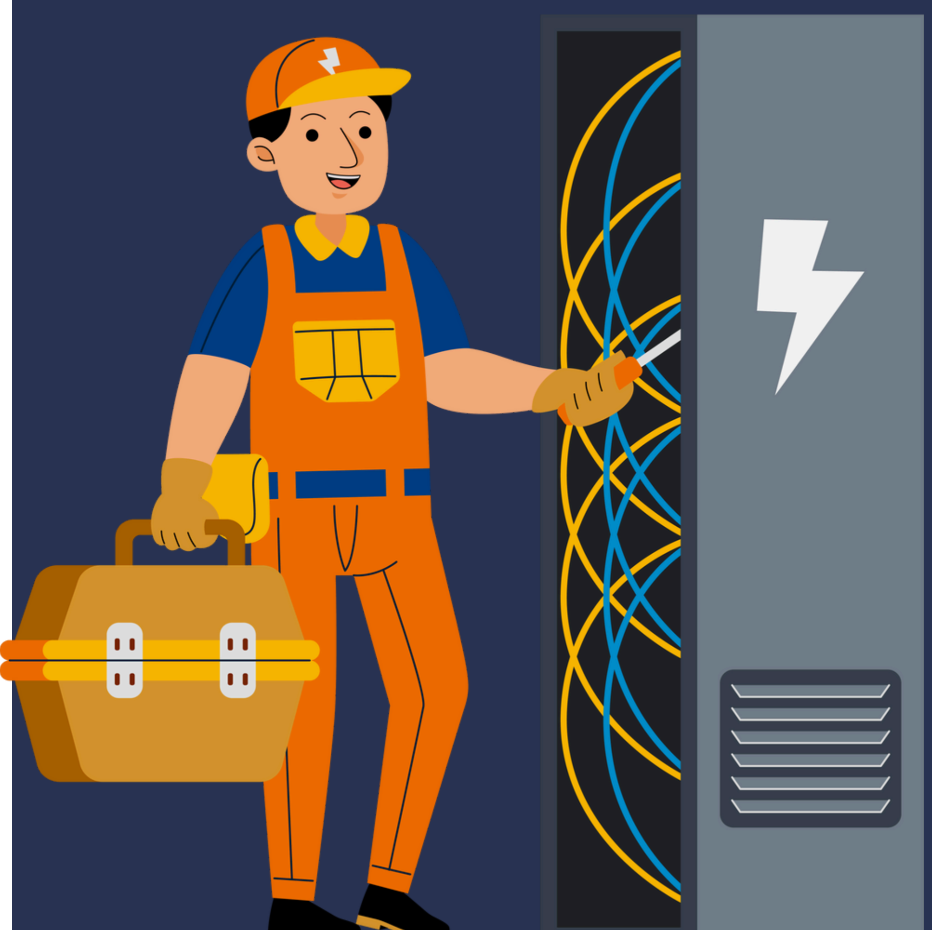
Educate Cloud

GCSE PHYSICS

ELECTRICITY UNIT AQA UNIT



CHECKLIST

AQA GCSE Physics **Topic Checklists**

4.2 Electricity

4.2.1 Current, Potential Difference and Resistance				
Topic	**Success Criteria**	**Progress**		
Standard Circuit Diagram Symbols	I can recognise and draw the standard symbols for: • switch (open) • switch (closed) • cell • battery • diode • resistor • variable resistor • LED • lamp • fuse • voltmeter • ammeter • thermistor • LDR			
	I can draw and interpret circuit diagrams.			
Electrical Charge and Current	I can state what is needed for electrical charge to flow in a circuit.			
	I can give a definition for electric current and describe what its size tells us about electrical charge.			
	I can recall and apply the correct equation to calculate charge flow.			
	I can rearrange the equation linking charge flow, current and time to calculate current or time.			
	I can compare the value of the current at any point in a single closed loop.			
Current, Resistance and Potential Difference	I can describe how the resistance and potential difference affect the current through a component.			
	I can recall and apply the correct equation to calculate the potential difference across a component.			
	I can rearrange the equation linking current, potential difference and resistance to calculate current or resistance.			
	I can use circuit diagrams to set up and check appropriate circuits to investigate the factors affecting the resistance of electrical circuits (required practical activity 3).			

CHECKLIST

Topic	Success Criteria	Progress		
	I can describe how the current through an ohmic conductor is related to the potential difference across the resistor.			
	I can describe what happens to the resistance of an ohmic conductor as the current through it changes.			
	I can describe how the current through a filament lamp is related to the potential difference across the resistor.			
	I can describe what happens to the resistance of a filament lamp as the temperature of the filament increases.			
	I can represent the relationship between the current through a diode and the potential difference across the resistor on a graph.			
	I can describe how the current flows through a diode.			
	I can describe what happens to the resistance of a diode when current flows in the reverse direction.			
	I can describe how the resistance of a thermistor changes as the temperature increases.			
Resistors	I can describe how thermistors can be used to control a circuit.			
	I can explain how the resistance of an LDR changes as light intensity changes.			
	I can describe how LDRs can be used to control a circuit.			
	I can explain the design and use of a circuit to measure the resistance of a component by measuring current through, and potential difference across, a component.			
	I can recognise and draw graphs that represent the relationship between the current and potential difference for: • an ohmic conductor; • a filament lamp; • a diode.			
	I can use circuit diagrams to construct appropriate circuits to investigate the I-V characteristics of a variety of circuit elements, including a filament lamp, a diode and a resistor at constant temperature (required practical activity 4).			

CHECKLIST

4.2.2 Series and Parallel Circuits				
Topic	**Success Criteria**	**Progress**		
Series and Parallel Circuits	I can state the two ways of joining electrical components in a circuit.			
	I can describe the current through components connected in series.			
	I can describe the potential difference across components connected in series.			
	I can describe the total resistance of two components connected in series and represent this as an equation.			
	I can describe the potential difference across components connected in parallel.			
	I can describe the current through components connected in parallel.			
	I can describe the total resistance of two components connected in parallel.			
	I can use circuit diagrams to construct and check series and parallel circuits that include a variety of common circuit components.			
	I can describe the difference between series and parallel circuits.			
	I can explain qualitatively why adding resistors in series increases the total resistance while adding resistors in parallel decreases the total resistance.			
	I can explain the design and use of dc circuits for measurement and testing purposes.			
	I can calculate the currents, potential differences and resistances in dc series circuits.			
	I can solve problems for circuits which include resistors in series using the concept of equivalent resistance.			

CHECKLIST

4.2.3 Domestic Uses and Safety

Topic	Success Criteria	Progress		
Direct and Alternating Potential Difference	I can state whether mains electricity is an ac or dc supply.			
	I can recall the frequency of the UK mains electricity supply.			
	I can recall the potential difference of the UK mains electricity supply.			
	I can explain the difference between direct and alternating potential difference.			
Mains Electricity	I can recall the colour of the live wire in a three-core cable.			
	I can recall the colour of the neutral wire in a three-core cable.			
	I can recall the colour of the earth wire in a three-core cable.			
	I can state the purpose of the live wire.			
	I can state the purpose of the neutral wire.			
	I can state the purpose of the earth wire.			
	I can recall the potential difference between the live wire and earth.			
	I can explain that a live wire may be dangerous even when a switch in the mains circuit is open.			
	I can solve problems for circuits which include resistors in series using the concept of equivalent resistance.			

CHECKLIST

4.2.4 Energy Transfers				
Topic	**Success Criteria**	**Progress**		
Power	I can explain how the power transfer in a circuit device is related to the potential difference across it and the current through it.			
	I can recall and apply the equation linking current, potential difference and power to calculate the power transfer in a circuit device.			
	I can rearrange the equation linking current, potential difference and power to calculate the current or potential difference in a circuit device.			
	I can recall and apply the equation linking current, power and resistance to calculate the power transfer in a circuit device.			
	I can rearrange the equation linking current, power and resistance to calculate current or resistance in a circuit device.			
Energy Transfers in Everyday Appliances	I can explain how the power transfer in a circuit device is related to the energy transferred over a given time.			
	I can describe what affects the amount of energy an appliance transfers.			
	I can describe how different domestic appliances transfer energy from batteries or ac mains to electric motors or heating devices.			
	I can describe how charge causes work to be done in a circuit.			
	I can recall and apply the equation linking energy transferred, power and time to calculate the amount of energy transferred by electrical work.			
	I can rearrange the equation linking energy transferred, power and time to calculate the power or time.			
	I can recall and apply the equation linking charge flow, energy transferred and potential difference to calculate the amount of energy transferred by electrical work.			
	I can rearrange the equation linking charge flow, energy transferred and potential difference to calculate the charge flow or potential difference.			
	I can describe, with examples, the relationship between power ratings for domestic electrical appliances and the changes in stored energy when they are in use.			

CHECKLIST

Topic	Success Criteria	Progress		
The National Grid	I can name the parts that make up the National Grid.			
	I can describe the purpose of the National Grid.			
	I can explain the purpose of step-up transformers.			
	I can explain the purpose of step-down transformers.			
	I can explain why the National Grid system is an efficient way to transfer energy.			

