Electricity

Health & Safety:

Teachers always need to risk assess practical activities for their children and defer to their health and safety advisor for the most up-to-date source of health and safety guidance.

This training cannot be relied upon as source of health & safety guidance.

Safety Talk:

It is important that a short safety talk is given every time the topic of electricity is introduced in the primary classroom. There is no reason for the pupils to be scared because the batteries we use in school are low voltage, but they need to know that mains electricity is a very different matter. Mains electricity can kill (240 Volts).

Background Knowledge

Static Electricity

Static electricity is not on the National Curriculum at primary level, but it is a shame to miss it out completely and it provides some important background for the children. It is a natural phenomenon that children thoroughly enjoy:

- Rubbing a balloon on a jumper or a head of hair – it will be attracted to and stick to a wall.
- Rubbing a balloon on a jumper or a head of, then placing it near chopped up pieces of tissue paper - (they are attracted to the balloon and jump up to it.
- Comb your hair vigorously and put the comb near chopped up tissue paper, which will be attracted to the comb.
- Getting out of the car first in the summer can be a shocking experience.
- Lightning

Electricity has always been around, long before mains electricity or batteries were invented. The common factor with all the above examples of static electricity is that friction is involved, something is rubbing against something else. Early experiments were done with materials that were good at producing static electricity.

- Glass rods were rubbed with silk.
- Ebonite rods were rubbed with cat's fur.

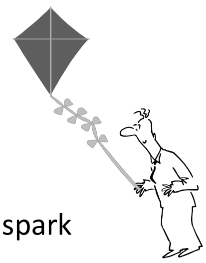
Lightning

Children are very aware of the existence of lightning! (It is very interesting to find out what the children think is going on in a thunderstorm). A touch of science can be very reassuring here: The lightning and the thunder actually occur at exactly the same time. It is a huge spark or discharge of energy, and if you hear the thunder, then you know that you are safe - the immediate danger is past! There is a time delay between the lightning and the thunder because light travels faster than sound. If the lightning is seen at the same time as the thunder is heard, then you are at the very centre of the storm and exactly where the lightning strikes. Lightning will discharge at the sharpest, highest point so it is safest to lie down by a hedge and certainly not to take shelter under a tree!

Church steeples usually have lightning conductors fitted to them so that if they are struck by lightning, the electricity is safely discharged to the ground. Again friction is involved in this phenomenon. Clouds are formed as water droplets rise because of evaporation and these droplets rub against the molecules in the air and become charged.

Recipe for a fried scientist:

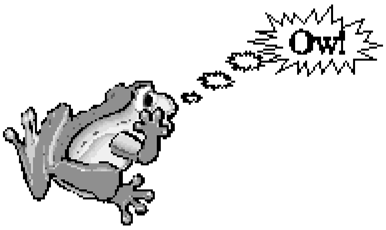
When batteries were first discovered, some brave/foolhardy scientists decided to experiment to find out if the current batteries produce is basically the same phenomenon as that in lightning. Benjamin Franklin was the man who first tried this out and, rather surprisingly, he lived to tell the tale!



He flew a kite in a storm so that it was struck by lightning and observed the almighty spark produced in a gap at the bottom of the thread (unlike the man in the cartoon, he did not hold the thread!). This spark was identical to one produced by a large voltage battery and the experiment was successful. Two other scientists tried a similar experiment and were not so lucky and died in the attempt. This is definitely not one to try at home or even mention to children!

Current Electricity

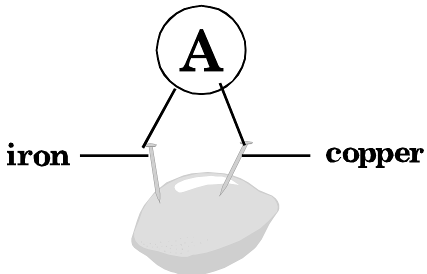
The first battery (or cell) was discovered by Luigi Galvani. He was dissecting a frog at the time. He happened to be using two dissecting tools each of different metals. He touched a



nerve and the dead frog's leg twitched! He had accidentally produced an electric current. This led to the development of what we now call the battery.

