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Physics Topic P4
Particles at Work – Electric circuits

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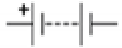
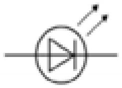
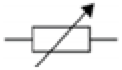
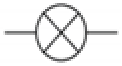
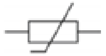
Section 1: Circuit Symbols

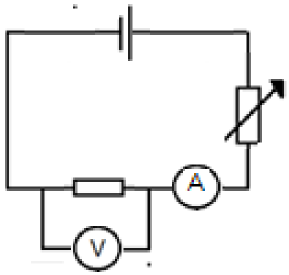
Symbol	Name	Function
	**Switch (open)**	Enables current to be switched on or off.
	**Cell**	Pushes electrons around a complete circuit.
	**Battery**	Supplies electrical energy, consists of two or more cells.
	**Diode**	Allows current in one direction only.
	**LED**	Light emitting diode emits light when a current passes through it in the correct direction.
	**Resistor**	Limits the current in a circuit.
	**Variable resistor**	Allows current to be varied.
	**Bulb**	Emits light as a signal when a current passes through it.
	**Fuse**	Breaks the circuit if current exceeds a certain amount.
	**Voltmeter**	Measures potential difference (voltage).
	**Ammeter**	Measures electric current.
	**Thermistor**	Temperature dependent resistor. Has high resistance when temperature is low.
	**LDR**	A light dependent resistor. Has high resistance when levels of light are low.

Section 2: Key Terms

Electric current	**Flow** of electric **charge**. Units amperes, A
Potential difference	The potential difference (**voltage**) between two points in an electric circuit is the energy transferred (or the work done) when a coulomb of charge passes between the points. Units volt, V
Resistance	Resistance is caused by anything that **opposes the flow of electric charge**. Units ohm, Ω
Charge	Anything **charged** that is **able to move within a circuit**. Electrons or ions. Units are coulombs, C
Series	A circuit with only **one route for charge to take**. The different components are connected in a line, end to end.
Parallel	A circuit with **more than one route for charge to take**. Each component **separately connected** to the +ve and –ve terminals.

Section 3: The standard test circuit

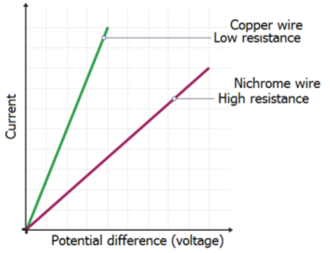
The standard test circuit is used to test components and determine the resistance of a component. By measuring the current through and potential difference across the component, the resistance can then be calculated and IV graphs obtained.

Standard test circuit		The **Ammeter** must be in **series** and placed **anywhere** in the **circuit**. The **voltmeter** must be placed in **parallel around** the **component** (so that it can compare the energy the charge has before and after passing through the component).

Section 4: Current-potential difference graphs

Increasing or decreasing the **potential difference** of the circuit will affect the current. Plotting current-potential difference results for different wires tells us about the resistance of these wires.

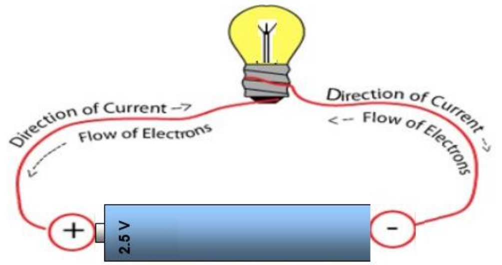
The **steeper the line**, **the lower the resistance** of the wire.



Section 5: Factors affecting resistance of a wire

Length of wire	The resistance of a wire is affected by length. Resistance of a **long wire is greater** than the resistance of a **short wire** because electrons collide with more metallic nuclei as they pass through.
Thickness of wire	The resistance of a **thin wire is greater** than the resistance of **a thick wire** because a thin wire has fewer electrons to carry the current.
Temperature	As **temperature increases** the metal nuclei begin to vibrate more. The electrons will have more chance of colliding and so **resistance increases**.

Electrical **current** is **NOT** the flow of electrons, it's the **flow of electric charge**, and as charge can be positive or negative then naturally **current** is in the **direction** of positive charge flow, and in the **opposite direction** to negative charge flow.