4.2.5 Static Electricity				
Topic	**Success Criteria**	**Progress**		
Static Charge	I can describe how some insulating materials can become electrically charged.			
	I can describe evidence that charged objects exert forces of attraction or repulsion on one another when not in contact.			
	I can explain how the transfer of electrons between objects can explain the phenomena of static electricity.			
Electric Fields	I can explain the concept of an electric field.			
	I can describe how the strength of an electric field around a charged object varies with distance from the object.			
	I can describe what happens to a second charged object placed in the electric field created around the initial charged object.			
	I can draw the electric field pattern for an isolated charged sphere.			
	I can explain how the concept of an electric field helps to explain the non-contact force between charged objects as well as other electrostatic phenomena such as sparking.			

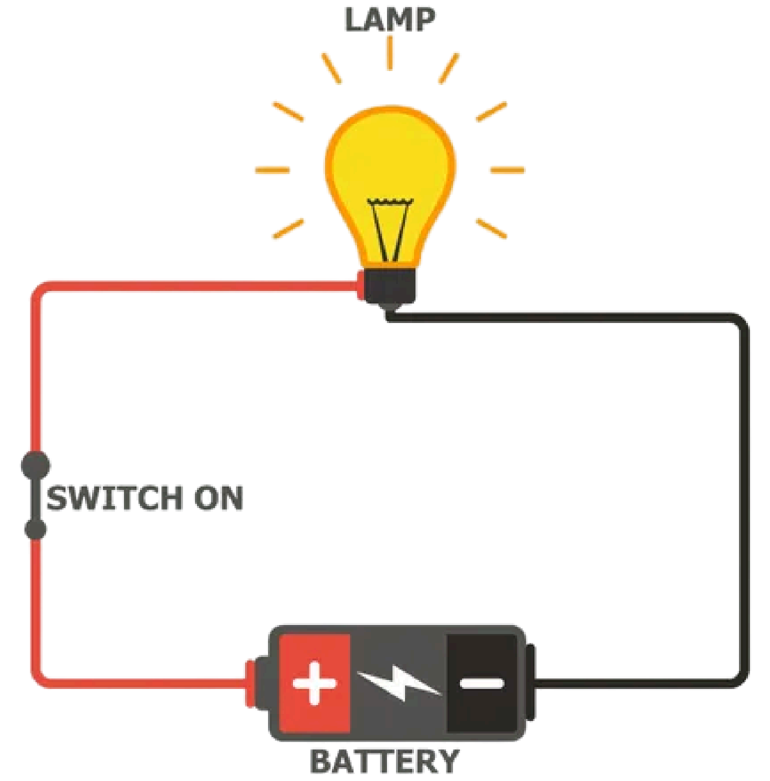
INTRODUCTION TO ELECTRICITY

Electricity is the flow of charge through a conductor. It involves the movement of electrons in a circuit.

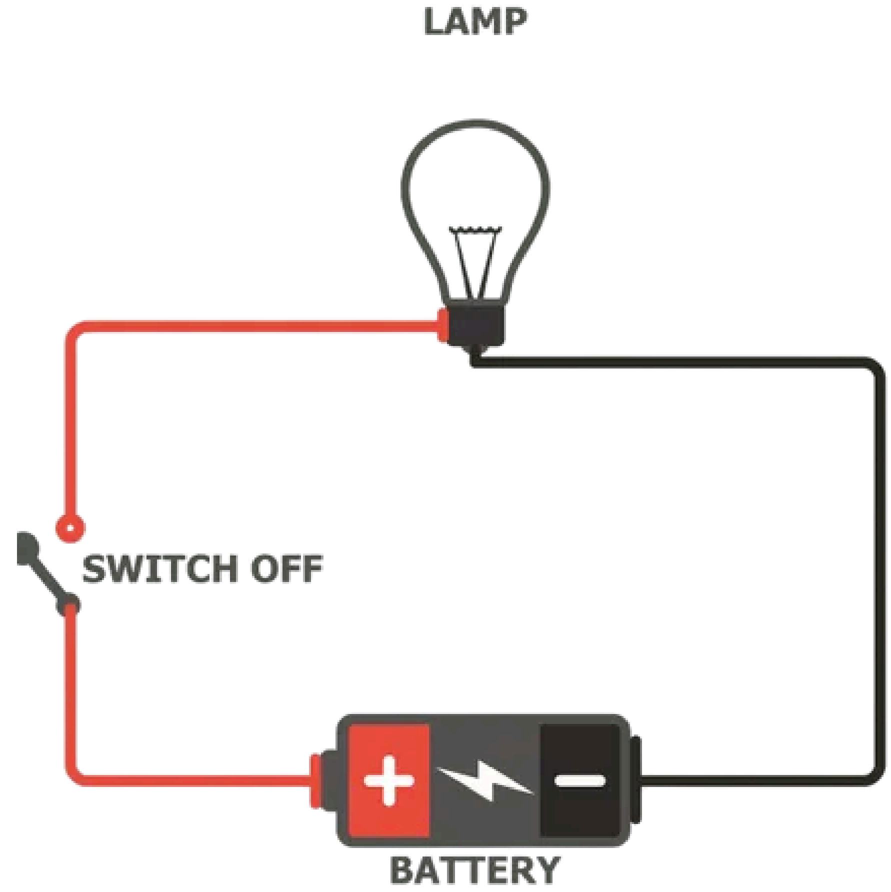
Key concepts: charge, current, potential difference (voltage), and resistance.

Closed Circuit

A closed circuit is like a full circle. Everything is connected, so electricity can run around the circle without stopping.



Closed Circuit

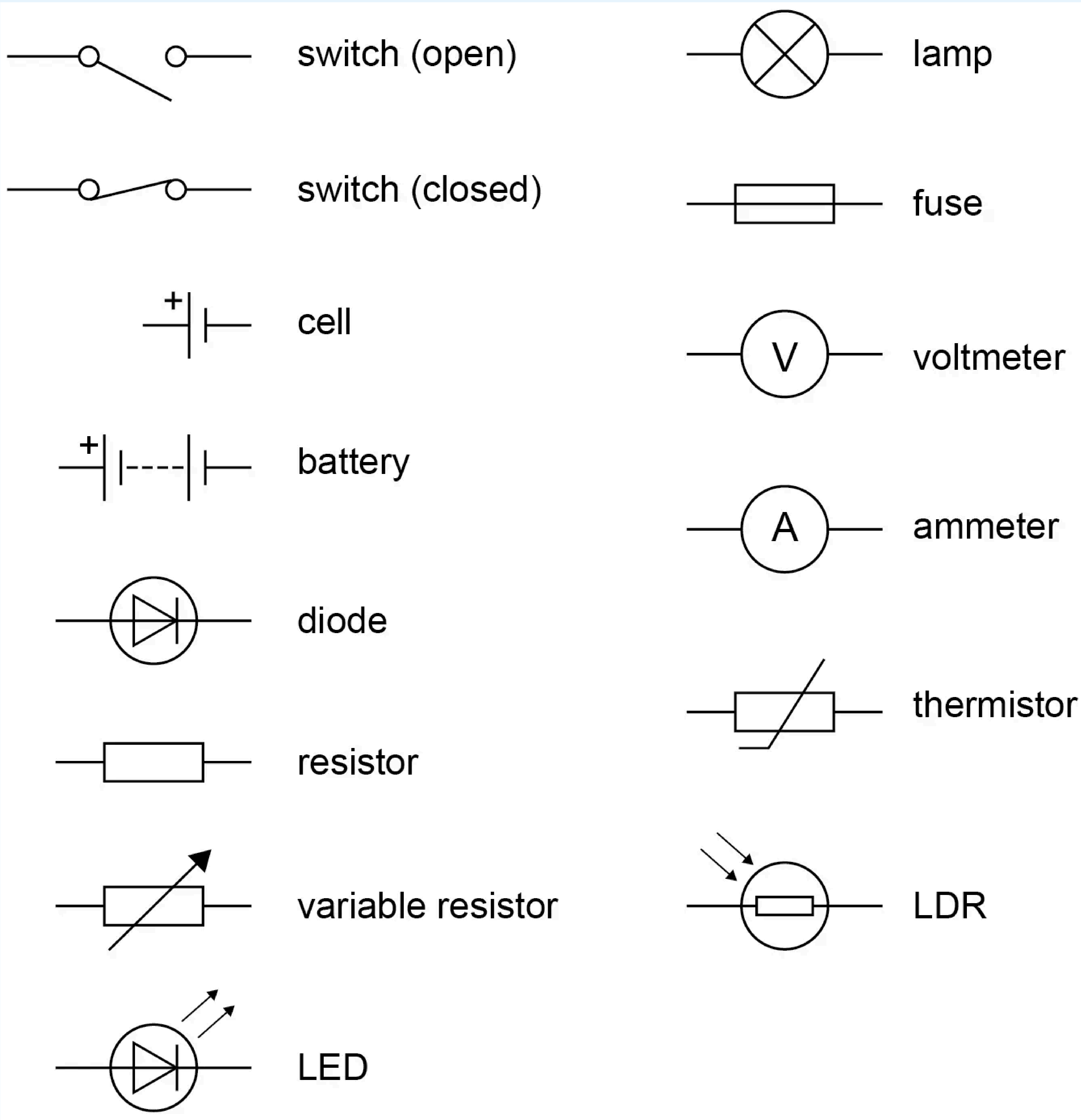


Open Circuit

Open Circuit

An open circuit is a broken loop where electricity cannot flow..

