ELECTRICITY & MAGNETISM

ELECTRICITY

- Many everyday appliances use electricity. Electricity is a convenient means of transferring energy over long distances. Energy is transformed from electricity to other forms of energy by *transducers*. An electric jug is an example of a transducer. It converts electrical energy → heat energy. A food processor converts electrical energy → kinetic energy + sound energy + heat energy. A lamp converts electrical energy → light energy + heat energy

- Atoms contain positive charges called protons and negative charges called electrons (and neutral particles called neutrons). Static electricity occurs when electrons are added or removed from a material. Neutral atoms become charged particles or ions by the addition or removal of electrons. Electric charges can build up on insulating materials rubbed together due to the friction between them. Electrically charged objects attract small objects placed near them. When two electrically charged objects are brought close together, they exert a force on each other. Two charged objects may either pull towards each other (attract) or push each other away (repel). These observations can be explained in terms of the positive (+) and negative (-) charge. Two objects which have the same type of charge repel. Two objects which have different types of charge attract.

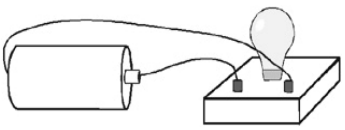
- The build-up of electric charges on the object is called static electricity because the charges stay on the object. They are stationary. Charge is lost to the air especially in wet or humid weather. Charge is also lost quickly if you touch the object with your hand (a process called “Earthing”).

- Simple experiments involving static electricity include: Holding a charged ruler beside torn up tissue paper; Rubbing a balloon on a jersey and stick it to a wall. Everyday examples of static electricity are: on clothing; from jumping on trampoline; walking across a synthetic carpet; combing hair on a dry day. Static electricity is very dangerous to computers.

- Electricity flows from places where there are many electrons to places where there are few electrons. This flow of electrons is called current. Current is measured with a meter called an ammeter. The unit of current is Amps (A).

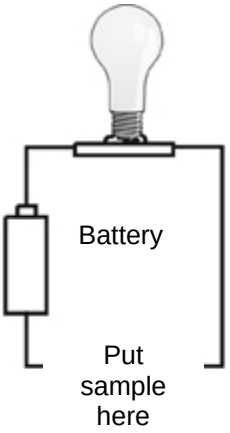
- Electrical cells and batteries store energy as chemical energy. This chemical energy can be turned into electrical energy when connected to electrical equipment. A simple cell can be made using two different metal electrodes dipped in dilute HCl, connected by a voltmeter. Electricity can even be made from fruits such as lemons using Cu and Zn electrodes, enough to power a small digital clock.

- A complete circuit, including a battery or power supply, is needed to make electrical devices work. An electric current is a flow of electrons. Switches can be used to control electrical devices.



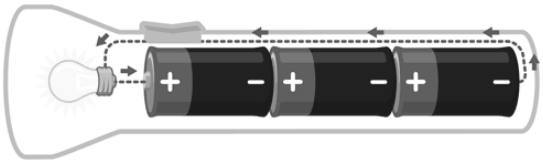
When a switch is open the wires are not connected, therefore current/electricity can not go through the circuit.

- All metals are conductors whilst most non-metals are insulators. A conductor is a material through which electrons can flow. For experts - Metals consist of positive nuclei in a ‘sea’ of electrons. These electrons are not strongly attracted to any one nucleus, so that when the metal is connected to a cell the electrons move easily through the metal to produce a current. In a non-conductor or insulator the electrons are held tightly by the positive charges and because of this the electrons can’t move and no current can flow when the insulator is



connected to a cell. To test an object to see if it is a conductor or an insulator, place it in the gap in the circuit eg a matchstick. If it is a conductor then the bulb will light. Since wood is an insulator so the bulb will NOT light.

- A torch uses a simple circuit. When the switch is closed the circuit is completed and the bulb lights.