The correct name is a cell, and a battery is really the name given to a collection of several cells joined together to produce a higher voltage, so 'cell' the singular and 'battery' the plural – more than one cell.

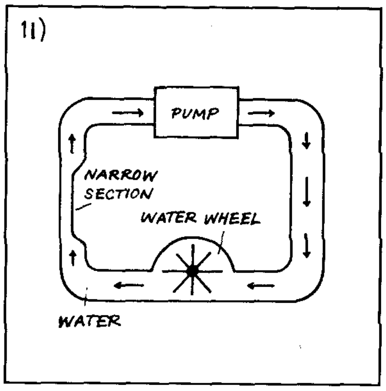
A cell can be made from a lemon:
It requires a very sensitive meter to detect this current.
This will not produce a sufficient current or voltage to light a bulb or, in fact, do anything very useful!



Models

The flow of electricity can be compared to a flow of water through a pipe.

- The water pump can be compared to the battery.
- The pipes can be compared to the leads.
- The thin pipe can be compared to a bulb.



It is, of course, important to realise the limitations of this water pipe model, e.g. nothing leaks out of the wire if it is cut!
An electric current is a flow of electrons. The battery gives the electrons a push which results in this current. But what are electrons?

Atomic Theory:

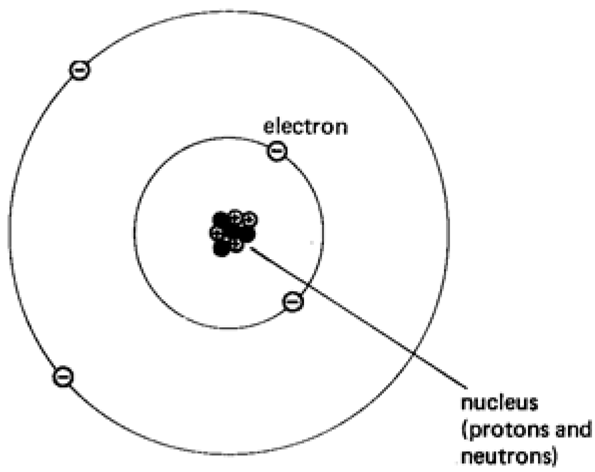
The ancient Greeks developed an atomic theory. In those days, science and philosophy were one and the same. The idea of the existence of atoms was arrived at through philosophy or 'thought experiments'. If you have a pure block of copper and cut it in half and then in half again, again and again……and so on, you will eventually arrive at the smallest 'bit' of copper that is still recognisably copper. This was called an atom of copper. This was then extrapolated to be true for all the elements. Atomic theory was born!

The theory has made rather drastic progress since those days and is highly complex. An atomic is vastly smaller than anything that we can see in everyday life -if the point of a pin is approximately 0.1mm in diameter, this makes it about 1 million atoms wide! This means that an atom something that is very difficult to envisage.

One of the amazing things that was discovered about the atom is that it mainly consists of empty space:

Theory today says that an atom is made up of three main components:

- neutrons - no charge
- protons - positive charge
- electrons- negative charge



It is important to bear in mind that this is a very simplistic model of the atom and that it is all much more interesting than this!!

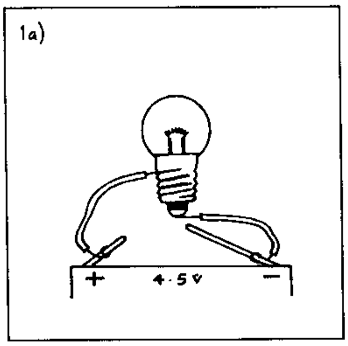
Most of the mass of the atom is concentrated in the nucleus which is very, very small. This results in the nucleus of an atom being massive but tiny!

The negative electrons are held in place by the attraction of the positive nucleus.