CIRCUIT SYMBOLS YOU MUST LEARN



WHAT IS ELECTRIC CHARGE?

Charge

Charge is a property of matter that causes it to experience a force when placed in an electric and magnetic field. Charges can be positive or negative.
Measured in Coulombs (C).

Every object is made of atoms containing protons, neutrons, and electrons.

- **Protons → positive charge**
- **Electrons → negative charge**
- **Neutrons → no charge**

In a neutral object:

- Number of protons = number of electrons → charges cancel.

<u>How objects become charged:</u>

Objects become charged ONLY when electrons are transferred.

- If an object loses electrons, it becomes positively charged.
- If it gains electrons, it becomes negatively charged.

Important: Positive charge never “moves.”

- Only electrons move. Protons stay fixed inside the nucleus.

ELECTRIC CURRENT

Electric Current

Current is the rate at which charge flows through a conductor.
Measured in Amperes (A)

Charge flow = current × time

$$Q = I\,t$$

Formula relating current and voltage

$$I = \frac{V}{R}$$

Where:

- I = current (amperes, A)
- V = voltage (volts, V)
- R = resistance (ohms, Ω)

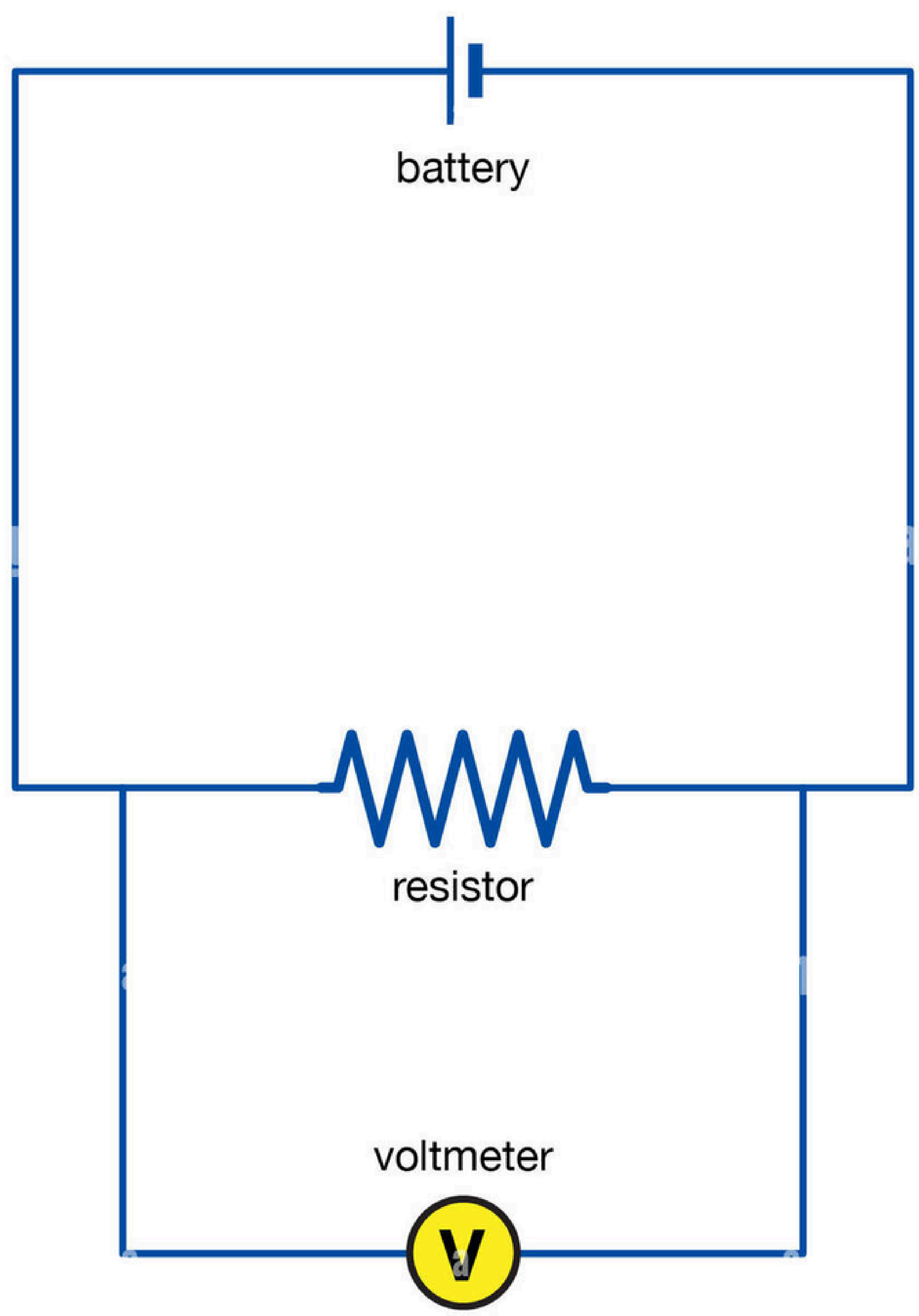
POTENTIAL DIFFERENCE (VOLTAGE)

Potential Difference

Potential difference is the work needed to move a unit charge between two points in a circuit.
Voltage is the energy per unit charge.
Measured in Volts (V).

Formula:

$$V = \frac{W}{Q}$$



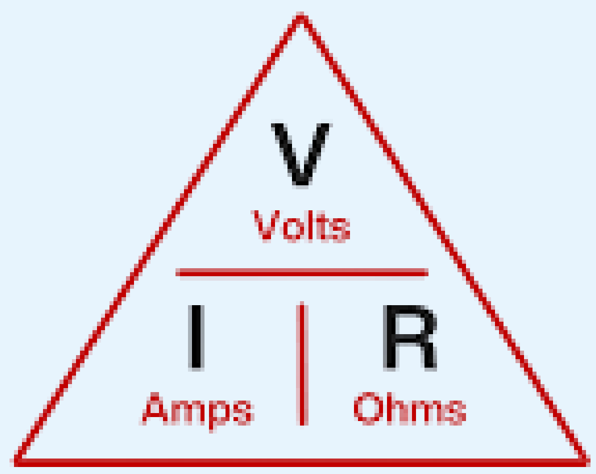
RESISTANCE

Resistance

Resistance determines how **easily** current flows through a material**.** It is the **opposition** to the flow of **electric current.** The resistance of a circuit can be increased by adding resistors (or variable resistors)to it. Every electrical component has a resistance, even wires

