Electricity and magnetism

The charge is the amount of electricity in a circuit.

The symbol for charge is Q.

The unit for charge is coulombs.

A capacitor is a device that stores charge.

Charge = current x time.

- Most materials fall into two groups: conductors and insulators.
- A conductor allows electrons to flow through it.
- An insulator is a barrier to electricity.
- An insulator may act as a store of electricity known as static electricity.
- There is a small third group called semi conductors - these are used in electronics.

- The current is carried by ELECTRONS.
- Metals contain a "sea" of free electrons (negatively charged) which flow through the metal.
- This is what allows electric current to flow so well in all metals.
- Electric current will only flow if there are charges which can move freely (electrons).

- There are some things that you need to know for the exam about the difference between CONVENTIONAL and ELECTRICAL current.
- CONVENTIONAL current flows from POSITIVE TO NEGATIVE.
- ELECTRICAL current flows from NEGATIVE TO POSITIVE.
- So electrons flow opposite to the flow of conventional current.

CURRENT - is the flow of electrons round the circuit.

VOLTAGE - is the driving force that pushes the current round.

RESISTANCE - is anything in the circuit that slows the flow down.

There is a relationship between these three which is summarised as OHM'S LAW:

V=IR

voltage=Current x Resistance

So if you increase the voltage - then more current will flow, if the resistance is constant.

If you increase the resistance - then lass current will flow if voltage remains constant.

Electromagnetic Induction

This is the idea that magnetism can travel from one object to another even though they are insulated.

- An example of how magnetic induction is used is in transformers.
- Two coils of wire are wrapped around an iron core.
- The primary coils are connected to the power supply.
- The secondary coils are connected to the device.
- An electromagnetic field is created from the primary coils.
- This induces a magnetic field in the core.
- This inturn induces a current in the secondary coil.
- The number of coils is proportion to the amount of voltage so a transformer is used to increase or decrease the voltage.
- Secondary voltage/primary voltage = Seconday turns/primary turns

The area around a magnet is known as the magnetic field.

Two like poles repel each other and two unlike poles attract each other.

Every magnet has two poles: North and South.

Magnetic fields travel from north to south so be careful to label a diagram in this way with an arrow on the line of field pointing towards south.

A compass can be used to detect a magnetic field.

When electricity passes along a wire, it forms a magnetic field.

Using direct current will make the field in circles around the wire. This can be tested by using a compass.

You need to learn the magnetic rules which includes the right hand grip rule.

If a coil of wire is used a stronger magnetic field is produced.

You also need to know about some devices that work by electromagnetism such as an electric bell and relay.

If you are asked to draw the magnetic field around a magnet REMEMBER:
The lines must travel around the magnet.
They must not touch each other.
Label the magnetic field with arrows going from north to south.

- Each component separately connected.
- If one of the components is disconnected then it does not effect those it is parallel with.
- All components get the full source voltage.
- Voltage the same in all components.

- The lower the resistance of a component the greater the current.
- Total current in the circuit is equal to the currents in its separate branches.
- Total current going into a junction is equal to the total current leaving it.

Series circuits

- Components are connected from end to end.
- If one component is removed or disconnected the circuit is broken.
- Total resistance is the sum of all the resistances.
- Same current in all parts of the circuit.
- Total voltage of the supply is shared between components.
- The bigger the resistance of a component, the bigger its share of voltage.

Static electricity

- There are two types of charge: + positive and - negative.
- An uncharged material has equal numbers of both so the material is balanced out.
- Friction between materials caused an exchange of charges.
- The negative charges move but positive stay where they are.
- Once a material is charged it will attract materials with the opposite charge and repel materials that have the same charge.
- An example of static electricity in industry is when painting cars. The car body is charged evenly and the paint is prayed on. The paint particles are attracted to the car and spread out because of the charge. This ensures the car is painted evenly.

Forces and motion

- Forces are usually a push or a pull.
- Forces are measured using a newtonmeter and the unit of force is Newtons.
- Forces work in pairs - as you push down on a table the table pushes up with equal force.
- When there is no change in velocity or shape of an object then the forces are balanced e.g. book on table
- When there is a change in velocity or shape of an object then the forces are not balanced e.g. person falling through ice.
- An example of a force is gravitational force. To work out the weight of an object (with gravity working on it) you use the following formula:
- Weight (N) = mass (kg) x gravitational force (N/kg)
- The main formula to use to work out forces is:
- **Force (N) = mass (kg) x acceleration (m/s/s)**
  OR F=ma

Hooke's Law

- Hooke's law simply states that **the extension of a spring (or other stretch object) is directly proportional to the force acting on it.**
- This law is only true if the elastic limit of the object has not been reached.
- If the elastic limit has been reached the object will not return to its original shape and may eventually break.

Pressure

Pressure is the amount of force acting upon a particular area of an object.

