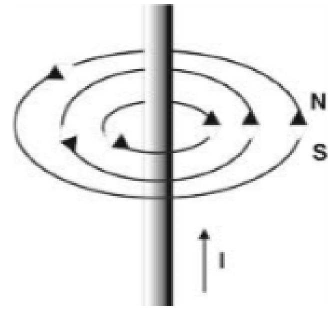
S2 ELECTRICITY & MAGNETISM
Electromagnetism

At the end of the section I can :

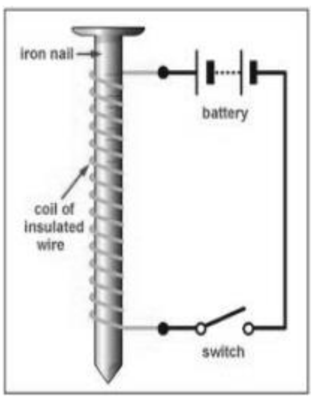
- ❑ 1 State that a magnetic field exists around a current-carrying wire.
- ❑ 2 Describe the parts of a basic electromagnet.
- ❑ 3 Give examples of practical applications of electromagnets.
- ❑ 4 State that a current carrying wire experiences a force when the wire is in a magnetic field.
- ❑ 5 Identify on a simple diagram of an electric motor, the **rotating** coil, the **field** coil (magnet), the **brushes** and the **commutator**.
- ❑ 6 State that a voltage may be induced when a coil of wire is moved within a magnetic field.
- ❑ 7 State that the size of an induced voltage depends on; the strength of the magnetic field, the number of coils of wire and the speed of movement.
- ❑ 8 State that the generation of electricity in a power station relies on the movement of conductors in magnetic fields or vice versa.
- ❑ 9 Identify on a simple diagram the major parts of **thermal**, **nuclear**, **hydro-electric** and **wind powered** generating stations.
- ❑ 10 Identify the energy change at each of the major stages of a power station.

Current Carrying Wire



When a current passes through a wire, a magnetic field is produced. By wrapping a wire round a soft iron core an electromagnet is produced.

The more wires that are wound together the greater the strength of the electromagnet. When the current is switched off, the magnetic field fails.



The Simple Electromagnetic

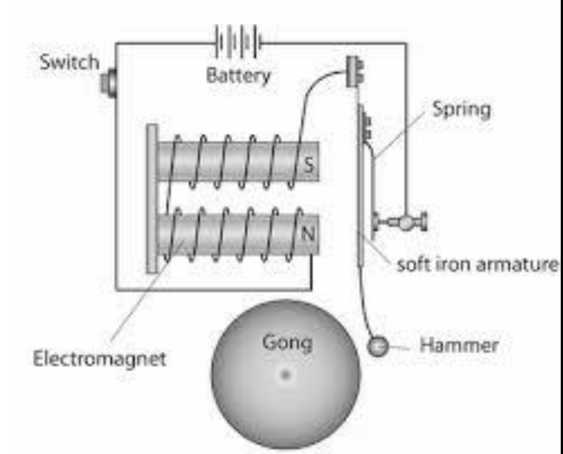
A simple electromagnet, like the one to the left, is easy to make and can be used to demonstrate the on–off mechanism which is put to use in many ways.

Typical uses of this effect are seen in a bell and a relay.

The Bell

In the bell the clapper is pulled towards the gong by the electromagnet but this causes a break in the circuit and the electromagnet fails.

The spring attached to the clapper makes the clapper return to its original position and the whole action starts again.



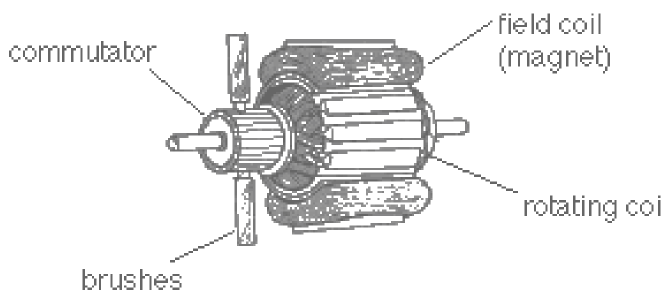
The Relay

A relay is an electromagnetic switch which can be used to operate a high current circuit.

The Electric Motor

When a wire carrying a current is placed between the poles of a magnet then the wire has a force acting on it. The direction of the force can be changed by reversing either the current or the direction of the magnetic field.