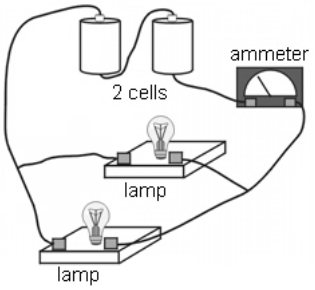


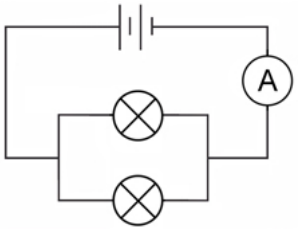
- Simple circuits can be constructed using batteries, wires, switches, bulbs, and buzzers. There are conventional symbols for battery, wires, switches and bulbs. Circuit diagrams are used to show the components of a circuit in a very clear way. They are a map of an electric circuit.

wire	switch	battery	bulb (lamp)	bell
				

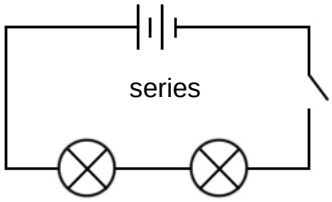
Switches should always be drawn open – we <u>don't</u> draw them closed:

- You should be able to visualise a circuit from a conventional circuit diagram, draw a circuit diagram of a working circuit eg.

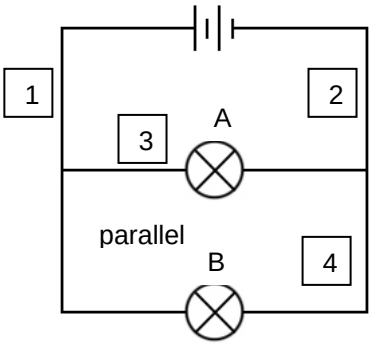




- In a <u>series circuit</u> the electrical components eg bulbs are connected one after another. There is only one path for the current. When the switch is open both lamps are off; when it is closed both lamps will light. If one bulb is unscrewed the other one will also go out. In a SERIES CIRUIT the effect of adding more cells is that the lamp(s) gets brighter. There is more current flowing. As more lamps are added in a series circuit the lamps get dimmer.

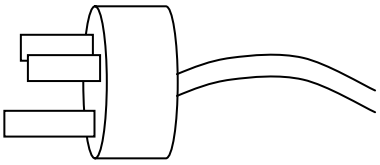


- In a <u>parallel circuit</u> the bulbs are in separate "strands" and there is a choice of paths for the current. The bulbs will be brighter in this arrangement than in the series arrangement. This time if one bulb is unscrewed the other one will still light as there is still a complete pathway for the current. A switch will do different things depending on where it is positioned. In position 1 (or 2) it will turn both A and B on/off together. A switch in position 3 will only control lamp A. A switch in position 4 will only control lamp B.



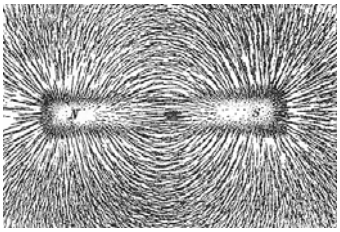
- In a parallel circuit the effect of adding more cells is that the lamps gets brighter. As more lamps are added in a parallel circuit the lamps stay bright. Electrical devices in our homes are connected in parallel so that we can control each thing separately from the other. (Christmas lights are a classic example of a series arrangement. If one bulb goes, none of the lights will work). House lights arranged in parallel mean that each one can be turned on and off independently of each other.
- A bimetallic strip is a strip of metallic material made up of two layers (strips) of different metals. The layers are bonded together. When the temperature of the strip is raised, one metal layer expands more than the other and the bimetallic strip bends. The strip is arranged so that when it bends it causes a circuit to be completed. The completed circuit then activates an alarm. The bending of the strip could be used to break a circuit eg in a thermostat to break a circuit, causing a heater to be switched and thereby controlling the temperature of the air in a room.