Primary Curriculum Knowledge

Making a bulb light:

N.B. It is far more useful for children to discover how to make a bulb light for themselves, rather than be shown how to do it – please refer to the Electrical Challenges sheet.



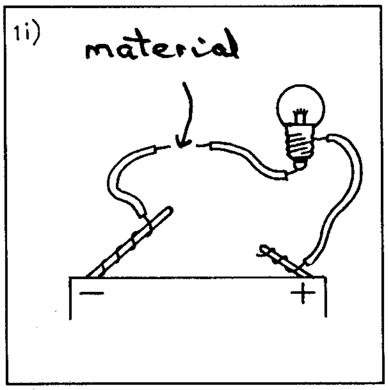
It can be discovered that the following criteria need to be met for the bulb to light:

- A complete circuit with no gaps
- Both ends of the battery must be connected within the loop

The circuit must be joined by conductors.

Conductors and insulators:

A circuit can be set up to find out which materials conduct electricity and which do not:



Again it is more beneficial to allow primary children to design their own circuit that they can take around the classroom and find out what does and doesn't allow electricity through it

Materials that conduct electricity are called **conductors** and those that do not are called **insulators**.

Conductors: metals, graphite (i.e. a pencil core) and some liquids (but most liquids require a higher voltage than can be used at primary level).

Insulators: plastics, wood etc.

Safety: Remember that with a higher voltage, all sorts of materials - including children - will become conductors so warn again about the potential dangers, especially with mains voltages.

On an atomic level, insulators have electrons that are tightly bound by the nucleus and so are not free to move even when given a push by the battery. The outer electrons in conductors are less tightly held and so are free to move when given a push by the battery.

Switches

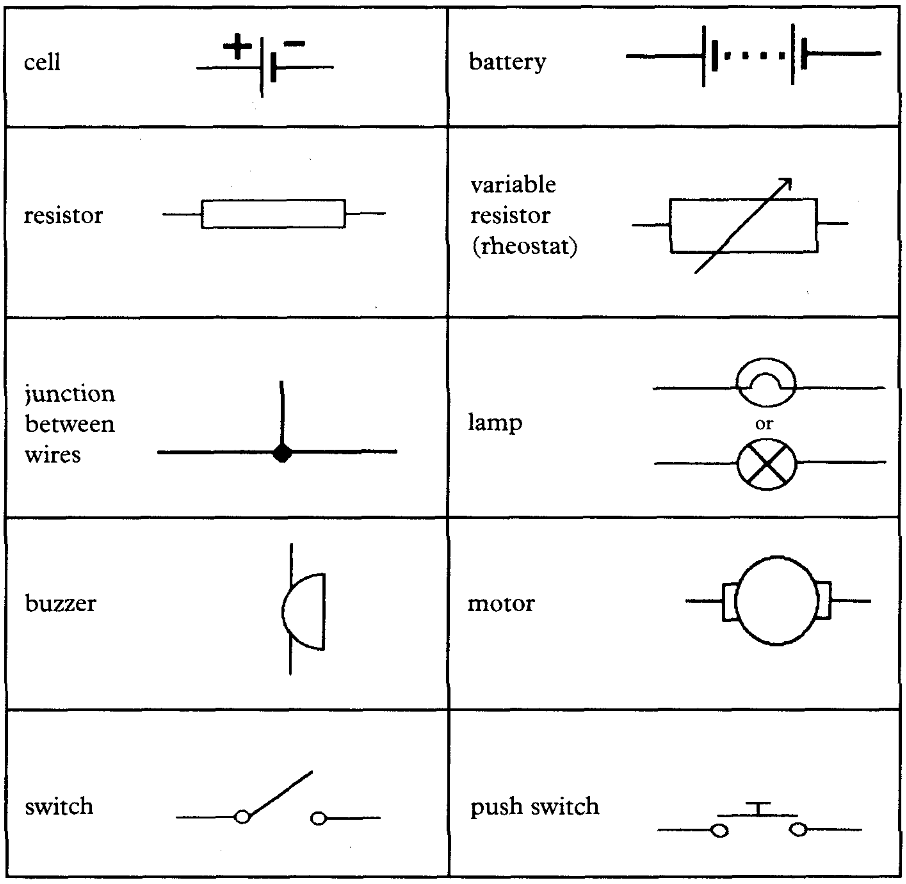
A switch is made by introducing a gap into a circuit. When the gap is closed, the switch is on, the circuit complete and current flows. The gap is made of air which is not such a good conductor of electricity.