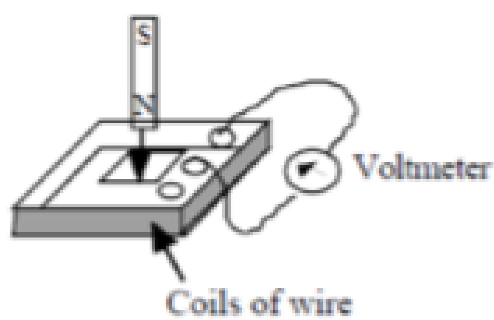
In an electric motor, coils of wire are placed between the poles of a magnet and, as a current flows in the wires, the coils will rotate. The coils will keep on rotating because of the **commutator**. This is a ring split into two which reverses the direction of current. Current is fed into the coils by the **brushes**.



Induced Voltage

If a conductor cuts across the lines of a magnetic field, then a voltage will be induced across the ends of a conductor. Note the magnet can move with the conductor stationary or vice versa. An induced voltage will be produced provided the conductor experiences a **changing magnetic field.**

Magnets with opposite poles facing.



Size of Induced Voltage

The size of the induced voltage depends on –

- **the magnetic field strength**
- **the number of coils**
- **the speed of the motion**

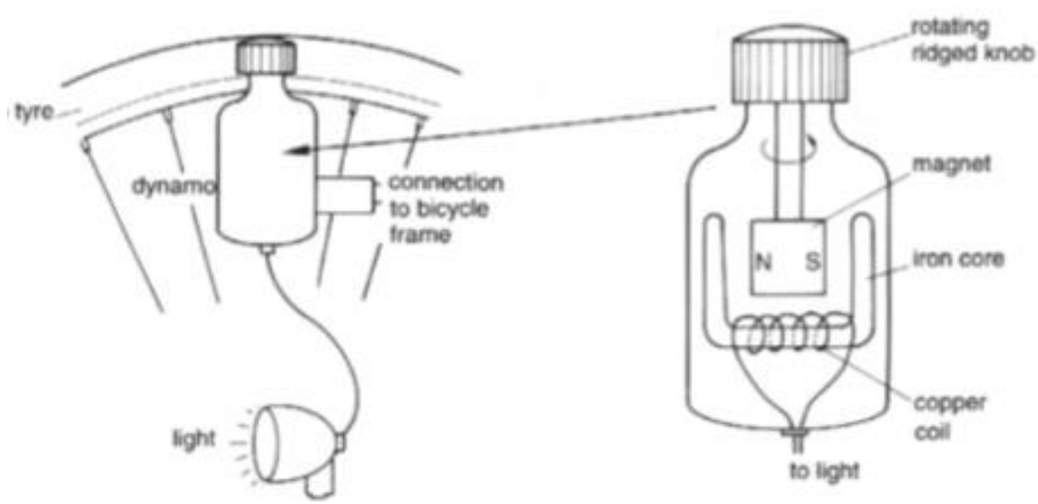
This is the foundation of electricity generation.

Dynamos

In S1, you looked at a dynamo which is a simple generator. **Generators change kinetic energy into electrical energy.**

They do the opposite of electric motors.

A bicycle dynamo is a small electrical generator. The magnet rotates inside a coil of wire and electrical energy is produced. This electrical energy is changed to light in the lamp.

