+
-
Diode
LED
Ω
Ohmmeter
A
Ammeter
V
Voltmeter
Other components
Fuse
Heater
M
Motor
Speaker

**Cells and Batteries:** strictly speaking one cell represents 1.5V, but of you write the voltage above it (e.g. '6V'), most people will understand the cell has 6 volts.

**Power Supplies:** come in all shapes and sizes; just label them as you want.

**Switches:** several types, I've shown the main two that you will come across

**Lamps/Bulbs:** either symbol could be used - it doesn't matter.

**Resistors:** a few types - **Fixed, Variable** (you can change the resistance), **Thermistor** (as it gets hotter, its resistance decreases) and **Light Dependent Resistor or LDR** (the more light that shines on it, the lower its resistance gets).

**Diode:** A diode is like an electrical valve, it only lets current flow one way. If it is connected with the arrow pointing to the negative terminal, current can easily flow, if it is the other way round, it will block the current.

A **LED or Light Emitting Diode** is just the same except it gives off light...

**Ohmmeter:** is connected directly to a resistor, of any kind, to find its resistance (no other circuit is used with it)

**Check in your syllabus to see if there are any more you need to know!**

## Know Your Formulae

Ohm's Law

The law actually says that the resistance of a metal conductor is the same whatever the current - unless it's getting hotter. However most people think of these equations when the law gets mentioned:

$$V = IR$$

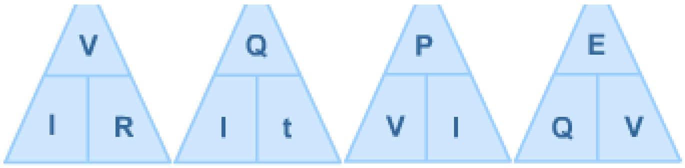
$$I = \frac{V}{R}$$

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

**Triangle method for rearranging a formula:**

Take the equation into a form where there is only multiplication and not division (V=IR in this case). The V goes on the top and the I and R slot in the bottom. Cover the one you want to know, and the other side of the equation will reveal itself.

**Below are equations for Voltage, Charge, Energy and Power shown in the triangle format:**




Voltage (V) in Volts, Current (I) in Amps and Resistance (R) in Ohms.

Charge (Q) in Coulombs, Time (t) in seconds and Power (P) in Watts.

***Always remember*** **to show all your working out, including writing the formula properly (not just the triangle!) and checking your units (e.g. check for mV or kW instead of V or W)**

**Prefixes:** These are little letters added to units to make them a different size, but always use the base unit if unsure. Base units are given in the topics, the ones to watch for are time (seconds) and mass (kilograms not grams).

| **Prefixes:** | **Name:** | **Value:** | **Example:** |
|---|---|---|---|
| M | Mega | x 1,000,000 | 1MW = 1,000,000W |
| k | kilo | x 1,000 | 1kg = 1,000g |
| c | centi | ÷ 100 | 1cm = 0.01m |
| m | milli | ÷ 1,000 | 1ms = 0.001s |

## Mains Supply (AC and DC)

We use two main sorts of electrical supplies, **DC** and **AC.**

**DC** - This is Direct Current. The current flows in one direction only and has a consistent value. Provided by batteries or DC adaptors/transformers that plug into the mains supply.

**AC** - This is Alternating Current. The current flows first one way then the other at a frequency of 50Hz. AC is what comes out of the mains sockets, usually at around 240V.

### The Ring Main

This is the name given to the circuit in your home. You only need to know that it is a **parallel circuit** and that the lighting circuit is separate from the circuit for sockets.

## The National Grid

This is the circuit that carries electricity all around the country, from the power stations to homes and businesses.

### Producing the Power

Energy is produced by burning fuel which turns water to steam; this drives a turbine, which makes electricity via a generator.

This electricity is a very high voltage and is passed over the National grid to a step down station then passed straight to your home.

### Why The High Voltage?

High voltage is used over the National grid, to keep current low. This stops energy being wasted.