Short circuits

A short circuit is not a good idea! This occurs when the two ends of a battery are joined directly by a wire, without a bulb, buzzer or something similar in the circuit. A very large current results which makes the wires very hot and it quickly results in a flat battery.

Circuit diagrams

It is much easier to record circuits when circuit diagrams are used. There are various accepted symbols: .



An effective way of demonstrating to children the usefulness of circuit diagrams is to ask them to draw a circuit so that it can be recorded for posterity. This will take them ages and will probably develop into quite a work of art. If circuit diagrams are introduced after this laborious process they will be greeted with some relief and they have the advantage that any scientist anywhere in the world will know what they mean.

Voltage

Voltage is measured in Volts. It is rather like the driving force that pushes electrons around the circuit. In fact the best way to explain Voltage at primary level is to say:

- **Voltage** is a measure of the 'push' given to the bits of electricity that flow around the circuit

Current

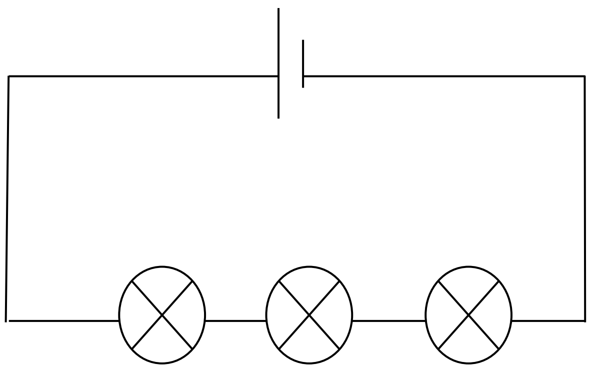
The current is a measure of the flow of electrons around the circuit. Electric current is measured in Amperes or Amps. The higher the current, the faster the electrons move.
This makes sense – the bigger the Voltage, then the bigger the push and the electrons move faster as a result so the current is bigger.

Electrical circuits.

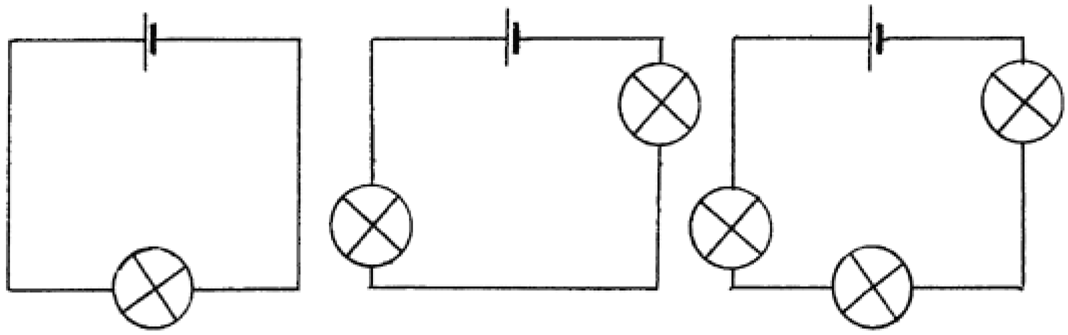
Once children can set up a circuit that lights one bulb, it is possible to ask them to discover how to light more than one bulb with just one battery or cell. There are two different types of circuit.

A Series Circuit.

This type of circuit has only one loop, e.g.

