Edexcel Physics IGCSE

Topic 2: Electricity

Summary Notes

(Content in **bold** is for physics only)

Energy and voltage in circuits

Current

Current I is measured in **amperes (A)** and is the **rate of flow of charge** at a **point** in the circuit.

- The current is given by I=Q/t, where Q is measured in **coulombs (C)** and t in **seconds (s).**
- In metals, current is due to a **flow of electrons.** In solutions it can be the flow of ions. Conventional current is the rate of flow of **positive** charge - this is in the **opposite** direction to the flow of electrons because electrons are **negatively** charged.
- Current is **conserved** at a **junction** in a circuit because charge is always conserved.
- Current is measured with an **ammeter** connected in **series** with the component.

Potential difference

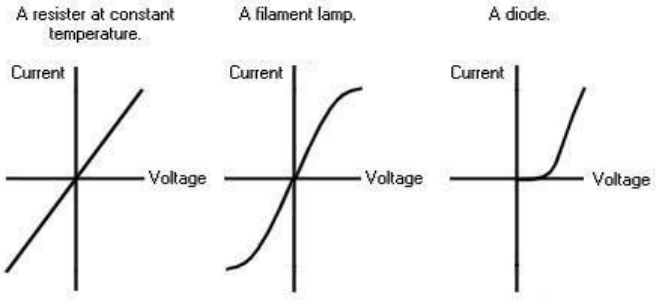
Potential difference V is measured in **volts (V where 1 V = 1 JC^{-1})** and is the **work done per unit charge** in moving **between two points** in a circuit.

- The potential difference is given by V=E/Q.
- It is measured with a **voltmeter** placed in **parallel** across the component.
- The higher the potential difference, the greater the current ($V = IR$).

Resistance

The **resistance** of a component is measured in **ohms (Ω)** and is given by the potential difference across it divided by the current through it, i.e. $R=V/I$. The greater the resistance, the harder it is for current to flow through the component.

In an **ohmic conductor** (such as a **resistor at a constant temperature**), the current is directly proportional to the voltage (i.e. it has constant resistance). In a non-ohmic conductor (such as a **filament lamp**), the resistance changes as the voltage and current changes.



In a filament lamp, this is because as the **current increases** through the filament, so does the **temperature,** which means **electrons and ions vibrate more** and **collide more, increasing resistance.**

A **thermistor** is a resistor whose resistance decreases as the **temperature** increases.
A **light dependent resistor** is a resistor whose resistance decreases as **light intensity** increases.

Electric circuits

Series:

- Components are connected **end to end** in one loop
- The **same current** flows through every component

- The **potential difference is shared** across each component - depending upon their resistance (i.e. the sum of the p.d.s across the components is equal to the total p.d. across the supply) - components with a higher resistance have a greater PD across.
- The total resistance in series is the **sum of the resistances** of each component $R_T = R_1 + R_2 \ldots$

Parallel:

- Components are connected to the power supply in **separate branches**
- The **current is shared** between each branch (i.e. the sum of the currents in the separate branches is equal to the current through the source) - because charge can only flow one way.
- The **potential difference** is the **same** across every branch
- Connecting lamps in parallel is advantageous because if one breaks, current can still pass through the rest.

Mains electricity

Dangers of electricity

Hazards:

- **Damaged insulation** – contact with the wire due to gaps in the insulation can cause an **electric shock** or pose a **fire hazard** by creating a short circuit.
- **Overheating of cables** – high currents passing through thin wire conductors cause the wires to heat up to very high temperatures which could **melt the insulation** and cause a **fire.**
- Damp conditions – water can conduct a current so wet electrical equipment can cause an **electric shock.**

Fuses and circuit breakers:

- A **fuse** is a thin piece of **wire** which overheats and **melts** if the **current is too high, protecting the circuit.** They have a current **rating** which should be slightly higher than the current used by the device in the circuit. The most common are 3A, 5A and 13A.
- **Circuit breakers** consist of an automatic **electromagnet** switch which **breaks the circuit** if the **current rises over a certain value.** This is better than a fuse as it can be **reset** and used again, and they operate **faster.**

Earthing metal cases:

- Earth wires create a **safe route** for current to flow through in the case of a **short circuit,** preventing electric shocks.
- Earth wires have a **very low resistance** so a strong current surges through them which breaks the fuse and disconnects the appliance.

Double insulation:

- Appliances with **double insulation** have either **plastic casings** completely covering their electrical components, or have been designed so that the earth wire **cannot touch** the metal casing, preventing them from giving an electric shock.