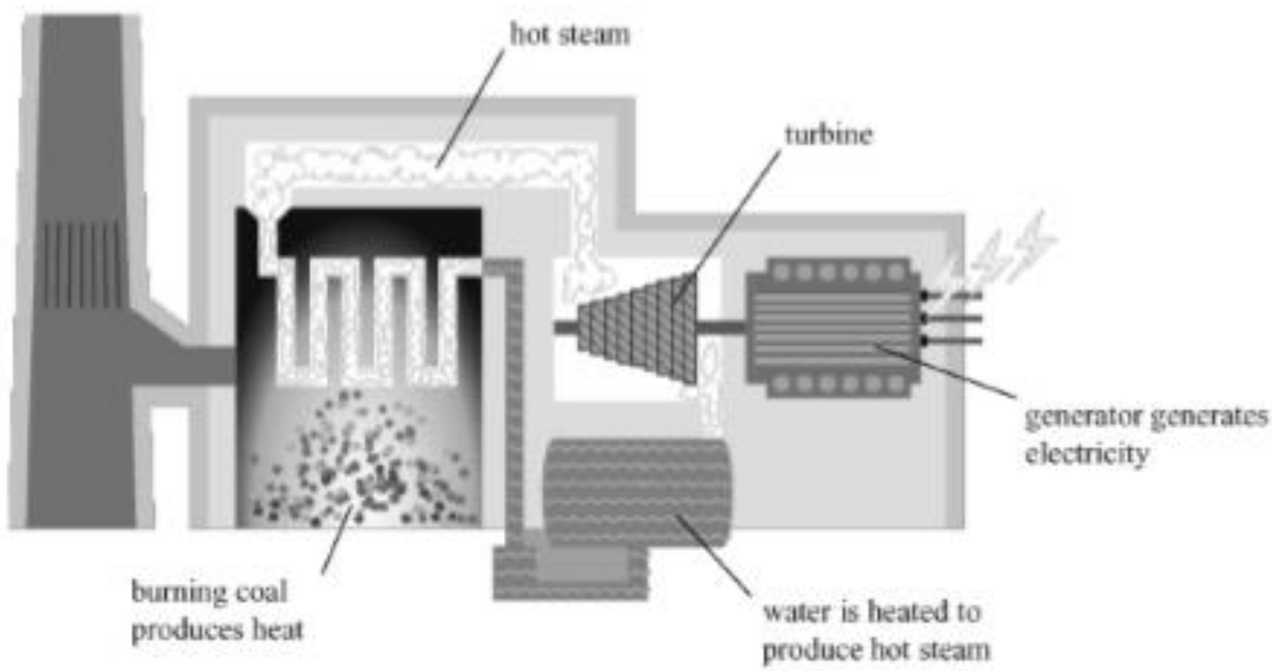


Generation of Electricity

On a larger scale, electricity is generated in power stations in a similar way. Generators in power stations (thermal, nuclear or hydroelectric) rely upon the relationship between electricity and magnetism in order to produce electrical energy.

Thermal Stations

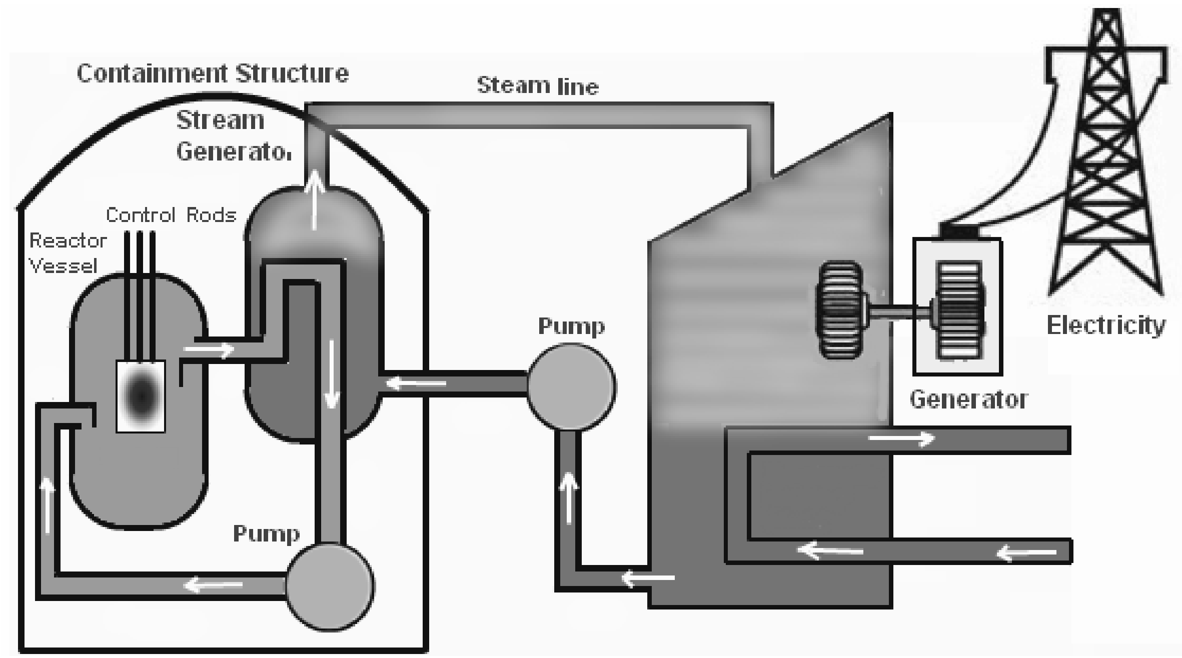
Thermal power stations generate electricity by burning fossil fuels. Oil or coal is burned to produce heat, which turns water into steam. The steam then travels at high pressure and turns a turbine which turns a generator which converts kinetic energy into electrical energy.



The burning of fossil fuels produces CO_2 which can contribute to global warming. Fossil fuels will also run out eventually and so we have to find alternative methods for generating electricity.