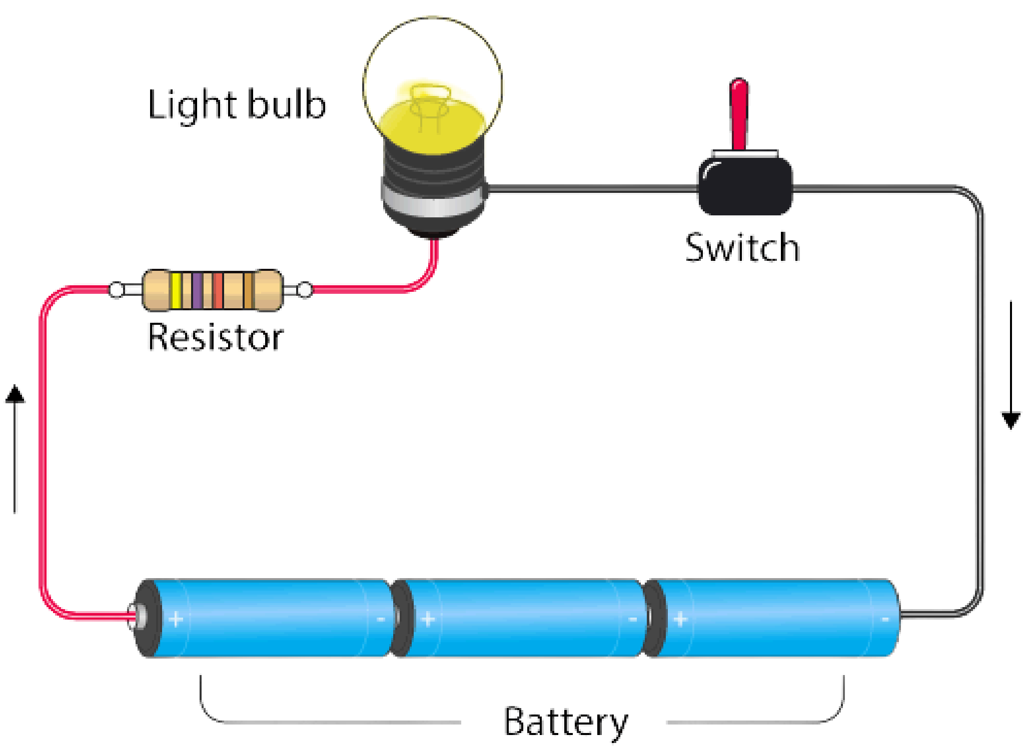
Measured in **Ohms (Ω).**

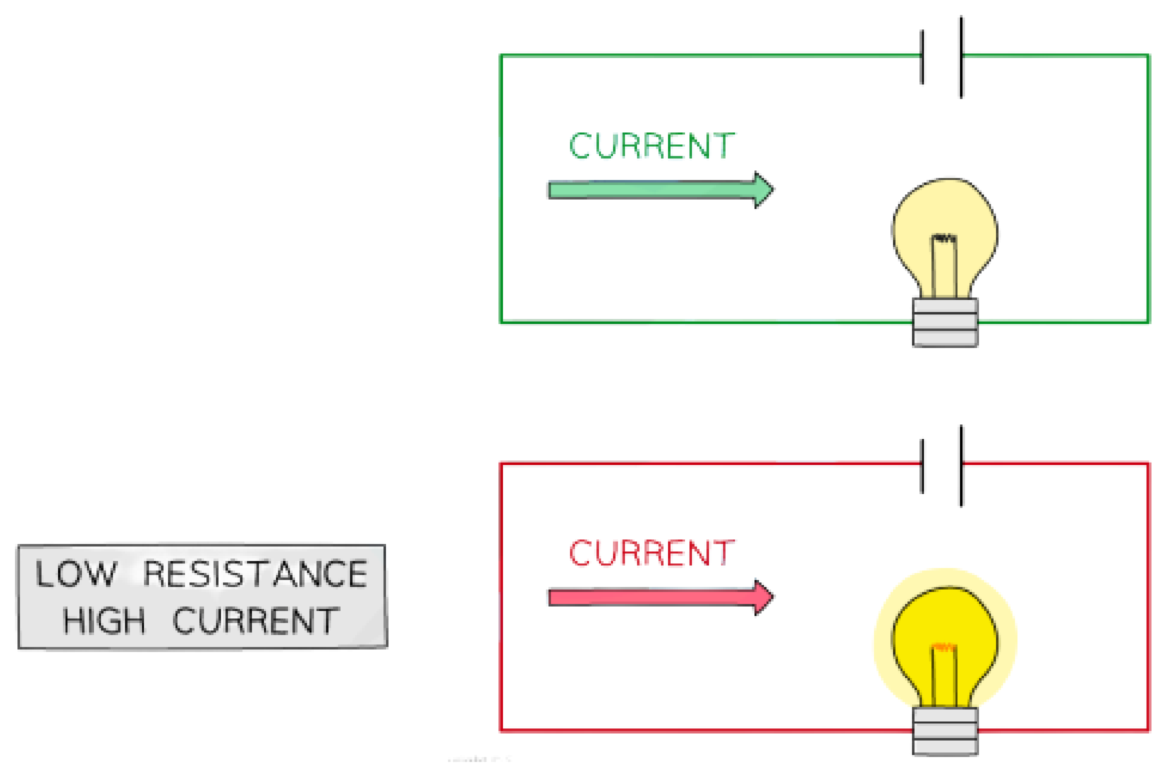
Formula:



$$R = \frac{V}{I}$$

Ohms = Volts ÷ Amps

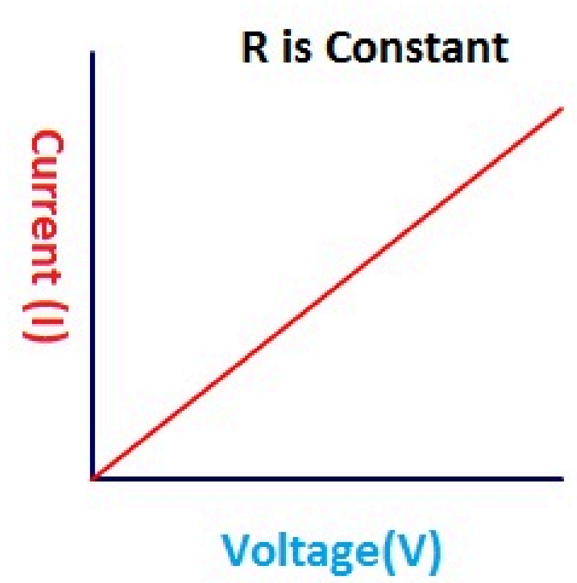




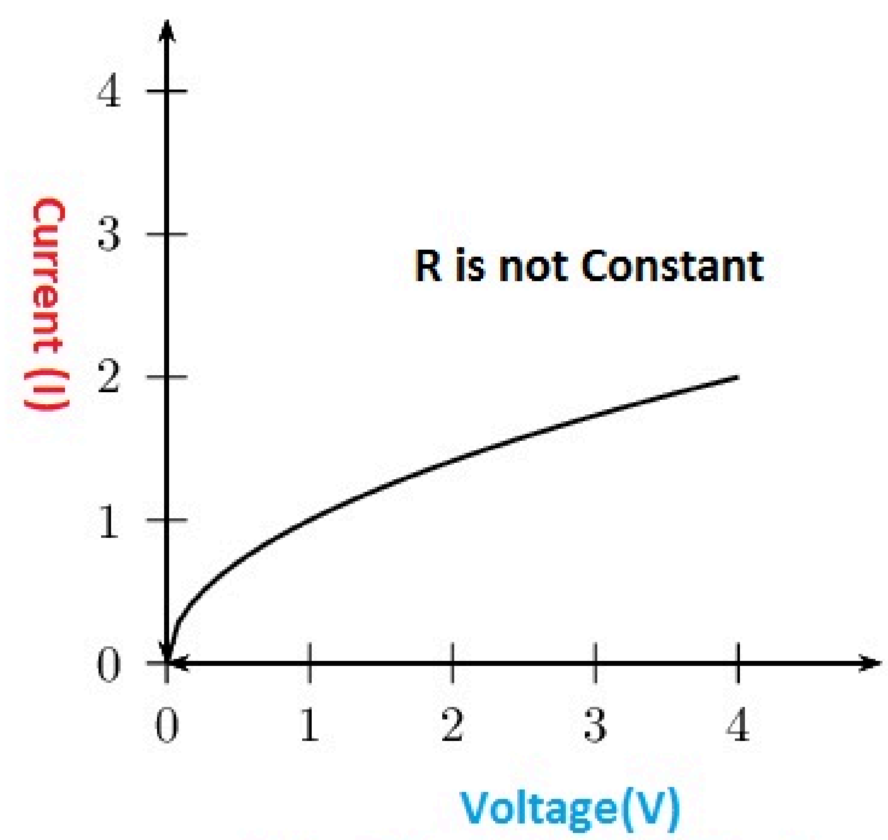
- The current through a component depends on both the resistance R of the component and the potential difference V across the component.
- The greater the resistance R of the component, the lower the current I for a given potential difference V across the component.
- The lower the resistance R of the component, the greater the current I for a given potential difference V across the component

OHM'S LAW

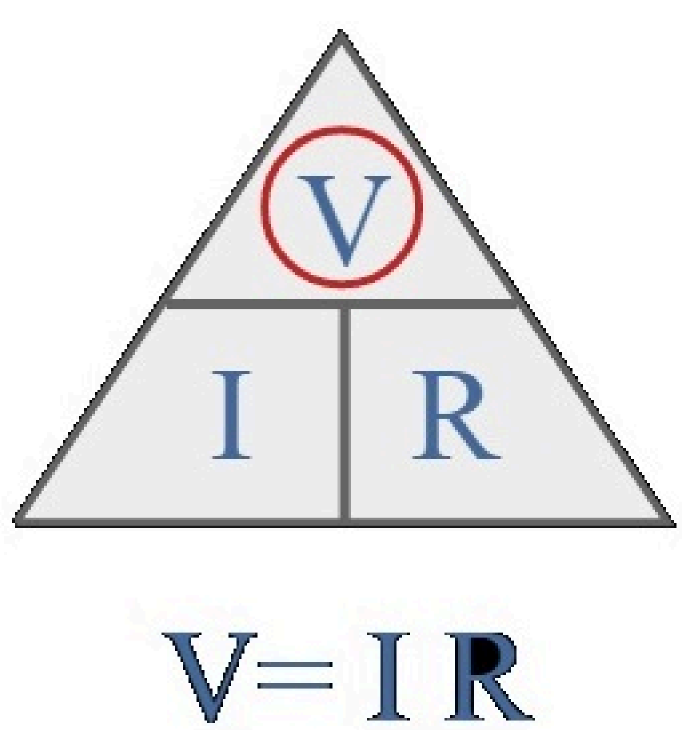
Ohm's Law states that the current through a conductor is directly proportional to the potential difference and inversely proportional to the resistance.