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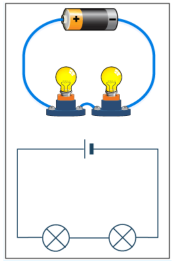
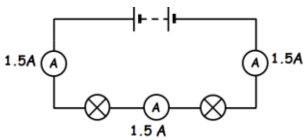
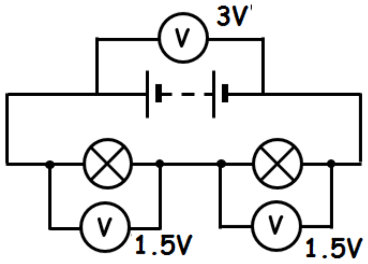
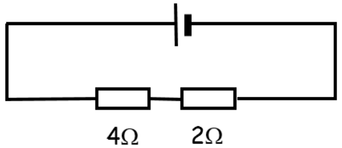
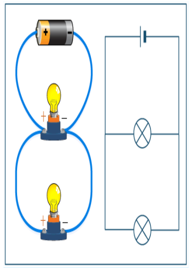
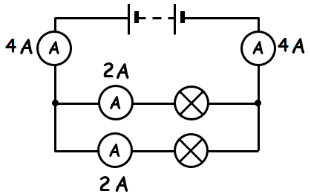
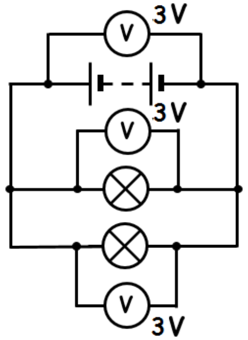
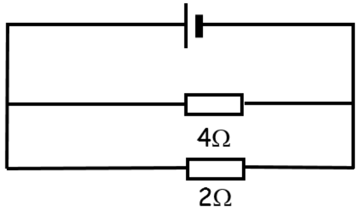
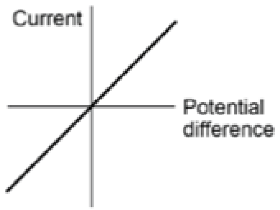
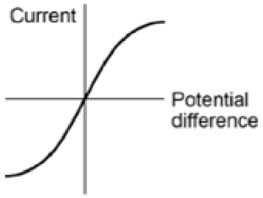
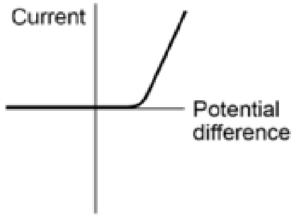
Section 6: V, I and R in Series and Parallel

Components connected in…	Current	Potential Difference	Resistance
Series 	The **current** is the **same everywhere** in the circuit and in every component. 	The total **potential difference** of the power supply is **shared** between the components. 	The **total resistance** is the **sum** of the **individual resistances**. $R_{total} = R_1 + R_2$ Adding **more resistors increases resistance.**  Total resistance = 6 Ω
Parallel 	The **total current** through the whole circuit is the **sum** of the **currents** through **the separate components.** 	The **potential difference** across each component is the **same.** 	The **total resistance** of **two resistors** is **less** than the **resistance** of the **smallest** individual **resistor.**  The **total resistance** for this circuit is **less than 2Ω** (the resistance of the smallest resistor). Resistance **decreases** as **more resistors** are added.

Section 7: IV Graphs

Graph	Example	Explanation
	**Ohmic conductor** (Fixed resistor or wire)	**Fixed Resistor or wires are Ohmic Conductors.** Current and potential difference are **directly proportional. Resistance is constant.**
	Filament Lamp (bulb) **non** Ohmic conductors	Resistance of a filament lamp is **not constant.** As temperature increases, resistance increases. **Ions** within the lamp **vibrate more**, increasing **collisions** with **electrons.**
	**Diode** or LED	**Diode/LED** The **current** through a diode/LED flows in **one direction only.** The diode has a **very high resistance in the reverse direction.**