Nuclear Power Stations

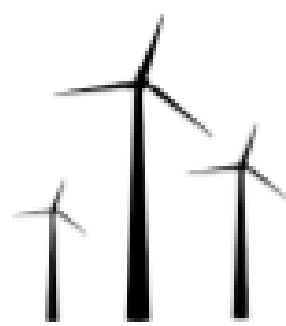
In a nuclear power station heat is created in a nuclear reactor. This heat changes water into steam which turns a turbine. The turbine, again, turns a generator which converts kinetic energy into electrical energy.



Nuclear power stations do not produce gases which contribute to global warming, but they produce radioactive waste which is harmful to humans and other living things.

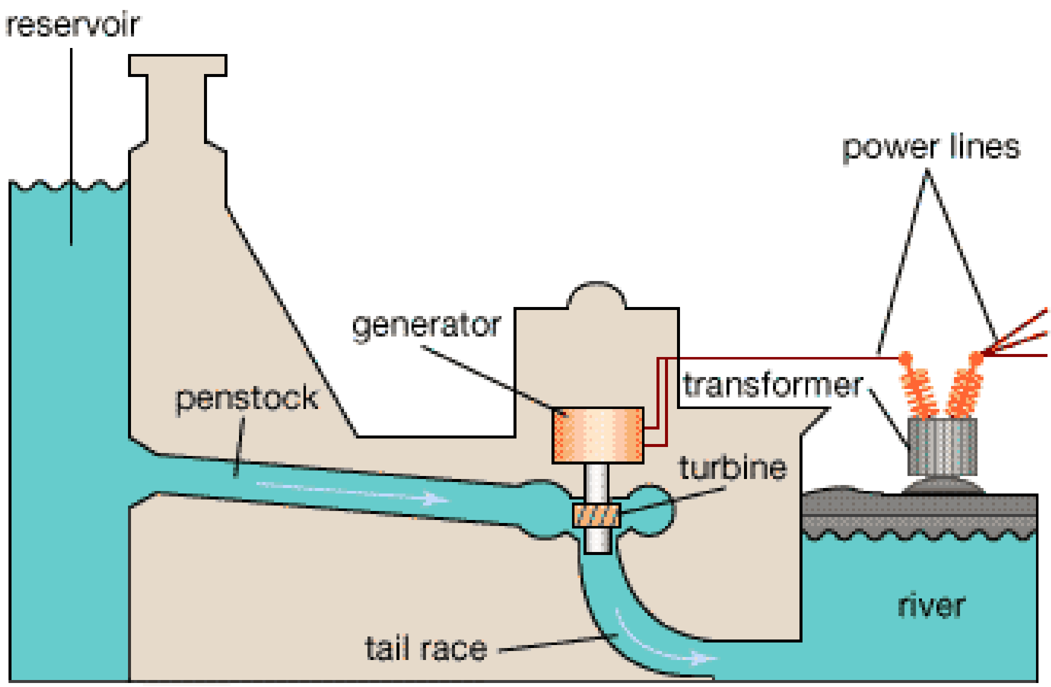
Wind Turbines

Wind turbines harness the kinetic energy of the wind and turn it into electrical energy via a generator.



Hydroelectric Power Stations

Hydroelectric power uses the potential energy of water stored in dams to turn dynamos and make electricity.



Hydroelectric energy is renewable- as long as it rains the dam will refill.

S2 ELECTRICITY & MAGNETISM
Charge

At the end of the section I can :

- ❑ 1 State that there are two types of electrical charge, positive and negative.
- ❑ 2 Describe how materials can be given an electrical charge by rubbing them.
- ❑ 3 State that like charges repel and opposite charges attract.

Charge

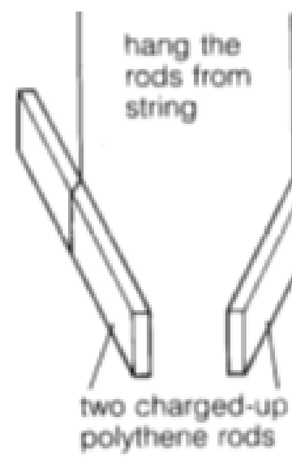
There are two types of electrical charge, **positive and negative.**

Electricity is a **flow of tiny, negatively charged particles called electrons.** Electrons are much smaller than atoms.

You carried out experiments in which pieces of plastic were rubbed to give an electrical charge.

Any material can be given an electric charge by rubbing.

When plastic rods which both had positive charges were brought close to each other the rods moved away - they repelled.

