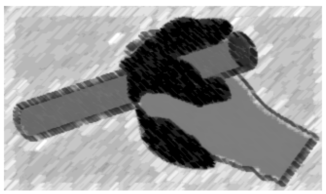
AS90937 Survival Sheet
Demonstrate understanding of aspects of electricity and magnetism

<u>Static Electricity</u>

- **electron transfer** causes static electricity
- results from an **imbalance of charges**
- can occur by **induction**, **friction**, and **contact**

You need to describe the **direction of motion of charges** during the charging process

Charging by friction: rubbing 2 insulating materials against each other causes charge separation. *The rod and cloth become oppositely charged as a result of **electrons** transferring from one to the other; there will be an excess of electrons and a negative charge on one surface, the other will be positively charged.*



A piece of copper does not get charged when rubbed with a cloth because copper is a conductor.

Charging by contact

Positive and negative charge

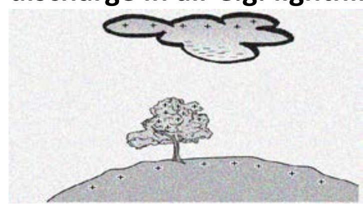
Charges are never created but are transferred from one surface to another. Charge is conserved – the total number of charges between the hand and the cloth remains constant.

- Unlike/opposite charges attract
- Only negative charges are displaced

Charging by induction

Induction charging charges an object without actually touching the object to any other charged object.

Electrical discharge in air e.g. lightning



Lightning can occur when there is charge separation. The bottom of the storm cloud is negatively charged, and the tree and the ground close to the lower end of the cloud become positively charged.

When refuelling an aeroplane, to avoid a spark caused by a build-up of static charge the refuelling tanker and the aeroplane are both earthed.

Detecting charge

Two charged objects will repel each other if they have the same type of charge (they are both + or both -). Two charged objects will attract each other if they have opposite charges. The only way to tell if an object is charged is to see if it repels another charged object. This is because charged objects will also attract small uncharged objects.

Conductors and insulators

Difference between conductors and insulators in terms of electron movement:

- conductors allow charges to move freely through them, e.g. metals
- insulators do not allow charges to move freely through them e.g. plastics

Difference between a conductor and insulator when charged by friction:

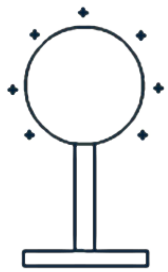
- Conductors allow charges to move freely in them (electrons repel each other and spread out). Any charge transferred / induced is quickly conducted away (e.g. to earth) leaving the metal neutral.
- Insulators don't lose charge easily as charges cannot move freely in them.

Tall buildings use **lightning conductors** to protect the building from lightning damage. It is a metal rod attached to the highest point on a building, connected to the ground by a thick metal strip. When the lightning strikes, the current flows through the metal strip – the easiest and shortest path - to the ground rather than through the building, protecting the building.

When you walk across a nylon carpet, you become negatively charged. When you then touch a metal handle you receive a shock because electrons jump from you to the handle.

Uniform Charge distribution

It has been found that a charged metal sphere has a uniform charge density all over its surface.



Non-uniform charge distributions

A pear shaped conductor, however, has a high density at the pointed part.

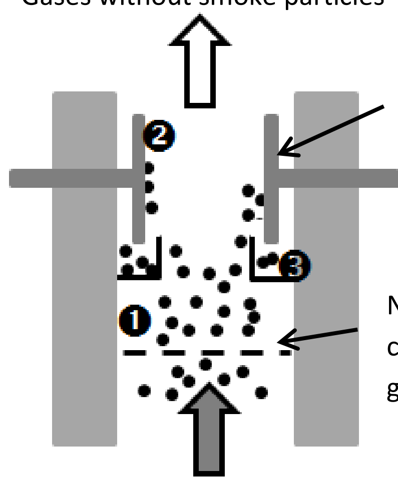
Earthing

When you ride in a car, electrons are exchanged between your clothes and the car seat, building up collections of excess charges. By the time you get out of the car, you have accumulated an overall charge, whilst the vehicle carries the opposite charge. To make things worse, the rubber car tyres and the soles of your shoes are insulators, stopping the charges from escaping to the ground. As you reach to close the metal door, electrons leap between your finger and the car… zap!

Electrostatic precipitators

Factories use static electricity to reduce pollution coming from their smokestacks. They give the smoke particles an electric charge.

❶ smoke particles pick up –ve charge
❷ -ve smoke particles attracted to +ve collecting plates
❸ collecting plates knocked to remove smoke particles
This keeps the pollution from going out into the atmosphere.



Additional Notes

DC Electricity

Series circuits and parallel circuits can be recognised by their behaviour:

In a series circuit, if one light bulb stops working (blows)… a break in a series circuit results in no current flowing through any component. The other light bulbs will not light up. It becomes an **incomplete circuit** and **no current** flows through it.

In a parallel circuit, if one light bulb stops working (blows)… the other light bulbs will stay on.