## Energy and the Cost

### Kilowatt-hours (kWh)

The kilowatt-hour is the common unit used by energy companies to measure electricity. This is a unit of **energy** not power or time. It is the amount of energy if a 1kW appliance was left on for 1 hour.

### The Cost

1kWh of electrical energy costs around 6p, though it may change depending on your supplier. So multiplying the number of Kilowatt-hours you use by the unit cost (approx. 6p), give you the total cost of the electricity you use.

## Safety

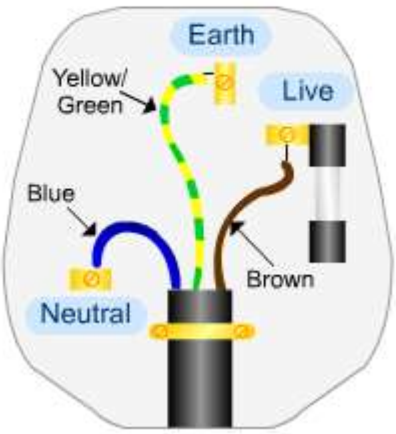
A common question is to give you a picture of domestic bliss and get you to identify the hazards, such as the person sticking their fingers in the toaster. **Things to look for are:**

1. bad wiring,
2. water near appliances,
3. too many double plugs/adaptors,
4. frayed wires.

Just use your common sense and you should get some easy marks!

### Wiring a Plug

One big problem used to be wiring plugs. By law now, all new appliances are fitted with one already, which helps, but you do need to know what's going on inside there:



## Fuses

Fuses help protect the circuit against faults. The key thing is to get the wire just thick enough to carry the current you want, but thin enough to melt if there is a current surge.

**Fuse Ratings**

Common sizes are 3, 5 and 13Amp fuses, but there are many others. Always choose one slightly higher than the current rating of the appliance, so that it doesn't blow under normal conditions.

Circuit Breakers

Fuses are not always effective at protecting you, so circuit breakers are also used. They automatically compare the current entering and leaving the circuit and even if there is the tiniest difference they 'trip' off.

**Earth**

The Earth (yes, I do mean our planet) is very good at soaking up loose charge. The earth in your house is probably connected to the plumbing (goes to ground) or a large metal spike in the ground somewhere.

**Double Insulation**

If something is completely cased in an insulator, like plastic, it is said to be double insulated, and does not need earthing. You can't get a shock from the case!

# Properties of Waves

**Frequency, wavelength, amplitude** and time period are used to describe waves.

Waves can be **transverse** or **longitudinal.**

**Transverse waves** - the vibration is at right angles to the wave motion, e.g. light, water waves and the electromagnetic spectrum waves.

**Longitudinal waves** - the vibration is parallel to the wave motion, e.g. sound and some earthquake waves.

**Wave Speed (m/s) = Frequency (Hz) x wavelength (m)**

Reflection is the bouncing of waves off a surface. There are three rules of reflection that you need to know.

1. The angle of incidence always equals the angle or reflection.
2. The distance from the object to mirror is the same as the distance from the mirror to the image.
3. The image is always the same size as the object but is laterally inverted.

**Refraction** is the bending of a wave when it goes from one substance into another. Refraction happens because the speed and wavelength of the wave changes as the wave goes into the other substance. The frequency of the wave stays the same.

**Total internal reflection** happens when the angle of incidence, of a wave going from a substance into air, is greater than the critical angle. The wave bounces off the boundary, obeying the rules of reflection.

**Dispersion** of white light produces a spectrum. This is caused by refraction. Light of different frequencies is refracted by different amounts. Red is refracted the least and violet the most. This causes white light to be split up into separate colours.

**Diffraction** is the spreading out of a wave as it goes through a gap, or around an object. The smaller the gap or the larger the wavelength the greater the diffraction.

Diffraction is most effective when the size of the gap is approximately the same as the wavelength of the wave.

You will need to be able to draw diagrams showing how waves reflect, refract and diffract.

# Uses of Waves

**Sound waves** are caused by particles vibrating. The frequency of the vibration decides the pitch of the sound. The amplitude of the vibrations decides the loudness of the sound.