Ohmic Devices Graph



Non-Ohmic Devices Graph

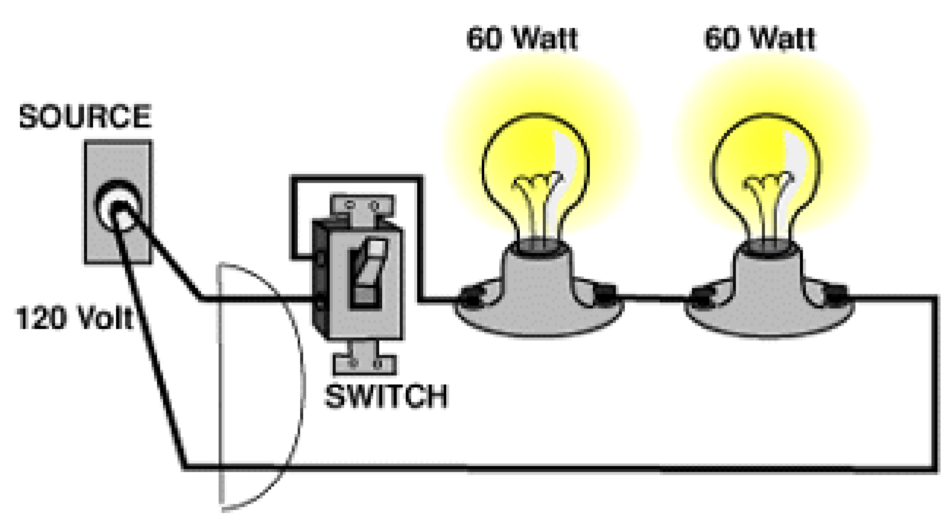


Where:

- I = current (amperes, A)
- V = voltage (volts, V)
- R = resistance (ohms, Ω)

SERIES CIRCUITS

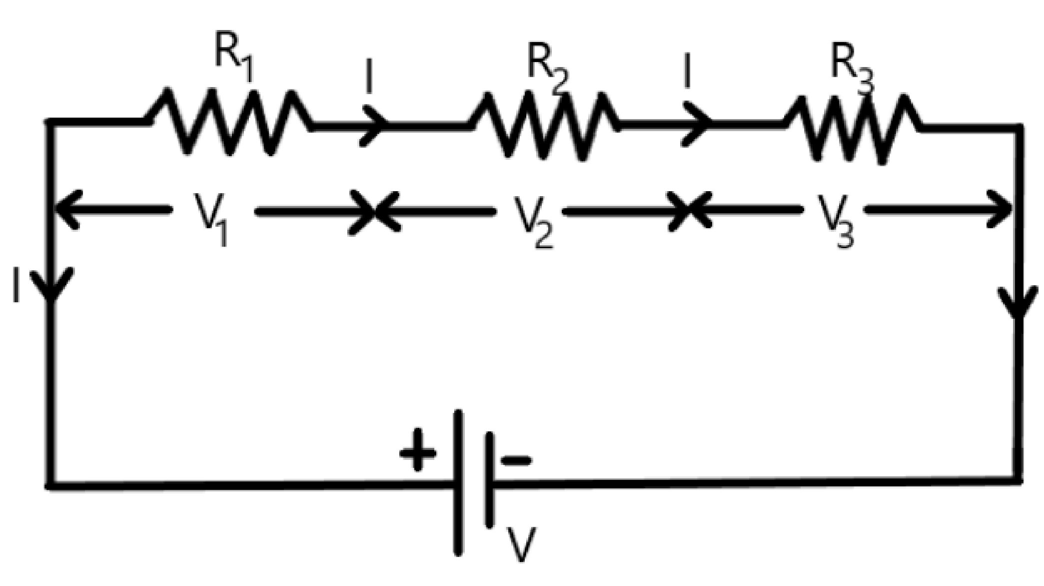
- A **series circuit** is a circuit where **components are connected end to end**, so the **current flows** through each component **one after the other.**
- **Current** is the **same** at **all points** in a series circuit.
- **Voltage** is **shared** among the **components**.
- The **total voltage** is the sum of the **individual voltages** across **each component**.



- In a **series** circuit, **resistors** are **connected end-to-end,** so the current has to pass through **each resistor** one after the other.
- In a **series circuit**, the total resistance is the sum of the individual resistances.
- **Formula**:

$$R_T = R_1 + R_2$$

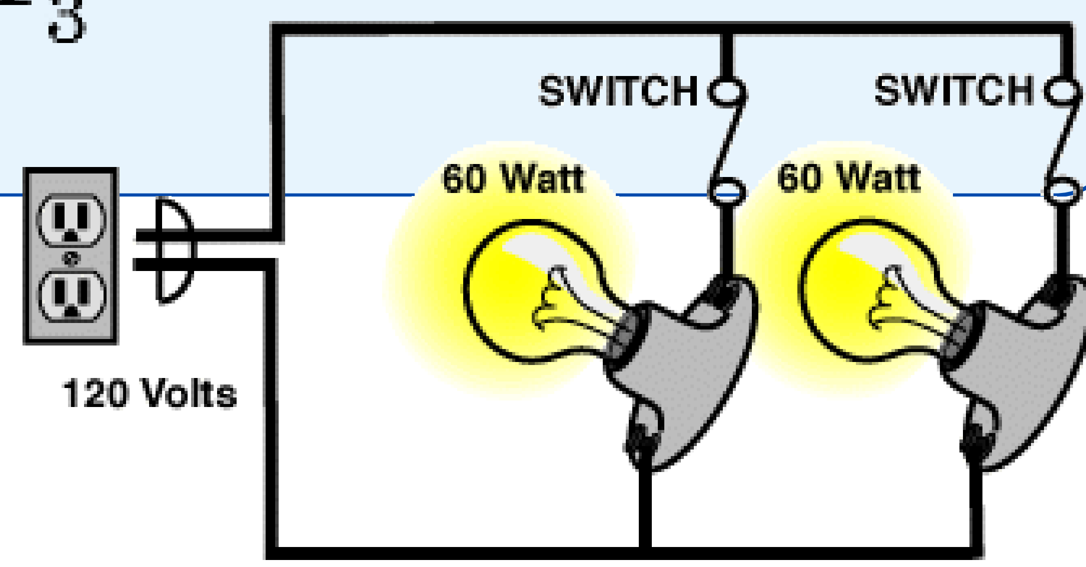
Series circuit



PARALLEL CIRCUITS

- A parallel circuit is one where components are connected along separate branches. Each branch gets the same voltage but may carry different amounts of current.
- Current splits at junctions.
- The total current is the sum of the currents through the individual components.
- **Formula:**

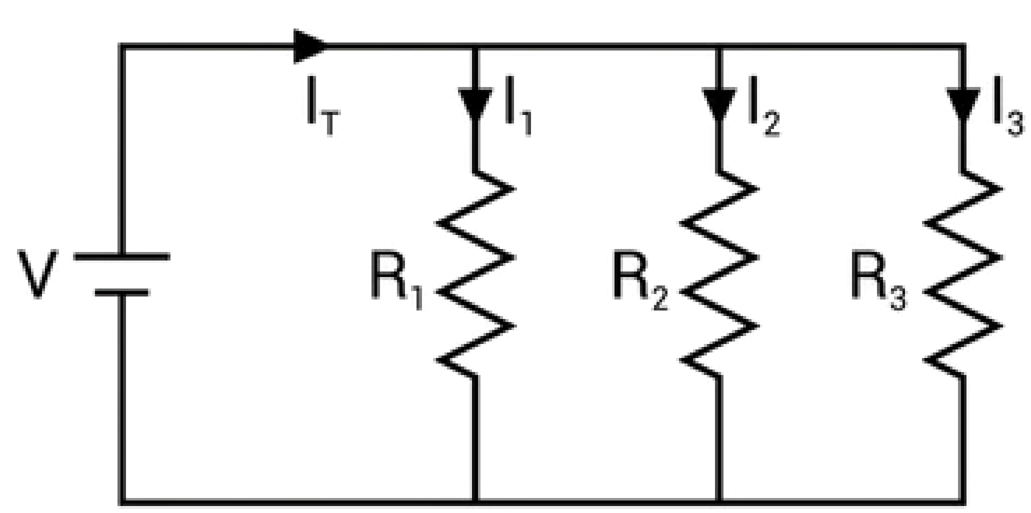
$$I_{total} = I_1 + I_2 + I_3$$



- In a parallel circuit, resistors are connected across the same two points, creating multiple paths for the current.
- **Formula for total resistance in parallel:**