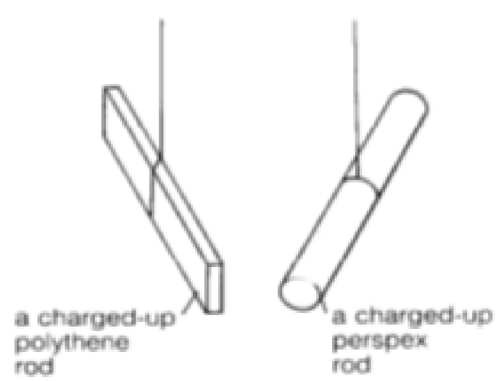


Positive is repelled by positive.
Negative is repelled by negative.

We say that **like charges repel**.

When a positively charged rod is brought close to a negatively charged rod they attract.

Positive charges are the opposite of negative charges.



We say that **opposite charges attract.**

S2 ELECTRICITY & MAGNETISM
Electrical Circuits

At the end of the section I can :

- ❑ 1 Distinguish between conductors and insulators and give examples of each.
- ❑ 2 Draw and identify the circuit symbols for a battery, lamp, switch, resistor, ammeter and voltmeter.
- ❑ 3 State that electric current is the movement of negative charges, called electrons.
- ❑ 4 State that current is measured by an ammeter and the unit of current is the ampere.
- ❑ 5 State that the voltage of a supply is a measure of the energy given to the charge in a circuit.
- ❑ 6 State that voltage is measured by a voltmeter and the unit of voltage is the volt.
- ❑ 7 Draw circuit diagrams to show how to position ammeters and voltmeters correctly in circuits.
- ❑ 8 State that increasing the resistance of a circuit causes the current in the circuit to decrease.
- ❑ 9 State that resistance is measured with an ohmmeter and the unit of resistance is the ohm.
- ❑ 10 Draw and identify the circuit symbol for an ohmmeter.
- ❑ 11 Give two uses of variable resistors.
- ❑ 12 Describe a series circuit.
- ❑ 13 State that in a series circuit the current is the same at all positions.

- ❑ 14 State that the sum of the voltages across the components in series is equal to the voltage of the supply.
- ❑ 15 Describe a parallel circuit.
- ❑ 16 State that the sum of currents in two parallel branches is equal to the current drawn from the supply.
- ❑ 17 State that the voltages across components in parallel is the same for each component.

Conductors and Insulators

A conductor is a substance which lets electricity flow through it easily.

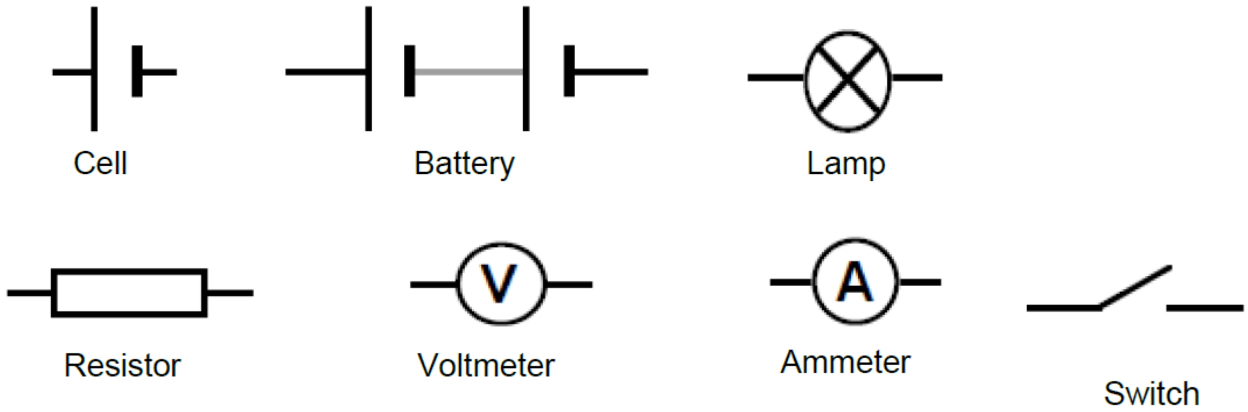
Metals are good conductors of electricity. Graphite - the "lead" in pencils is a non metal which conducts electricity.

An insulator is a substance which does not let electricity flow through it easily.

Metals are used at the centre of wires to conduct electricity and plastic is used to insulate the wires.

Electrical Symbols

Each electrical component is represented by a symbol, which is easy to draw. The symbols are used to draw electrical circuits. All scientists in the world- no matter their language have agreed to use the same symbols.