The **resistance, R,** of a light bulb can be measured by applying a voltage, V, across the light bulb and measuring the current, I, that flows through it.

$$V = IR$$

This can be rearranged to R = V/I

The **power, P** used by light bulbs depends on both the current, I, flowing through the light bulb and the voltage, V, across the light bulb.

$$P = IV$$

Resistors in series

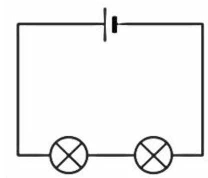
The total resistance in a series circuit is calculated by this formula:

$$R_T = R_1 + R_2 + \ldots$$

e.g. 8 identical light bulbs are connected in series. The resistance of each bulb is 12.5 Ω. Calculate the total resistance of the circuit.

R_T = 12.5 + 12.5 + 12.5 + 12.5 + 12.5 + 12.5 + 12.5 + 12.5 = 100 Ω

In a **series** circuit there is only one path for the current.



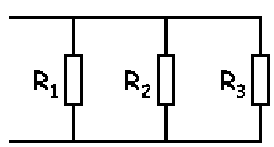
- The current in a series circuit is the same at all places in the circuit.
- The supply voltage is shared between components in a series circuit.
- The sum of the voltages across components in series is equal to the voltage of the supply.
- The voltages across the components in a series circuit are in the same proportion as their resistances. This means that if two identical components are connected in series, the supply voltage divides equally across them.

If 10 light bulbs are connected in **series** to a battery of 20 V each will have 20/10 = **2 V** across them (which may mean they glow dimly).

Resistors in parallel

The total resistance in a parallel circuit is calculated differently (and is not required at level 1).

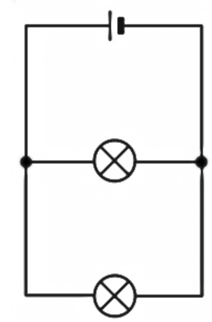
When resistors are added in parallel the total resistance decreases.



In a **parallel** circuit there is more than one path for the current to follow.

At some points in a parallel circuit there will be junctions of conductors.

Junctions are shown by dots on circuit diagrams.



- The current in a parallel circuit splits into different branches then combines again before it goes back into the supply. When the current splits, the current in each branch after the split adds up to the same as the current just before the split.
- The voltage across components in parallel is the same for each component.
- Parallel circuits require more wires and consume more energy per second or power.

If 10 light bulbs are connected in **parallel** to a battery of 20 V they will each still have **20 V** across them (which means they glow brightly but the battery will run out of energy quickly).

The **power, P,** is also equal to the energy, E, divided by the time, t.

$$P = \frac{E}{t}$$

A Watt is a measure of Joules per second.

This can be rearranged to E = P x t

e.g. The voltage of a power supply is 60 V and the current drawn from it is 0.6 A. Calculate the energy drawn from the supply in 2 minutes.

E = P x t   E = 0.6 x 60 x 120   E = 4320 J

<u>Magnetism</u>

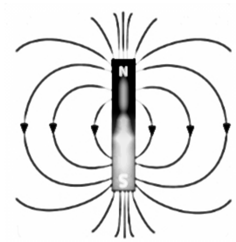
A Magnetic field

A magnetic field is a region in which a force is felt from

- a magnet
- an electric current.
- a magnetic field due to a solenoid

The magnetic field strength can be shown by the proximity of lines of force.

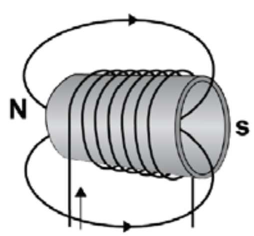
- lines are close together – strong magnetic field is strong
- lines far apart – weak magnetic field



Field is strongest near the poles and weaker towards the centre of the bar magnet.

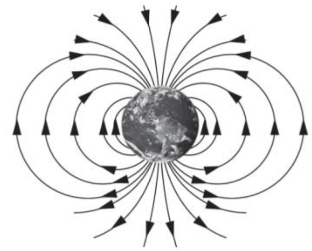
The shape of magnetic field produced by a solenoid and the polarity of the solenoid

- Use letters N and S to mark north and south poles of coil
- Draw magnetic field pattern produced **outside** coil.
- Indicate direction of magnetic field with arrows.

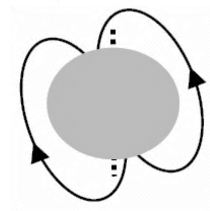


Right hand grip rule for a solenoid: fingers point in direction of the current around coil and then thumb points to N end of solenoid.

The magnetic field of the Earth



Compasses – which are magnetic North poles – are attracted to magnetic South poles.

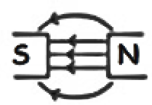


The North (seeking) pole of the Earth is actually a (magnetic) South pole. The South (seeking) pole of the Earth is actually a (magnetic) North pole.
In NZ we live closest to a magnetic North pole.