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

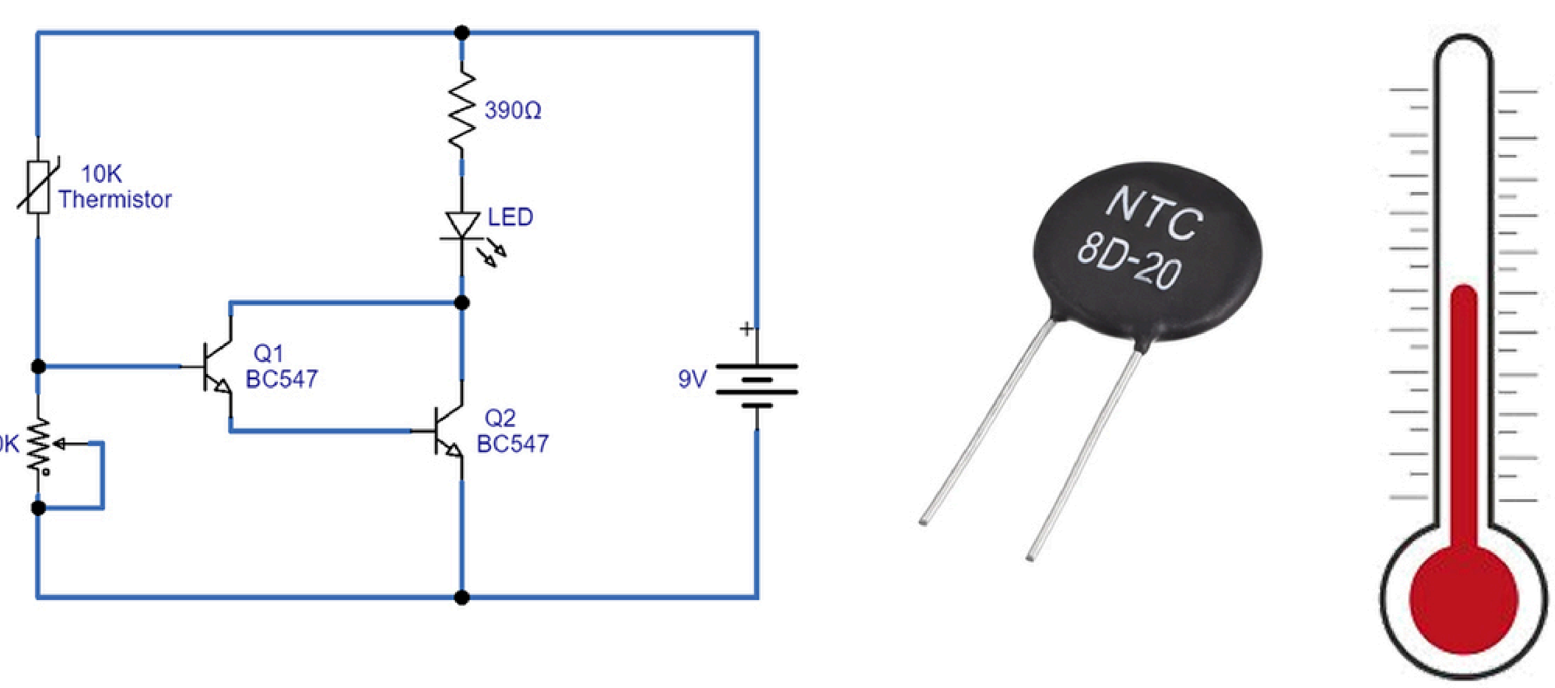
Adding more resistors in parallel creates additional paths for the current to flow, which reduces the overall resistance.



THERMISTORS

- A thermistor is a temperature-dependent resistor, commonly used in circuits where the temperature needs to be monitored or controlled.
- Negative Temperature Coefficient (NTC) thermistors decrease in resistance as temperature increases.
- Positive Temperature Coefficient (PTC) thermistors increase in resistance as temperature increases.

Temperature Sensor Circuit



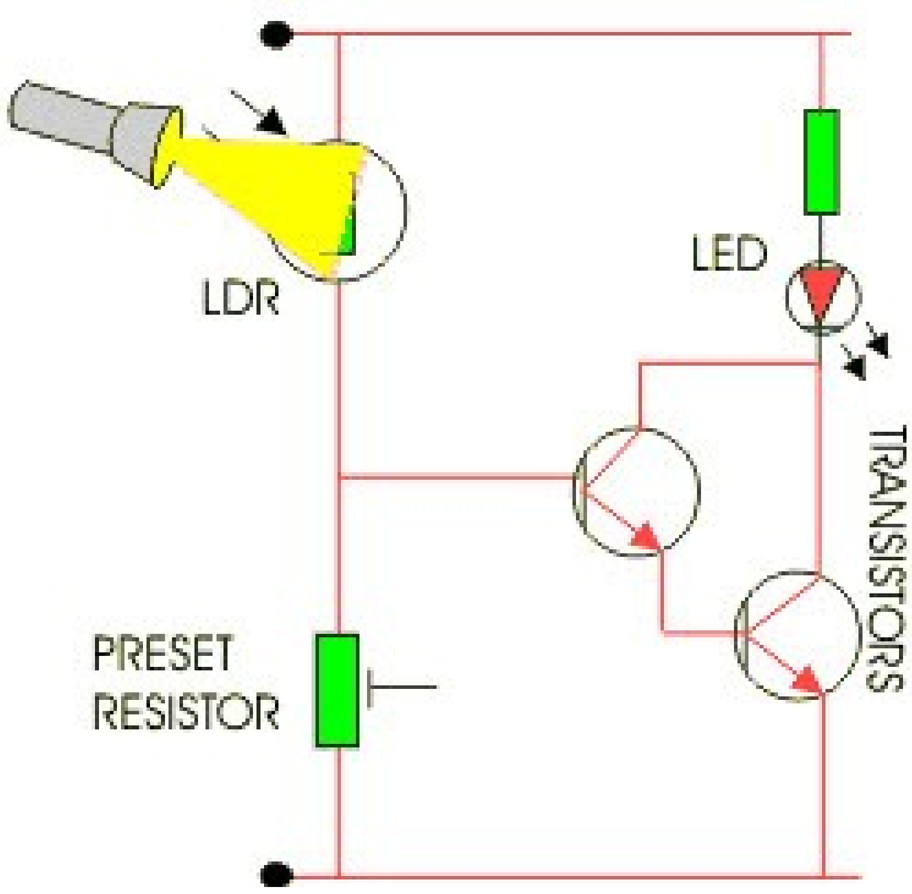
Application

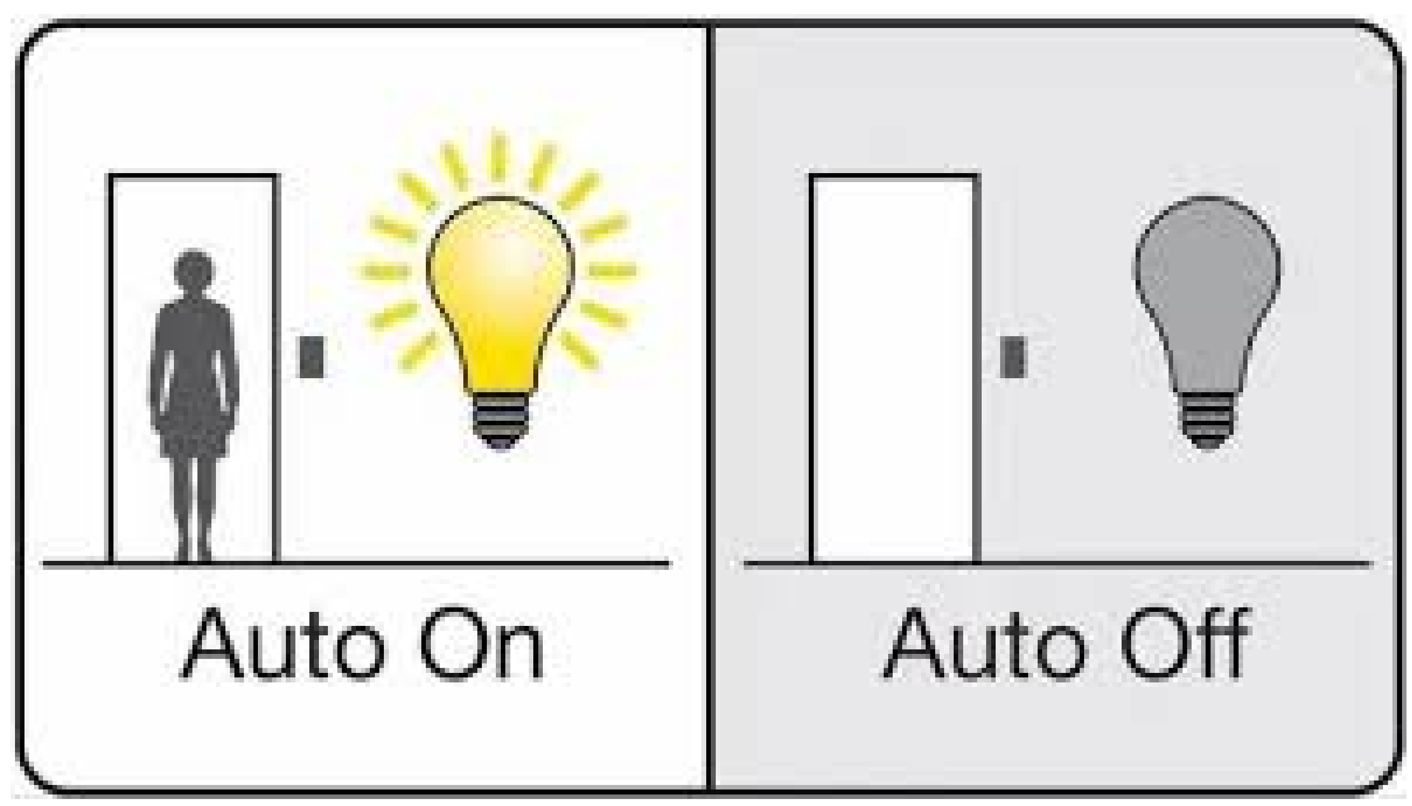
- Temperature sensors in thermostats (e.g., in fridges or air conditioning).
- Overcurrent protection in circuits (PTC thermistors).
- Inrush current limiting in power supplies to prevent damage during startup.