**Ultrasound waves** are high frequency sound waves, which are beyond the human hearing range. Ultrasound is used for seeing babies in the womb, detecting cracks in metal and cleaning instruments.

**Waves** can be represented on an oscilloscope screen, which can be used to measure the characteristics of the waves. You should be able to find the amplitude and time period of a wave from an oscilloscope screen.

**The electromagnetic spectrum** is a series of waves that all travel at the same speed in a vacuum. They are all transverse. Each part of the spectrum has different uses and dangers. Each part of the spectrum has a different frequency and wavelength. Gamma waves are at the high frequency end of the spectrum. Radio waves are at the low frequency end. You will need to know the uses and dangers of each part of the spectrum.

Different surfaces and materials absorb different frequencies of waves. White surfaces reflect most waves. Black surfaces absorb most waves.

Information can be carried along copper cables as electrical signals, or along optical fibres as electromagnetic wave pulses.

**Optical fibres** have advantages over copper cables. Optical fibres can carry more information; the signals can travel faster and lose less energy as they travel along the cable.

There are two types of signals, **analogue** and **digital**. **Analogue** signals have a continuous range of values. **Digital** signals have only two values, on (1) and off (0).

Digital signals have advantages over analogue signals. Digital signals are easier to transmit as they are less affected by noise; it is also possible to send more information, in a certain time, as a digital signal than as an analogue signal.

# Forces, Moments and Pressure

**A force can do one of four things to an object:**

1. Make it **speed up** - accelerate.
2. Make it **slow down** - decelerate.
3. **Change its direction.**
4. **Change its shape.**

If something is doing one of these four things there must be a **net** force acting upon it.

## Newton's First Law

**'Everybody continues in a state of rest or uniform motion unless acted upon by an external force.'**

Something without a **net** force acting on it will either **stay still** or **move at a constant speed** in a straight line until you apply a force to it.

## F = ma

**Newton's Second Law:**

- F is the force in Newtons, N.
- m is the mass in kilograms, kg.
- a is the acceleration in m/s2.

This shows that if you keep the mass constant and double the applied force the acceleration will double.

## Hooke's Law, elastic and plastic behaviour

**F = kx**

An **elastic material** is one that will return to its original shape when the force applied to it is taken away.

A **plastic (or inelastic) material** is one that stays deformed after you have taken the force away.

If you apply too big a force a material will lose its elasticity.

## In solids

**If a force is applied over a smaller surface area you get a larger pressure.**

Pressure can be calculated using the following equation:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Force will be in newtons, N.

Area will be in either $m^2$ or $cm^2$.

If the area is in $m^2$ then the pressure will be measured in Pascals or $N/m^2$.

If the area is in $cm^2$ then the pressure will be in $N/cm^2$.

### In liquids

1. Pressure increases with depth.
2. Pressure acts equally in all directions.
3. Pressure is transmitted through liquids.

### Hydraulics

All hydraulics systems work because the pressure is the same throughout the system.

A really good example of this is a **car brake system.** You need to know all about this for your exams.

### In gases

Although gases are compressible (squashy) they exert a pressure because of the gas particles bouncing off things.

### Boyle's Law

**For a fixed mass of gas the pressure x the volume of the gas stays the same.**

**In other words, as you squeeze a gas its pressure will go up and its volume will get less.**

**Important point:** The temperature and mass of gas must stay the same for this to be true!

**We can write this as:**

Pressure x volume = constant **or** $P_1V_1 = P_2V_2$

### Moments

Moments make things turn or rotate. They are caused by forces but are not forces themselves. Like forces, moments have a direction. We say they are either clockwise or anti-clockwise, to show which way they will make something turn.

**The bigger the force causing the turning effect the bigger the moment will be.**

**The further the force is from the pivot the bigger the moment will be.**

**The size of a moment can be calculated using:**

Moment = Force x Distance

Force is measured in newtons, N.

Distance is measured in either m or cm.