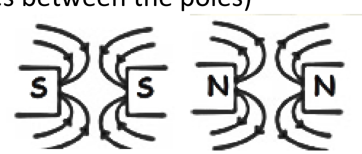
If two magnetic fields are of equal strength where a compass is located there will be equal forces on a compass needle.
The forces are in opposite directions so the net force on the needle is zero; needle points northward due to Earth's magnetic field.

Field direction – from N to S

Strong field between unlike poles



Between like poles net magnetic force = 0 (shown by no lines between the poles)



Calculate the magnetic field strength produced by a current carried in a cable

The strength of the magnetic field produced by a current-carrying straight conductor can be calculated by:

$$B = \frac{kI}{d}$$

e.g. If $k = 2.0 \times 10^{-7}$ T m A^{-1}, calculate the strength of the magnetic field 0.14 m away from the wire, due to the constant current. State the unit of the magnetic field strength.

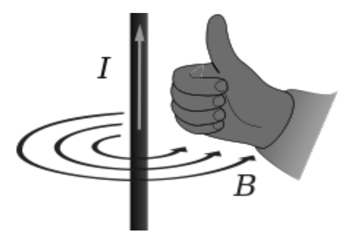
$B = kI/d = 2.0 \times 10^{-7} \times 2.5/12 = 4.2 \times 10^{-8}$ T

To increase the strength of an electromagnet:

- Use more coils of wires
- Increase voltage/current supplied to the coil
- Use a soft iron core (soft iron does not retain its magnetism once the circuit is broken).

Right-hand grip rule

Use the right hand grip rule to find the direction of the magnetic field produced by a current carrying straight conductor.
If you wrap your right hand with your thumb pointing in the direction of the current, your fingers indicate the direction of the magnetic field.

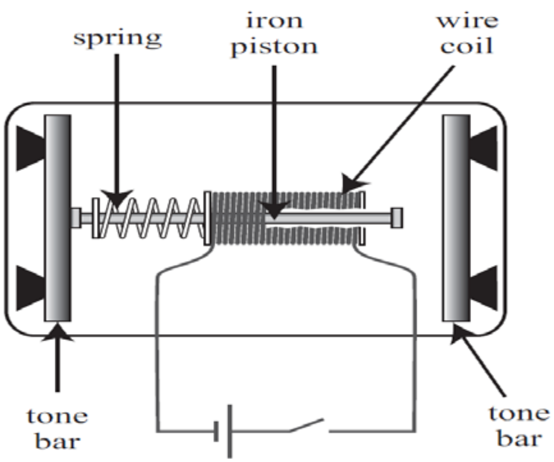


Relays

A relay is an electrically operated switch. It works on the principle of a magnet attracting iron when a current is flowing and releasing it when the current no longer flowing.

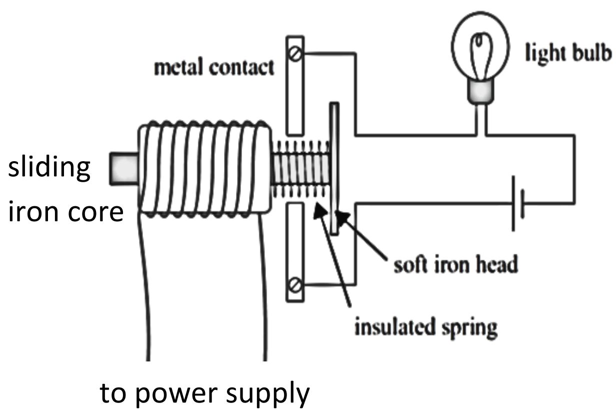
The workings of a chime doorbell

When the solenoid (wire coil) is “switched on”, it becomes magnetised and the piston is pulled to the right to the hit the right tone bar.
When the solenoid is turned off, it becomes non-magnetised and the piston is pulled to the left by the spring to hit the left tone bar.



Using a relay to switch on a light bulb.

The relay has a coil containing a sliding iron core to turn on the light bulb.

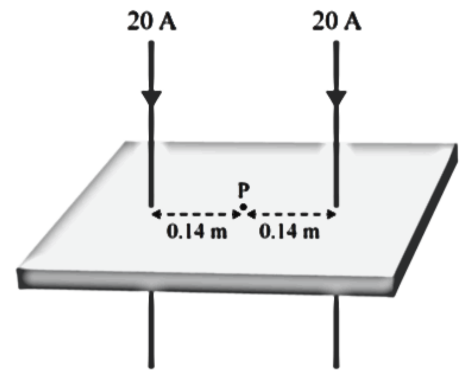


When the current flows, the **coil becomes magnetised** and **pulls soft iron core** to the left. The head of the core touches the two metal contacts thereby completing the light bulb circuit.

The effect of combining two magnetic fields from current-carrying straight conductors

Current flows in the downward direction in both wires as shown in the diagram.

The point P is 0.14 m away from each wire.



- The strength of the magnetic field at P is zero.
- At point P, fields from both wires meet in the opposite direction.
- The fields are equal in strength, because they are caused by equal currents flowing at equal distance from P.

Additional Notes