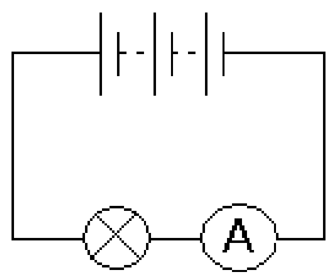
Current

Current is the flow of charges (electrons) around a circuit.

Current is measured in amps - short for Amperes. The symbol for amps is A.

Measuring Current

Current is measured with an ammeter, **to measure current the ammeter is placed in the circuit alongside the component.**



The ammeter in the circuit, above, is measuring the current flowing through the bulb.

Voltage

Batteries provide electrons with the energy to move. The push a battery gives to Electrons, is called the voltage of the battery.

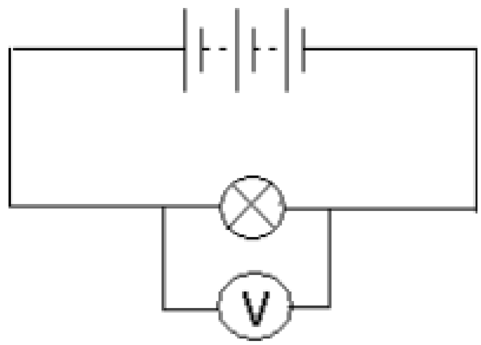
Voltage is a measure of the energy given to the charge (electrons) in a circuit.

When batteries are joined together the voltages can add or cancel depending on the way the batteries are joined.

Voltage is measured in Volts. The symbol for volts is V.

Measuring Voltage

Voltage is measured with a voltmeter, **to measure the voltage across a component the voltmeter is placed across the component.**

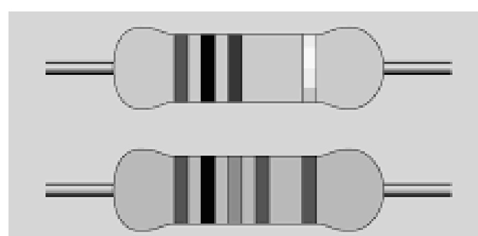


The voltmeter in the circuit, above, is measuring the voltage across the bulb.

Resistance

Materials oppose current and some materials oppose it more than others.
This opposition to current is called resistance. Every material has an electrical resistance. The greater the resistance, the smaller the current that flows. Every electrical component has resistance.

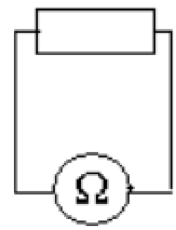
Components called resistors are used to provide resistance in circuits.
Resistors cause electrical energy to be changed to heat energy.



Resistance is measured in ohms. The Greek letter omega (Ω) is the symbol for ohms.

Measuring Resistance

Resistance can be measured with an ohmmeter.
To measure resistance, connect the ohmmeter directly across the resistor or component.

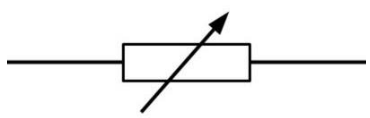


Variable Resistors

Variable resistors are resistors in which the resistance can be changed. This can be done by altering the length of wire in the variable resistor. The longer the wire, the greater the resistance. Variable resistors are used to control the current flowing in a circuit.

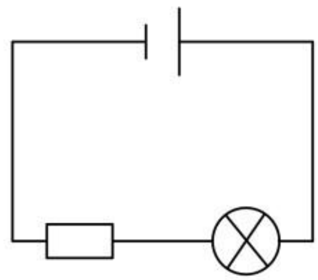
Variable resistors have many uses. They are are used in volume or brightness controls on televisions, dimmer switches on lights, thermostats etc.

The symbol for a variable resistor is



Series Circuits

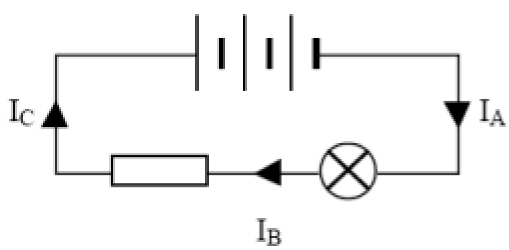
A series circuit is a circuit in which the components are connected one after the other, in series. There is only one path for the current to follow. Any break in the circuit will stop the flow of charge and cause the whole circuit to stop working.



A series circuit with a cell, a lamp and a resistor.

Current in a Series Circuit

In a series circuit the current is the same at all points because there is only one path for the current to flow through.