Section 8: Equations to learn

Charge = current x time Q = I x t	Charge flow - coulomb (C) Current – amperes (A) Time – seconds (s)
Potential difference = current x resistance V = I x R	Potential difference – volts (V) Current – amperes (A) Resistance – ohms (Ω)
Energy transferred = charge x potential difference E = Q x V	Energy = joules (J) Charge flow - coulomb (C) Potential difference – volts (V)

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Particles at Work – Static Electricity (triple)

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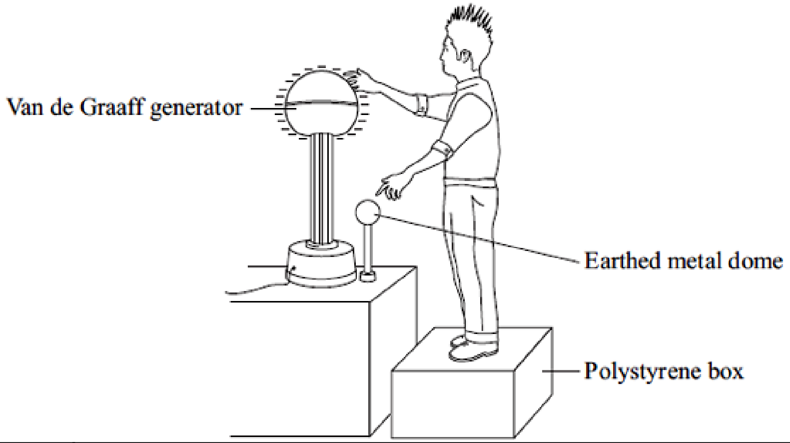
Section 9: Static electricity

Static electricity is all about charges which are **not free to move**. This causes them to build up in one place which leads to **sparks** or **shocks** when they finally do move.

Build up of **static** is caused by **friction**	When **two insulating materials** are **rubbed together**, **electrons are scraped off** one and dumped on the other. This leaves a **positive static charge** on one, and a **negative** static charge on the other.
Only electrons move	When electrons (negatively charged particles) move, ions form. **Both positive and negative electrostatic charges form** as a result.
Positive charges don't move	A positive charge is always caused by **electrons being removed** (so the positive charges don't move!)
Like charges repel	Two things with the **same charge** will **repel** each other.

Van de Graff Generator



When the Van de Graaff generator is switched on, **each hair gains** the **same negative charge**. Similar **charges repel** so the students **hair stands on end**.

Examples of **static electricity**

- **Attracting dust**: many objects around a house are insulating materials and get easily charged. Dust particles are attracted to anything that's charged (TV screen, glass, plastic etc.)
- **Clinging clothes and crackles**: When synthetic clothes are dragged over each other (in tumble drier or over your head) electrons get scraped off leaving static electricity.
- **Bad hair days**: Static builds up on hair, each strand having the same charge, so they repel each other.

Section 10: Key Terms

Static electricity	It's the movement of electrons from one insulator to another. The insulator that loses electrons becomes positively charged and the insulator that gains the electrons becomes negatively charged
Insulator	An electrical insulator does not easily allow electricity to pass through it.
Earthing	Connecting a charged object to the ground using a conductor (e.g. copper wire) prevents build up of charge.

Section 11: Dangers

Lightning	Lightning is a sudden electrostatic discharge that usually occurs during a thunderstorm. This occurs between electrically charged regions of a cloud, between two clouds, or between a cloud and the ground.
Synthetic clothes	Static charge can build up on synthetic materials if they are rubbed against each other. The charge can eventually build up large enough to cause a spark, dangerous if close to flammable gases or fuel fumes.
Grain chutes, paper rollers, fuel pipes	Static can build up when grain shoots out of pipes/paper drags over rollers/fuel flows out of filler pipes. Can lead to a spark which might cause an explosion in dusty or fumey places (like petrol station)
The solution to the problem	Earthing of objects prevents build up of static charge. Earthing cables can be attached to prevent sparks. Conducting soles in shoes prevent static electricity from building up hence preventing you getting a shock.

Section 12: Uses

Electrostatic paint sprayers	Used to paint bikes and cars providing a fine even coat.
Defibrillator	A shock from a defibrillator can restore normal heart rhythm. Consists of two paddles connected to a power supply which are placed on the patients chest. The charge passes through the paddles to the patient which makes the heart contract.