LIGHT DEPENDENT RESISTOR

- An LDR is a type of resistor that changes its resistance based on the amount of light falling on it.
- The resistance of an LDR is high in the dark and low in bright light.
- LDRs are used in circuits where light levels need to be monitored.

LDR





Application

- Automatic lighting systems (e.g., streetlights that turn on at dusk).
- Light-sensitive alarm systems (detecting changes in light levels).
- Solar panels (used for monitoring light exposure for optimal energy generation).

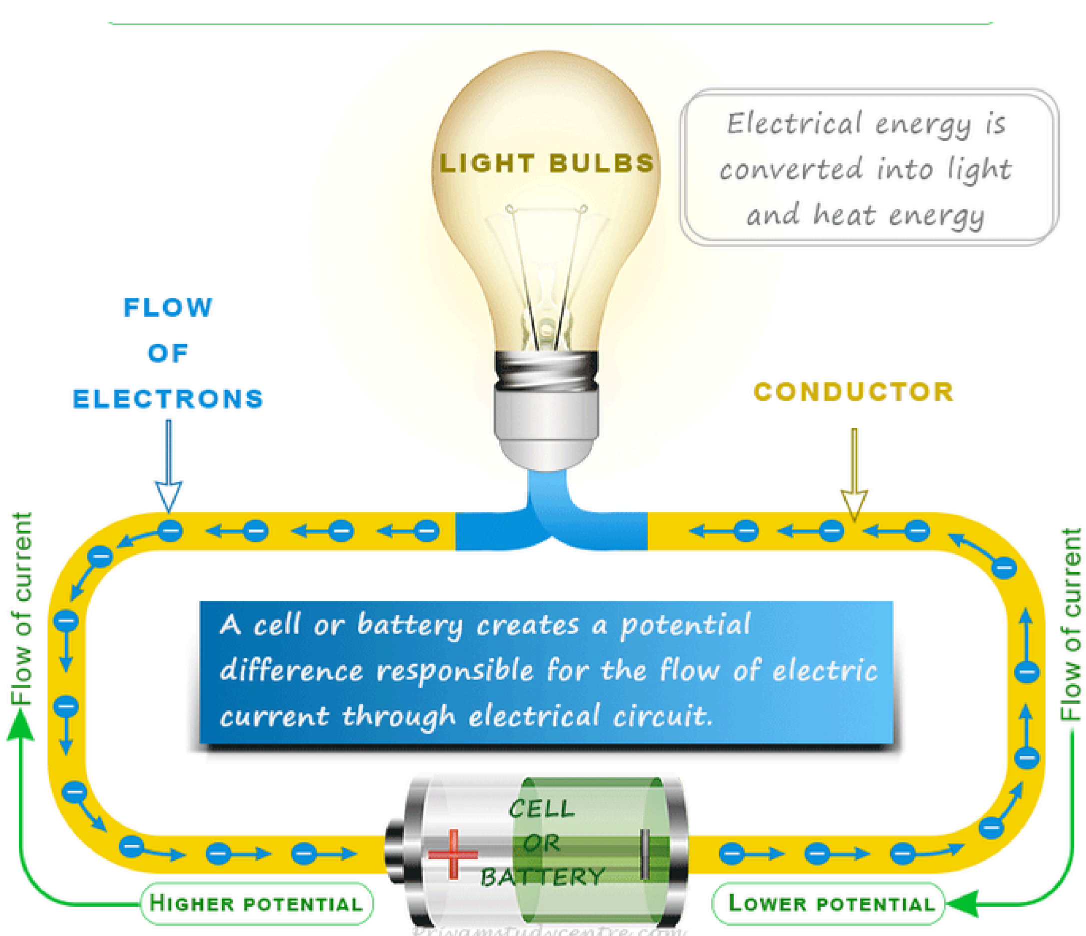
POWER & ENERGY

- **Power** is the rate at which **electrical energy** is converted into other forms (e.g., heat, light).
- It's measured in **watts (W)**.
- Formula for Power:

$$P = VI = \frac{V^2}{R} = I^2R$$

where P is power, V is voltage, and I is current.

- **Energy** is the total amount of work done by electrical power over time.
- Formula: E=Pt, where E is energy (in joules), P is power (in watts), and t is time (in seconds).



ELECTRICAL SAFETY

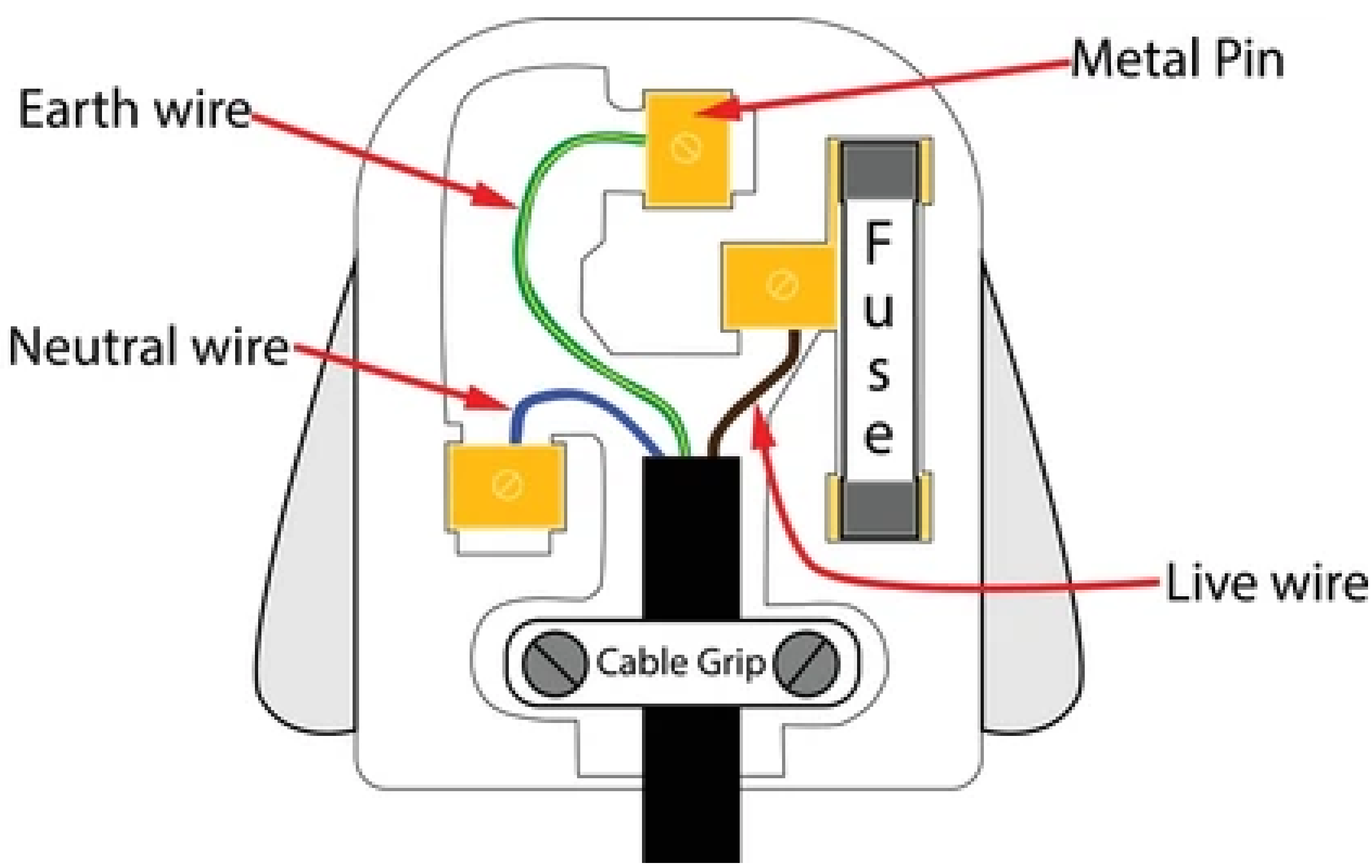
Earth wire is used to prevent electrocution by providing a safe path for current to flow to the ground in case of a fault.

Live wire carries alternating potential difference (~230V) to the appliance.

Neutral wire completes the circuit.