If the distance is in m then the moment will be measured in **Nm.**

If the distance is in cm then the moment will be measured in **Ncm.**

## Distance

As we all know, the distance between two points is how far apart they are. In science, we normally use metres as our unit.

We often represent how the distance between two points changes using a distance: time graph.

## Speed

Speed is how fast something is going. It is how quickly something covers a certain distance and can be worked out using the equation:

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

## Acceleration

This is how quickly something gets faster. So if you were running and getting 1m/s faster every second you would have had an acceleration of 1 m per second per second. We normally write this 1 m/s2.

**We work out by the equation:**

$$\text{Acceleration} = \frac{\text{Change in speed}}{\text{Time taken}}$$

# Energy Transfers

## Types of energy

**Energy** cannot be created or destroyed it can only change from one form into another.

There are many types of energy including,

- **sound**
- **heat**
- **light**
- **kinetic**
- **nuclear**
- **potential energy**

**Kinetic energy** is movement energy. **Potential energy** is stored energy. There are three main forms of potential energy including gravitational, chemical and elastic.

**Sankey diagrams** can be used to represent energy changes. The size of the arrows represents the amount of that type of energy.

Energy is measured in Joules, J or kilojoules, kJ.

## Conduction

**Heat energy** always moves from hotter objects to colder objects.

Heat energy is conducted through solids by particles vibrating and passing on the movement to neighbouring particles.

Metals are best at conducting heat. As well as the vibrating particles, they move the heat energy by free electrons moving between their atoms.

The poorest conductors are gases as their molecules are too far apart to affect each other much.

Air is a very bad conductor. Most insulators work because of trapped air.

## Convection

**Convection** is hot gases or liquids rising and cooler gases and liquids sinking to replace it. As substances heat up the density decreases, which is what makes them float.

This movement of molecules is called a convection current. It can only happen in a gas or liquid where the molecules are free to move around.

## Radiation

**Radiated heat energy** is infrared radiation. All hot objects radiate heat.

Black, dull surfaces are the best emitters of heat radiation. Lighter, shinier surfaces are poor radiators of heat.

Radiated heat can also be absorbed by cooler objects. Black is the best absorber. Surfaces coloured silver or white will reflect the radiated heat.

## Ways to save energy in the home

Reducing heat losses from a home means less damage to the environment and lower heating bills.

Installing insulation costs money. The payback time is how long it takes for the savings to cover the cost.

Each strategy has to reduce conduction, convection, radiation or any combination of them.

Common strategies are double-glazing, loft insulation, tank lagging, lined curtains, cavity wall insulation, blocking up disused fireplaces and putting foil behind radiators.

Other conservation strategies include using of low-energy light bulbs, turning down heating thermostats, fitting draught excluders and switching off unattended appliances.

## Non-renewable fuels and power stations

The fossil fuels are **oil, gas** and **coal**. They are non-renewable, which means that they cannot be replaced. They will eventually run out.

These fuels have many uses but the main ones are heating, transport and generating electricity.

In power stations, the fuel is burnt and the heat turns water into steam. That steam pushes around a turbine that is connected to a generator. The generator produces electricity.

This process is the same for all power stations.

Nuclear power stations don't burn the fuel. Uranium fuel generates heat that turns water into steam just like in other power stations.

Nuclear accidents are rare, but can be serious. The waste from the reactors can be radioactive. It is easy to store it safely for now but it will stay radioactive for years.

## Environmental impacts of burning fuels

**Carbon dioxide** is the most common of several gases that contribute to the greenhouse effect. The result is global warming. This would result in the weather being more extreme and the ice caps melting raising the sea levels.

**Sulphur dioxide** is the most common cause of acid rain. It dissolves in rainwater to form an acid. The acid rain harms plants, animals and stonework.

## Alternative energy sources

Most of the alternative energy sources are renewable. This means there is either an endless supply of them so that they will not run out, or they can be easily replaced.

**Hydroelectric power** is only possible where the geology is right, such as Scotland. Water runs fast down an incline and turns a turbine.

Some developing countries get all their energy from HEP schemes on large dams. The large lake made behind the dam drastically alters the surroundings.