Electrical transfer of energy

Energy, measured in **joules (J)**, is transferred from **chemical** energy in the **battery** to **electrical** energy used by **circuit components** and then to the **surroundings.**

- The **power** of a component is measured in **watts (W)** and is given by P=IV (by using V=IR, this can be shown to be equivalent to $P=I^2R$ and $P=V^2/R$). Using this equation, the energy transferred is given by E=IVt.

Alternating current and direct current

In a **direct current,** the current only flows in **one direction** whereas in an **alternating current,** the current continuously **changes direction.**

Mains electricity is an alternating current (a.c.) whereas the current supplied by a **cell or battery** is direct current (d.c.).

Description	Symbol
Conductors crossing with no connection	
Junction of conductors	
Open switch	
Cell	
Battery of cells	
Power supply (DC)	
Power supply (AC)	
Transformer	
Ammeter	A
Voltmeter	V
Fixed resistor	
Variable resistor	

Description	Symbol
Heater	
Thermistor	
Light-dependent resistor (LDR)	
Diode	
Light-emitting diode (LED)	
Lamp	
Loudspeaker	
Microphone	
Electric bell	
Earth or ground	
Motor	M
Generator	G
Fuse/circuit breaker	

Electric charge

Charge is measured in coulombs, C. There are **positive** and **negative** charges; **opposite** charges **attract** and **like** charges **repel.**

- Atoms are composed of protons, electrons and neutrons. Protons have a charge of **+1**, electrons have a charge of **-1** and neutrons have a charge of **0**.
- Charging a body involves the **addition** or **removal** of **electrons -** charging atoms creates ions.
- **Conductors** such as **metals** allow electrons to flow through them whereas **insulators** such as **plastics** impede the flow of electrons.
    - When two insulators are **rubbed** together, friction causes electrons to move from one to the other and they become charged. The material that loses electrons becomes **positively charged** and the material that gains electrons becomes **negatively charged**.
    - The **magnitude** of the charge on each material is equal, since they lose/gain the **same number** of electrons.
    - For example, when a **rod** is rubbed with a **cloth,** electrons are transferred from the rod onto the cloth and the rod becomes positively charged.

The charges cannot move within the insulator so they build up - this is known as **static electricity**.

Consequences of static electricity can be seen in a number of phenomena.

- Lightning:
    - Electrostatic charge can build up on clouds due to **friction**.
    - When this charge becomes large enough, the clouds **discharge** through the air to the earth. This results in **lightning**.
- Charged balloon on a wall:
    - A positively charged balloon will stick to a wall if moved close enough.
    - Positive charges in the wall are **repelled by the balloon** and move to other parts of the wall. This leaves a **negative charge** on the area of the wall closest to the balloon.
    - The **attraction** between the **negatively charged wall** and the **positively charged balloon** makes the balloon stick.
- Comb picking up bits of paper:
    - Rubbing a comb against an **insulator** will cause it to pick up an electrostatic charge due to the **transfer of electrons**.
    - The charge on the comb **repels** like-charged in the paper, leaving the paper closest to the comb with an electrostatic charge **opposite to the comb**.
    - This end of the paper is then **attracted** to the comb.

Electrostatic phenomena caused by the movement of electrons have many useful applications but also pose many risks.

- Dangers of electrostatic charges include:
    - Static charges pose a risk of **electric shock**. If a person touches an object with a large amount of static charge, electrons will flow through the person's body to the **earth**.
    - When **fuelling aircraft and tankers,** if enough charge builds up on the vehicle or pump it can create a **spark.** This can ignite the fuel and cause a **fire or explosion.** For safety, an *earthing* wire can be attached so that the charge instead flows into the earth.
- Safety measures when using electrostatic charges include:
    - **Earthing** involves offering electrons an **alternative pathway** to the earth.

- This prevents too much electrostatic charge form **building up** on the surface of an insulator. Less electrostatic charge **reduces the risk** of electric shock, or the harm it can cause.

- Uses of electrostatic charges include:
  - In an **inkjet printer,** droplets of **ink** are **charged** and pass between **two charged metal plates,** one of which has a positive charge and the other a negative charge. The droplets are attracted to the plate with the opposite charge and repelled by the plate with the same charge and **deflected** towards a specific place on the paper.

  - In a **photocopier,** the image of a document is projected onto a **positively charged plate;** where light falls onto the plate, the charge leaks away. **Negatively charged toner particles** are attracted to the remaining positive areas. Paper is then placed over the plate and the toner is transferred to it, making the photocopy.