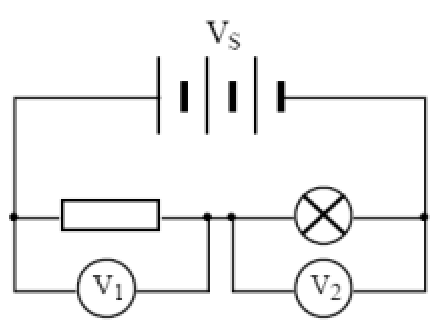


$I_A = I_B = I_C$

Voltage in a Series Circuit

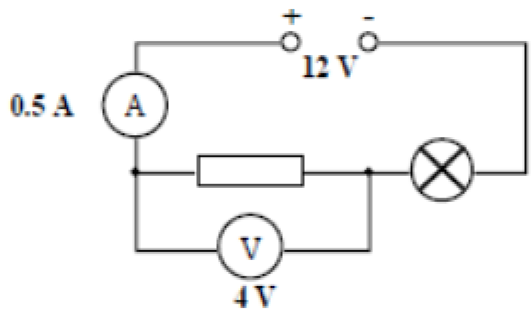
The sum of the voltages across the components in a series circuit is equal to the voltage of the supply.

$V_s = V_1 + V_2$



Series Circuit Example

In the circuit below the ammeter reading is 0.5 A and the voltmeter reading is 4 V.



(a) What is the current through the lamp?

The current through the lamp is 0.5 A as the current is the same at all points in a series circuit.

(b) What is the voltage across the lamp?

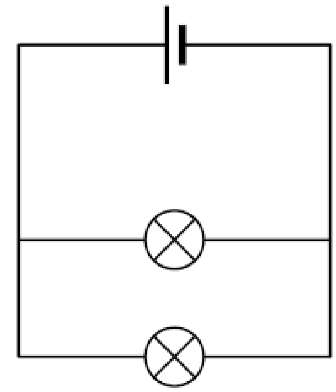
Voltage across lamp = Supply voltage - voltage across resistor = 12 - 4 = 8 V

Parallel Circuits

A parallel circuit is a circuit which has more than one path (branch) for the current to follow.

A break in one of these paths will not prevent other paths from carrying charge.

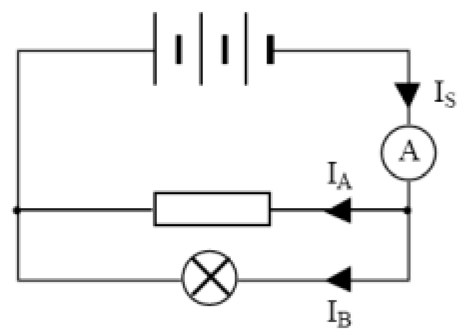
The parallel circuit, opposite, has a component on each branch.



Current in Parallel Circuits

In a parallel circuit the current has more than one path to follow.

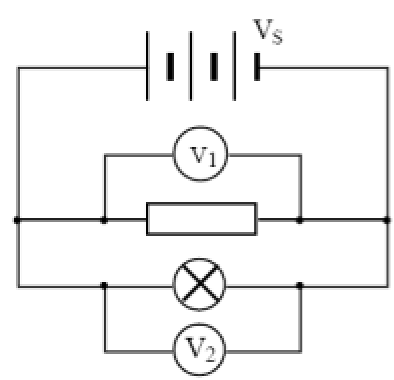
This means that the supply current splits between each parallel branch.



$$\boxed{I_s = I_A + I_B}$$

Voltage in Parallel Circuits

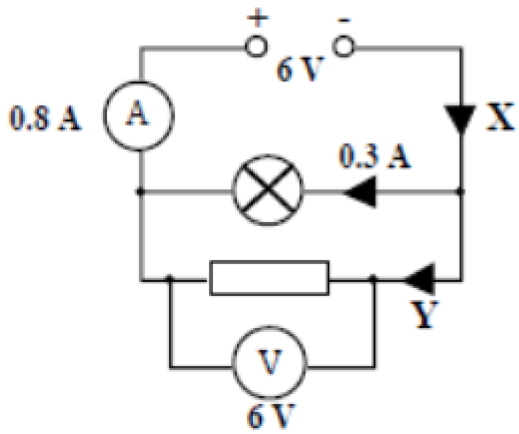
In a parallel circuit the voltage across each branch (each component) is the same.



$$\boxed{V_s = V_1 = V_2}$$

Parallel Circuit Example

In the parallel circuit below the ammeter reads 0.8 A, the current through the lamp is 0.3 A and the voltmeter reads 6 V.