- The formula for calculating the pressure on an object is:
- **Pressure (N/m^2) = Force (N) / Area (m^2)**
- The unit N/m^2 is known as Pascals.
- This formula shows that by decreasing the area you will increase the pressure e.g. knives need to excert a big pressure so they have a very narrow area.
- **Pressure in solids.** The pressure only acts in one direction in solids.
- **Pressure in liquids.** The pressure in liquid gets higher as you go down. The pressure of liquids acts in all directions not just down.
- **Pressure in gases.** Gas molecules are free to move anywhere therefore pressure of gases acts in all directions. The pressure gets higher as you go down because of the weight of the gas (air).

Momentum

- Momentum is the measure of how difficult it is to change an objects' velocity.
- Momentum can be increased by increasing the mass of the object or the velocity of the object.
- e.g. a lorry going at 80km/h down a hill with a very heavy load would have a big momentum. - It would be very difficulat to stop! (If this was an exam question you would have to convert hours to seconds and km to m)
- The formula for calculating momentum is:
- **Momentum (kgm/s) = mass (kg) x velocity (m/s)**
- Conservation of momentum just shows that momentum is never lost but just transferred from one object to another e.g. if the big lorry runs into a car then all the momentum will be transferred to the car.

Acceleration

- Acceleration is the rate of change in velocity of an object.
- The most common unit of acceleration is m/s/s which can also be written as m/s^2 or ms^{-2}. This means the rate of change in velocity per second.
- For example if an object increased its velocity by 2 metres every second then its acceleration would be 2m/s/s.
- Accelaration = change in velocity / time taken for change.
- Therefore if an object travels from stationary to 5 m/s in 2.5 seconds then its acceleration = 5/2.5 = 2m/s/s.
- Uniform acceleration is just the name given to a constant acceleration.

Speed and velocity

- Speed is the change of movement of an object.
- Velocity is the speed of an object **in a certain direction.**
- The most common unit for both speed and velocity is m/s which shows how many metres an object has moved in one second.
- Average speed = distance moved / time taken.
- Average velocity = distance moved in a certain direction / time taken.

Formulae

Here are the formulae for speed, velocity and acceleration. You will probably be expected to learn these for your GCSE exam:

- Average speed = distance moved / time taken
- Average velocity = distance moved in a certain direction / time taken
- Acceleration = change in velocity / time taken
- **Remember all of these formulae can be rearanged.**
- **e.g. distance = average speed x time taken**

- Below are the formulae you can use when calculating problems which have uniform acceleration (constant acceleration). You probably will be only expected to be able to use these and not learn them but *make sure you check this with your teacher.*
- $v = u + at$
- $s = (u + v)/2 \times t$
- $s = ut + \frac{1}{2}at^2$
- $v^2 = u^2 + 2as$
- **What the letters stand for:**
- u = initial velocity
- t = time
- v = final velocity
- s = distance travelled
- a = acceleration (must be constant)

Waves

Waves

Waves do not carry matter but they transfer energy.

There are two main types of wave: **Transverse Waves** and **Longitudinal Waves.** Below is some information and examples of both:

Transverse waves:
A transverse wave moves across the direction in which the wave is travelling.
An example of a transverse wave is the sea - imagine the shape of a wave.
Another good example is a light wave.

Longitudinal waves:
Longitudinal waves look like this: ||| | | || || | |||| | | | ||
They have a series of compressions and rarefractions.
A compression is when the wavelength (distance between each wave) is small.
A rarefraction is when the wavelength is large.
Longitudinal waves pass on energy as a series of vibrations.
These are sound waves.

Wavelength. The wavelength is the length of a wave e.g. the distance between one crest (high part) and the next crest.

Frequency. Measure of how many waves pass in one second.

Amplitude. The distance between the crest of the wave and the centre line.

Formulae. There are two main formulae on the topic of waves:
Velocity (m/s) = frequency (Hz) x wavelength (m)

Speed (m/s) = distance (m) / time (s)

Electromagnetic Spectrum

- Below is the electromagnetic spectrum; starting with short wavelengths and getting longer. We have also included some common uses which you may need to give in an exam question
- **Gamma rays.** Cancer treatment
- **X-rays.** Medical uses and security (at airports etc)
- **Ultraviolet.** Sun tanning
- **Visable light.** Human sight
- **Infrared.** Cooking (heat)
- **Microwaves.** Cooking
- **Radio waves.** Communication

Light

The primary light colours are red blue and green. They can be mixed, as follows, to form secondary light colours:
red + green = yellow
red + blue = magenta
blue + green = cyan

By using a prism, white light can be separated into all the different (dispersion) colours that make up white light. These are (starting with long wavelength):
red, orange, yellow, green, blue, indigo, violet

Reflection:
The angle of incident always equals the angle of reflection. These are measured against the normal which is an imaginary straight line at a right angle to the mirror.

Refraction:
Refraction is the process that occurs when light travels from one material to another, it is either speed up or slowed down. This has an effect on the light and bends it. The denser the material, the slower the speed of light.

Sound

Sound waves are caused by vibrations in the air. They cannot travel through vacuums. The denser the material, the faster sound can travel.

Sound waves are reflected and this is heard by us as an echo. The echo is the sound being reflected - just like light reflected from a mirror.

Ultrasound has a very high frequency and we canv not hear it but bats use it to fly and it is also used to look inside the body.