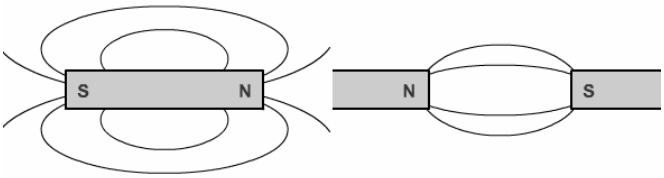
- Mains supply can provide dangerous currents which can cause serious injury or death to users. If you find someone who may be electrocuted it is important not to get electrocuted yourself! The source should be switched off (if safe to do so) or the shocked person pushed away using an insulator such as a wooden broom. If the person is unconscious, send for medical aid. If their breathing and heartbeat have stopped they must be given mouth-to-mouth resuscitation and heart massage. Electric shock can cause muscle spasms, weakness, shallow breathing, rapid pulse, severe burns, unconsciousness, or death. In a shock, the path that electric current takes through the body gets very hot, burns occurring all along that path, including the places on the skin where the current enters and leaves the body.
- It is not only giant power lines that can kill or injure you. If you touched a power line while you were in contact with the ground (or standing on a ladder or roof) electricity would travel through you. If your kite got tangled in a power line and you touched the string, electricity could travel down the string and into you on its way to the ground. You can also be killed by a shock from an appliance or power cord in your home. It is dangerous to get the toast out of a toaster with a metal knife as the knife will conduct the electricity to you if you touch the heating element and you will receive a shock and could get electrocuted. You should not have a "mains" stereo balanced on the edge of the bath as you bath as water will conduct electricity so you have a greater chance of getting a shock when wet or you might knock the stereo into the water and electrocute yourself.
- In a three pin plug, the bottom pin (**earth** pin) is the longest so it always makes connection first when you plug it into the socket. If there is a fault, the appliance is already earthed before the electricity starts to flow. The other two pins are called **phase** and **neutral.** The phase wire is the live wire. This is how the current reaches the appliance. The neutral wire is the return wire from the appliance to complete the circuit. The colour code for mains wiring is Earth (E) – green/yellow; Neutral (N) – blue; Live (L) – brown. The cable is made up of inner wires of copper, because copper is a good conductor. The outer layers are flexible plastic, because plastic is a good insulator. The plug has a plastic or rubber case, because plastic and rubber are good insulators. The pins made from brass, because brass is a good conductor.



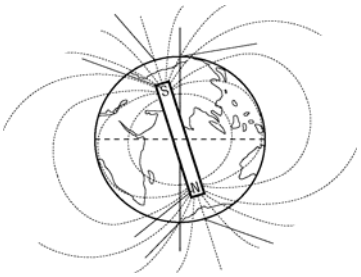
MAGNETISM

- There are forces between magnets and that magnets can attract (pull towards) and repel (push away from) each other. North and North repel, South and South repel but North and South attracts (opposites attract). Magnetism can operate through air, water, paper, plastic etc.
- If you have several magnets you could investigate which magnet is strongest by seeing how many paper clips a magnet can hold in a chain or by finding out how close a magnet has to be to a paperclip until it attracts it.
- Field patterns produced by bar magnets can be visualized using iron filings. This is the magnetic field pattern around a bar magnet, and two attracting magnets.

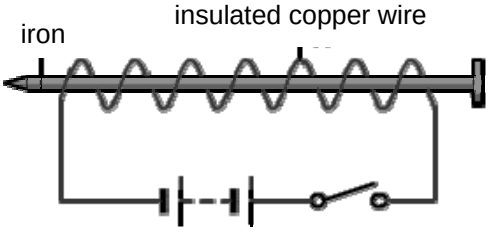




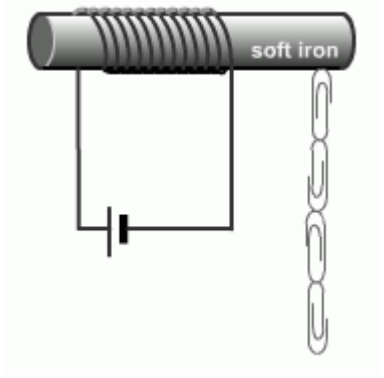
- Magnets attract some metals but not others. Other materials are not attracted to magnets. Only iron, cobalt and nickel and some iron alloys eg steel are attracted. Aluminium cans are not magnetic whereas 'tins' are largely made of iron and are magnetic.
- It is sometimes difficult to distinguish between a magnet and a magnetic material. When two magnets are put together there is either attraction or repulsion, but when a magnet and a magnetic material are put together there is just attraction.
- The Earth has a magnetic field. It's like there is a giant bar magnet inside it (see diagram) but if course there isn't! The most common natural permanent magnetic substance is lodestone (magnetite). Magnets have a north pole and a south pole, and that when freely suspended the magnet will line itself up in the north-south direction. Compasses as small bar magnets pivoted in the middle so that they can swing freely and point North. The North (seeking) pole of the Earth is the pole that the north pole of a magnet seeks – it's actually a south pole.