(a) What is the voltage across the lamp?

The voltage across the lamp is 6 V as the voltage across each branch in a parallel circuit is the same.

(b) What are the current values at X and Y?

The current at X is 0.8 A as it is the supply current (it has not split between the branches yet).

The current at Y is 0.8 - 0.3 = 0.5 A (as the supply current of 0.8 A is split between the branches).

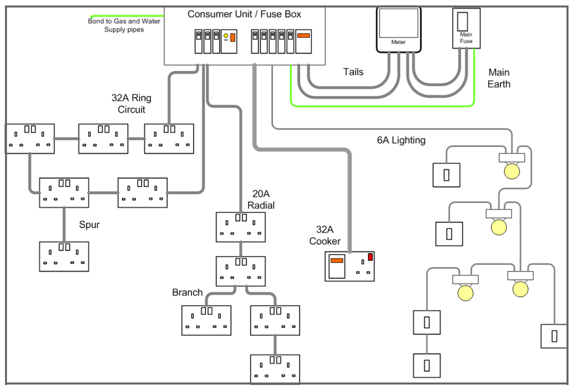
S2 ELECTRICITY & MAGNETISM
Household Electricity

At the end of the section I can :

- ❑ 1 State that the mains voltage is 230 volts.
- ❑ 2 Identify the live, neutral and earth wire from the colour of their insulation.
- ❑ 3 State where each pin wire must be connected for a plug.
- ❑ 4 State that the earth wire is a safety device.
- ❑ 5 State that fuses in a plug are intended to protect flexes.
- ❑ 6 Draw and identify the circuit symbol for a fuse.
- ❑ 7 State that circuit breakers can be used instead of mains fuses.
- ❑ 8 State the advantages of using circuit breakers instead of mains fuses.
- ❑ 9 State that the human body conducts electricity and that moisture increases its ability to conduct.

Household Electricity

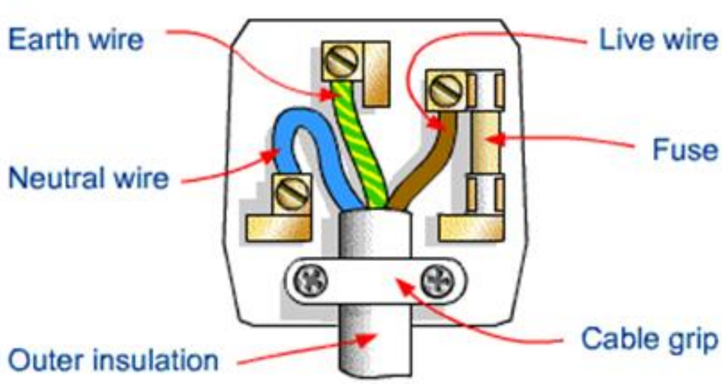
Electricity supplied to houses is called mains electricity. Every electrical appliance in your house is connected to the mains electricity by wires and a plug. All appliances in Britain are designed to operate at **the mains voltage, 230 volts**.



To ensure that all the appliances receive this voltage **household circuits are connected in parallel.**

The Plug

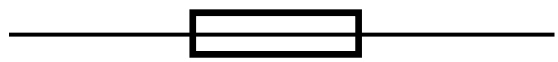
All appliances are connected to the mains by a plug, which must be wired correctly. It is dangerous to operate an appliance if the wires are not connected as shown below.



The **live wire is brown**, the **neutral wire is blue** and the **earth wire is green and yellow**. The live and neutral wires carry the current to the appliance.
The earth wire is a safety device.

The Fuse

The fuse in a plug is a safety device to protect the cable. It melts if the current in the cable gets too high. All plugs contain a fuse, which is next to the live pin and wire. The correct value of fuse must be used for the appliance connected to the plug to operate safely. The symbol for a fuse is shown below:



The two sizes of fuse recommended for use in the mains plugs are 3 A and 13 A.
The power rating of an appliance is used to choose the correct fuse.

Consumer Units

Electricity enters our homes through the consumer unit which contains mains fuses. Each circuit in the home is connected to an appropriate mains fuse in the unit which protects the wiring.

Modern consumer units contain circuit breakers. **A circuit breaker is an automatic switch that can be used instead of a fuse.** Circuit breakers react quickly to large currents and can be reset.

Safety in the Home

Playing with electricity can be deadly. Carelessness can be dangerous, too. Despite this, many people get into bad habits when they use electricity.

Sockets should not be overloaded, frayed wires should not be used, appropriate fuses should be used and electrical appliances should not be used around water. **Moisture increases the conductivity of the human body.**