Waves and tides have a lot of energy. Few schemes exist because of technological problems and environmental objections.

Solar power converts the suns energy into electricity using solar panels. These panels are expensive to make.

Wind farms are groups of wind turbines that generate electricity from wind. Some people don't like wind farms because they spoil the view or make a noise.

**Geothermal energy** uses the natural heat in volcanic rock to generate electricity.

Gas called methane is produced when matter rots. This gas can be used to generate heat to produce electricity.

Burning rubbish is not a way to avoid pollution but it does preserve fossil fuels as well as avoid rubbish having to be put in landfill sites.

Crops can be grown to be burnt in a power station. Another version of this is to process the crops into alcohol and use it instead of petrol in cars.

# Energy Calculations

Work is done whenever a force acts over a distance, e.g. a car motor produces a forward force to move the car a certain distance.

Energy is measured in Joules, **J.**

The work done or energy transferred can be calculated using:

**Work done or energy = force x distance**

When working out the work done the force must be in the same direction as the movement. If more than one force is acting in that direction then the resultant force must be used.

Kinetic energy is the amount of movement energy an object has. Kinetic energy can be calculated using:

**kinetic energy = ½ x mass x velocity$^2$**

Gravitational potential energy is the extra amount of stored energy an object has because it is higher up. GPE can be calculated using:

**Change in gravitational potential energy = mass x gravity x change in height**

This is the same thing as **GPE = weight x height**

Power is the rate at which work is done, or in other words, the amount of energy transferred per second. Power is measured in Watts, W or J/s.

**Power can be calculated using:**

**power = energy transferred / time taken**

**or**

**power = work done / time taken**

Energy is often lost to the surroundings as heat energy. This is wasted energy as it cannot be easily used again.

Efficiency tells us how much energy is wasted when an energy transfer has happened. The more efficient something is the less energy that is wasted.

**Efficiency can be calculated using:**

1. $\frac{\text{Power out}}{\text{Power in}} \times 100\% = \text{efficiency as a \%}$

2. $\frac{\text{Energy out}}{\text{Energy in}} \times 100\% = \text{efficiency as a \%}$

# Radioactivity

**Atoms are made up of:**

- **protons;**
- **electrons;**
- **neutrons.**

Protons and neutrons are in the nucleus and the electrons orbit the nucleus. Protons have a positive charge, electrons have a negative charge and neutrons have no charge. The shape of the atom was discovered using the alpha-scattering experiment. This showed the original plum-pudding model to be wrong!

**Atomic notation** is used to describe atoms. The top number is the mass or nucleon number. It tells us how many protons and neutrons there are in the nucleus. The bottom number is the proton or atomic number, which tells us how many protons are in the nucleus. During reactions the total number of protons and neutrons must stay the same.

**Isotopes** of an element have the same number of protons but a different number of neutrons in the nucleus. It is this different number of neutrons that makes some isotopes unstable and radioactive. These isotopes are called radioisotopes.

**Ionisation** is where an electron is removed from a neutral atom, leaving the atom with a positive charge.

**Radiation causes ionisation.** This can be used to detect radiation, as the amount of ionisation can be measured with a Geiger-Muller tube.

**Ionisation** can damage or kill living cells; this can cause cancer to develop.

**Alpha particles, beta particles** and **gamma waves** are the three main types of radiation emitted during radioactive decay. All three types of radiation are emitted from the nucleus of the atom.

When radiation is emitted the unstable atom loses energy to become more stable. If alpha or beta particles are emitted, new elements are formed because of the change in the number of protons in the nucleus.

**Alpha, beta** and **gamma radiation** all behave slightly differently due to the way they are made up. Alpha ionises the most over a small distance but is not very penetrating. Gamma is the most penetrating but ionises less over the same distance.

**Decay equations** can be used to work out what new daughter element will be produced when radioactive decay takes place.

Safety precautions must be taken when handling radioactive substances. These include, using long handled tongs, pointing sources away from people, wearing lead lined clothing, not inhaling or eating sources.