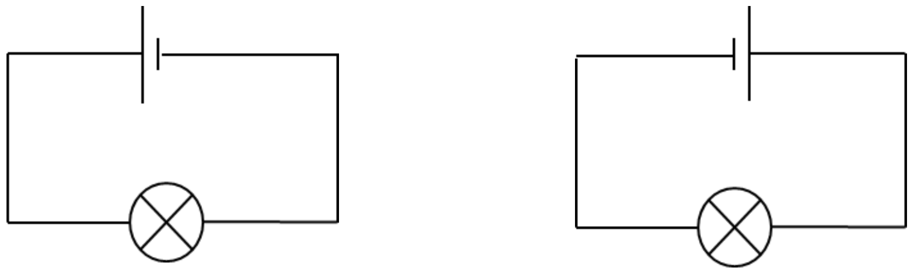


Primary children are only required to learn about series circuits but when working through the challenge sheet, they are likely to discover parallel circuits so these are discussed below. If we call the brightness of one bulb in series with one cell 'normal brightness', then when more bulbs are added into a series circuit, they become dimmer:



normal brightness   dimmer   even dimmer

One thing to note is that a bulb lights no matter which way round the battery is in the circuit:

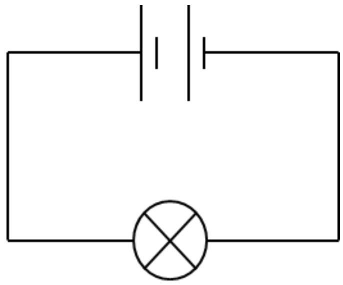


So the bulb lights with equal brightness in each of the above circuits.

However, it ***does matter*** which way round the cell is for a buzzer. So if a buzzer does not seem to work, try changing the way round it is connected in the circuit. The cell needs to push the electrons round in a certain direction for the buzzer to work but we will not concern ourselves as to why here.

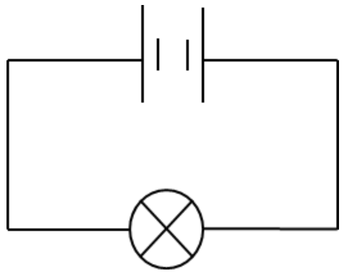
Also it matters for a motor – the motor will turn one way but then reverse its motion if the cell is connected the other way round. This is ever so useful if children are using motors to drive Lego cars because they can go forwards and backwards.

When two cells are in a circuit, it depends how they are connected as to what happens:



circuit a

The 2 cells push together in the same direction so the push is stronger and the electrons move faster so the current is bigger and the bulb is brighter.



circuit b

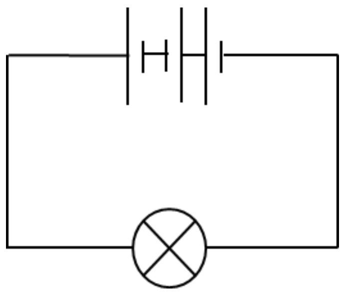
The 2 cells are pushing in opposite directions so they effectively cancel each other out and there is no current and the bulb does not light

If the bulb in the circuits above was replaced with a buzzer, then when the cells were in the same direction (circuit a) , the buzzer would be louder - be careful though because it matters which way round the cells are pushing the electrons so if this doesn't work, turn the buzzer around in the circuit. The buzzer would not ever work in circuit b.

A motor will turn faster with 2 cells connected in the same direction as in circuit a and not work at all in circuit b.

In all these cases, the Voltages add up – two 1.5V cells connected as in circuit act like one 3.0V cell. Of course, 2 or more cells make a battery!

Children can be challenged to think what might happen in this circuit where 2 cells are in one direction and the other in the opposite direction:



It is always best to ask the pupils to predict this and then to try it out practically.

What happens is the 2 batteries in opposite directions cancel each other out and the brightness is just the same as if there were just one cell in the circuit – the bulb lights at what we have called 'normal brightness'.