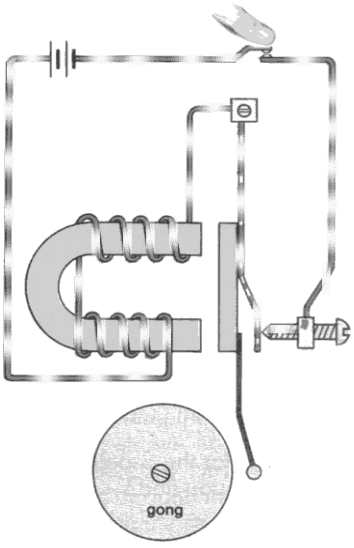
- An electric current flowing in a coil of wire produces a magnetic field. An electromagnet can be made using a battery, and a coil of insulated copper wire. An electromagnet can be made stronger by: increasing the number of turns (how many times the wire is wound); and by increasing the current; using a soft iron core. A coil of wire is called a solenoid.



- Electromagnets are used in devices, eg electric bells, relays. You can make an electromagnet using insulated copper wire, nail (iron core), power supply and a switch. Investigations might include: How many paper clips can be picked up using 2V with 10 windings, 20 windings, 30 windings etc. What if the voltage is increased from 2V to 4V?
- Magnets have a variety of uses. Examples of uses of permanent magnets in the home include: fridge magnets, cupboard door latch, magnetic knife holder, magnetic screwdriver etc.
- Uses of electromagnets. Electrically operated switches (relays) use electromagnets. Electromagnets are used in door bells, buzzers, loud speakers, relays, telephones, electric motors and generators, the 'maglev' train and for lifting scrap metal. Cranes use electromagnets to pick up cars as can drop the car after it has been moved simply by turning off the current.



- Electric bells use electromagnets. When the switch is closed there is a complete circuit, current flows and the coil of wire around the iron core makes an electromagnet. The magnet pulls the striker towards the bell gong and the striker makes a noise. As it does the circuit is broken, current no longer flows and the striker is no longer attracted to the magnet and moves back away from the bell again. The circuit is then reformed, the electromagnet is made again and the striker is attracted again. The process repeats over and over again and we hear a constant ringing sound.



ELECTRICITY GLOSSARY

- Atom: The smallest particle of an element that can exist and still retain the properties of that element.
- Battery: A device used for generating electricity through an electrochemical reaction; a battery unit is made from one or more cells.
- Cell: Contains positive and negative electrodes surrounded by an electrolyte. A chemical reaction occurs within the cell which generates electricity (releases electrons). One or more cells connected together is called a battery.
- Charge: A given quantity of electricity.
- Circuit: A complete path for an electric current.
- Closed circuit: Where the current flows from the battery through an electrical device providing power, and returning back to the battery.
- Compass: An instrument with a rotating magnetic usually used for locating the Magnetic North Pole.
- Conductor: Anything an electrical current can pass through easily.
- Current: A flow of electricity.
- Electrical device: Anything that uses electricity or batteries.
- Electricity: A type of energy in which small particles (called electrons) move through a device.
- Electron: Part of an atom; a negatively charged particle that is found outside of the nucleus of the atom.
- Filament: A very fine wire.
- Fuse: A safety device used in a circuit to prevent overloading. A thin piece of wire (located within a devices operating circuit) which will burn up if a larger electric current goes through it than it was designed to carry. A fuse must be replaced when it is "blown".
- Insulated wire: Wire surrounded by plastic covering.
- Insulator: Materials that electricity has a hard time flowing through (e.g. plastic coating on wires, leather, wood, etc.).
- Negative terminal: The point on the battery where electrons LEAVE.
- Open circuit: An incomplete path, electricity can not cross the break in the circuit.
- Parallel circuit: Provides more than one path for electricity to flow.
- Positive terminal: The point on the battery where electrons ENTER.
- Series circuit: One path (loop) for electricity to travel through all loads. If one bulb or battery is disconnected, the circuit will NOT work.
- Simple circuit: Consists of a battery (power source), wire (conductor), an electrical device (component) and switch (control) connected together to form a closed circuit.
- Switch: A device used to control the flow of electricity.