The half-life of a substance is the time it takes for half of the original parent atoms to decay. It is also the time it takes for the count rate of a substance to fall to half the original value.

**Radiation** is used in medicine to cure cancer, in industry to detect the thickness of materials and in dating.

Background radiation is radiation that is produced around us all of the time. Sources include certain rocks, cosmic radiation, radon gas in the air, nuclear waste and experiments, medical uses and some foods. The background radiation needs to be subtracted from experiment results on radioactivity.

# Magnetism and Electromagnetism

### *Magnetic fields*

A magnet has a magnetic field around it. This field is strongest at its poles.

**The arrows always point from the North pole to the South pole.**

- Opposite poles will attract.
- Similar poles will repel.

### *Currents and magnetic fields*

All currents have a magnetic field around them.

A straight wire has a circular magnetic field around it. A coil of wire has a magnetic field around it, that is the same shape as a bar magnet.

If the conventional current flows the other way, the magnetic field will be in the opposite direction. As you move further away from the wire, the magnetic field gets weaker, which is why the lines are drawn further apart.

These types of magnets are called **electromagnets.**

### *Electromagnets are far more useful than permanent magnets because:*

1. They can be switched on and off.
2. The strength of the magnetic field can be changed, by altering the current.
3. They can easily be made into a variety of shapes and are less expensive to make.

### *The magnetic field around a coil electromagnet can be increased by:*

1. Increasing the current in the wire.
2. Putting more loops on the coil
3. Placing an iron or steel core inside of the coil.

Iron and steel behave slightly differently as cores, because iron is **magnetically soft** and steel is **magnetically hard.**

**Magnetically soft, for example, iron:**

**Magnetically hard, for example, steel:**

| | |
|---|---|
| Easy to magnetise. | Harder to magnetise. |
| Loses its magnetism quickly when the current is switched off. | Stays magnetic after the current is switched off. |

Most electromagnetic devices use iron as the core, because they want the magnetism to change quickly.

### *The motor effect*

When two magnets are close together, they affect each other and produce a force. The same happens when any two magnetic fields are close together.

If a wire carrying a current is placed in a magnetic field a force is produced. This is called the **motor effect.**

The direction of the force will depend on the direction of the magnetic field and the direction of the current in the field.

**To make the force bigger:**

1. Increase the size of the current.
2. Increase the strength of the permanent magnet.

### *Electric motors*

An electric motor uses the motor effect to spin a coil of wire inside a magnetic field.

To increase the speed of the motor:

1. Increase the current in the coil.
2. Increase the number of loops on the spinning coil.
3. Increase the strength of the magnet.

### *Loud speakers*

The alternating current that represents a sound wave flows through the coil. As the current carrying coil is inside a magnetic field a force is produced, which makes the coil move. This pulls the paper cone in the same direction. As the current changes direction, the force produced changes direction. This makes the paper cone move the opposite way. The backward and forward motion of the cone produces a sound wave in the air.

### *Relays*

When the small current in the input circuit is switched on, the electromagnet becomes magnetic and attracts the iron armature. The armature rotates towards the electromagnet, pushing the contacts together. This switches on the large current in the output circuit.

### *There are two main ways to generate electricity:*

1. Moving a wire in a magnetic field.
2. Moving a magnet in a coil of wire.

### *To increase the voltage or current generated:*

1. Spin the coil faster.
2. Put more loops on the coil.
3. Use a stronger magnetic field.
4. Use a coil with a larger area.

### *Transformers*

Transformers are able to change the voltage of an alternating current. This is used on the national grid. The larger the voltage, the lower the amount of wasted heat energy in the cables. However, these large voltages are too dangerous to use in the home, so transformers are used to reduce the voltage to a safe level.

### *Calculating the size of the output voltage*

**You can work out the size of the voltage using the following equation:**

$$\frac{\text{Voltage across the primary coil}}{\text{Voltage across the secondary coil}} = \frac{\text{Number of loops in the primary coil}}{\text{Number of loops in the secondary coil}}$$

This means that if there are twice as many loops on the secondary coil, then twice the voltage will be across the secondary coil, and so on.

# Space

The Solar System is made up of the nine planets, including the Earth, that orbit (go round) the Sun.

The four inner planets are called **terrestrial planets** and are small rocky planets: Mercury, Venus, Earth, Mars.

Between Mars and Jupiter, there is an asteroid belt, which may be the remains of a planet.

The next four are called **gas giants** and are large planets made up of gas: Jupiter, Saturn, Uranus, Neptune.

The moon orbits the earth in 28 days and the Earth orbits the sun in 365¼ days. Each planet takes a different amount of time to orbit the sun.

**Velocity is speed with direction.**

If something is going in a circle, its velocity is changing, even if its speed is constant.

We call the force that keeps things moving in a circle a **centripetal force.** The centripetal force always **acts towards the centre** of the circle.

Satellites are also held in orbits around the Earth by the gravitational attraction of the Earth.

***There are two main types of satellites:***

1. **Geo-stationary orbit satellites:**

   The satellite rotates around the Earth once every 24 hours, so it is able to stay over one point on the Earth.

2. **Polar orbit satellites:**

   The satellite can orbit the Earth many times in a day and see the whole Earth as it travels.

***Seasons:***

The Earth has seasons because it rotates on an axis, which is tilted.

**The seasons change two significant things on the earth:**

1. The length of the day and night.
2. The temperature and weather, due to the intensity of the sun.

The moon orbits the Earth every 28 days. As it goes around, it is caught in the shadow of the Earth; this is why we see different amount of the moon as the month goes by.

The moon and the Sun cause the sea to have tides. This is because of the gravitational attraction between the Sun, moon and water in the sea. The moon has the biggest effect, as it is closer to the Earth.

Our solar system is a collection of planets orbiting a star. Our Sun is gravitationally bound to a huge collection of other stars. This collection of stars is called a **galaxy.** Our galaxy is called the Milky Way. There are lots of galaxies in the Universe.

### *The Big Bang theory:*

There is evidence that the Universe is expanding.

This evidence is found when we look at the electromagnetic radiation emitted from other galaxies.

The **Doppler Effect** makes waves appear to have a longer wavelength if their source is moving away from you. It also means the wavelength will appear shorter if something is moving towards you.

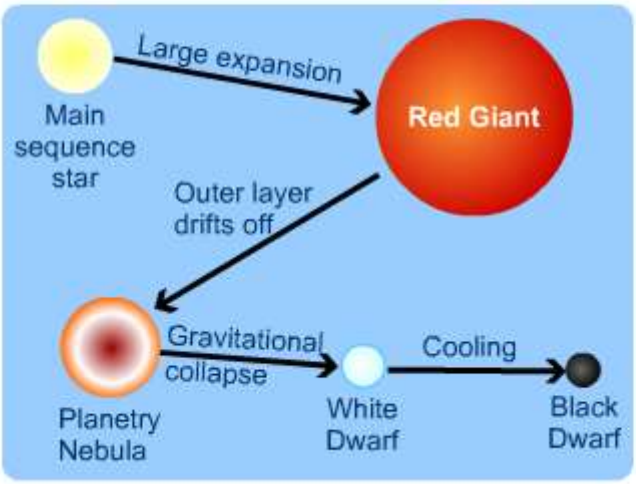
### *3 main possibilities of how the world might end...*

1. If there is too much matter in the Universe, the gravitational attraction between all the masses will eventually pull all the galaxies back together into a big crunch. - **Closed universe.**
2. If there is not enough matter in the Universe, everything will keep moving apart forever. - **Open universe.**
3. If there is just the right amount of matter in the Universe, the expansion of the Universe will slow down until it is expanding so slowly that it will appear the Universe has stopped expanding. - **Flat universe.**

Stars start off in the same way, but their end depends on how much mass they have.

**Nuclear fusion:** Gravitational attraction pulls hydrogen atoms together. The initial star will be big and cold. As it pulls its mass closer together, the hydrogen atoms will start to fuse together to make helium atoms. A huge amount of energy is released.

**The following diagram shows the life of a star:**



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