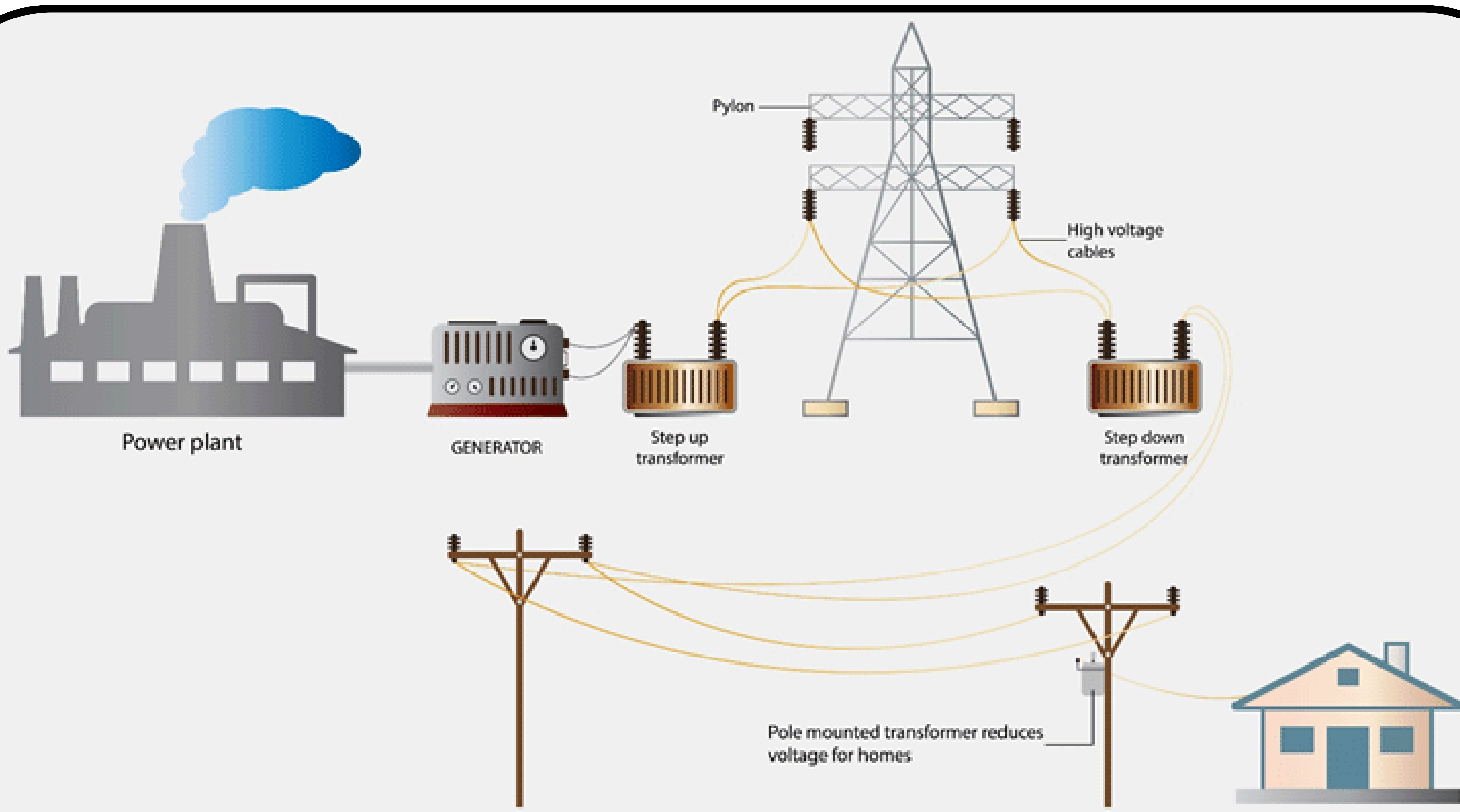
Fuse acts as a safety device to protect circuits by melting and disconnecting the circuit when the current exceeds safe levels.

Insulation on wires and components prevents accidental contact with live parts, reducing the risk of electric shock.



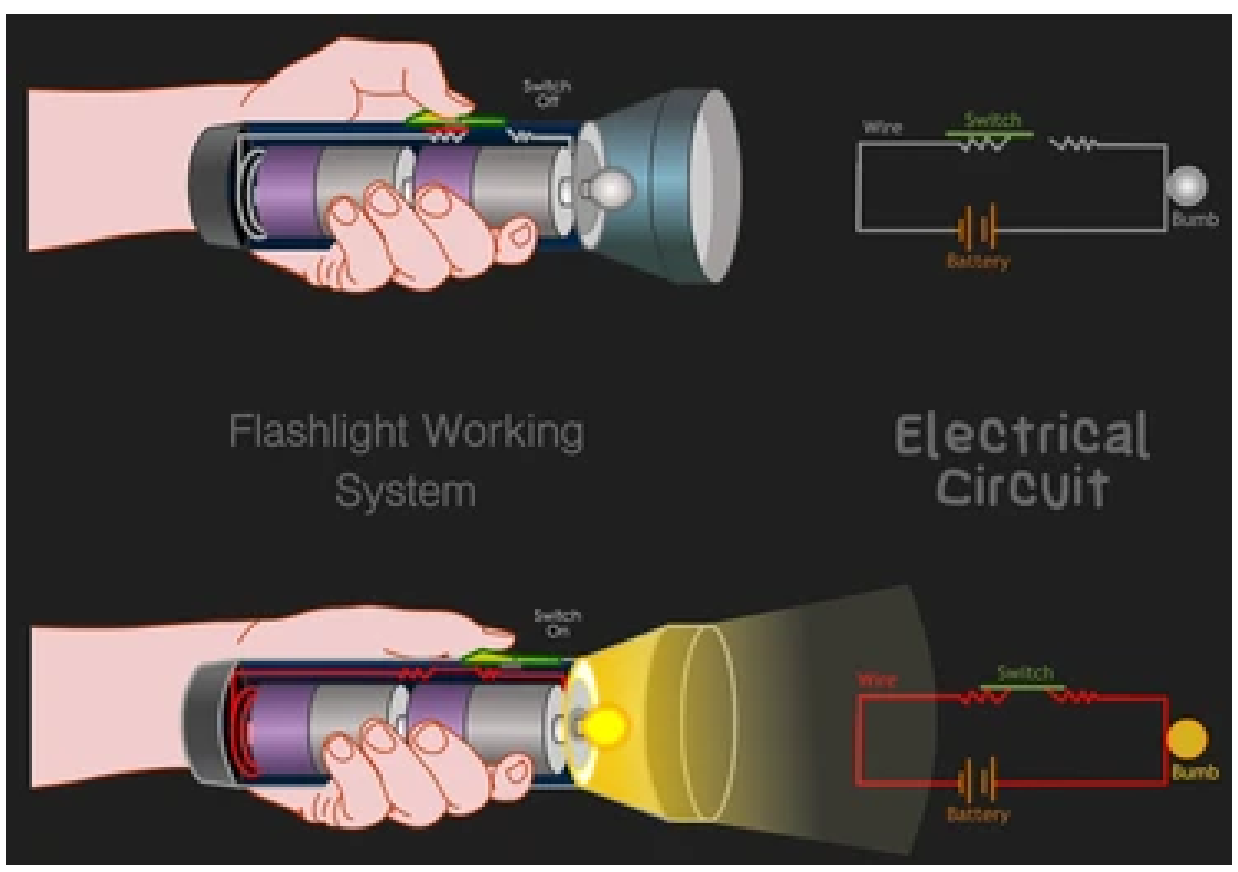
NATIONAL GRID

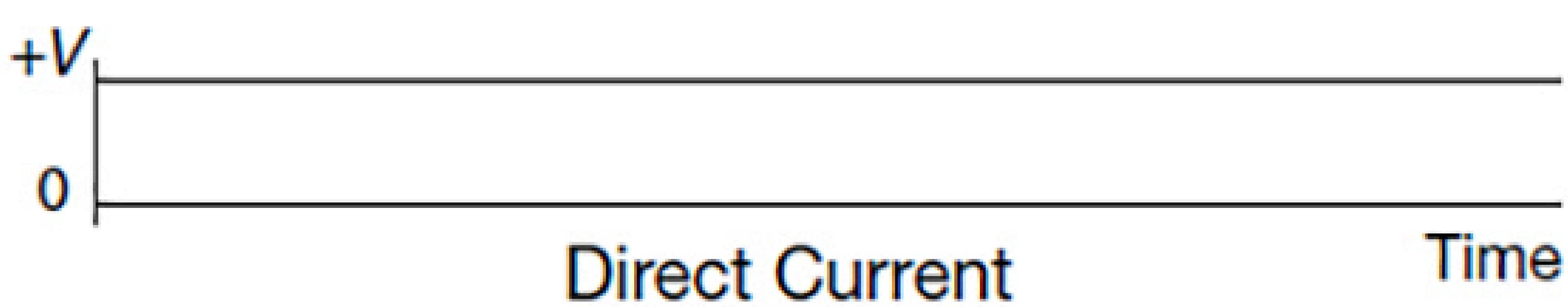
- The National Grid is a network of power stations, transmission lines, and substations that delivers electricity across the country.
- It uses alternating current (AC) because it is efficient for long-distance transmission.
- The frequency of mains electricity in the **UK is 50 Hz** and the **voltage is 230 V.**



DIRECT CURRENT (DC)

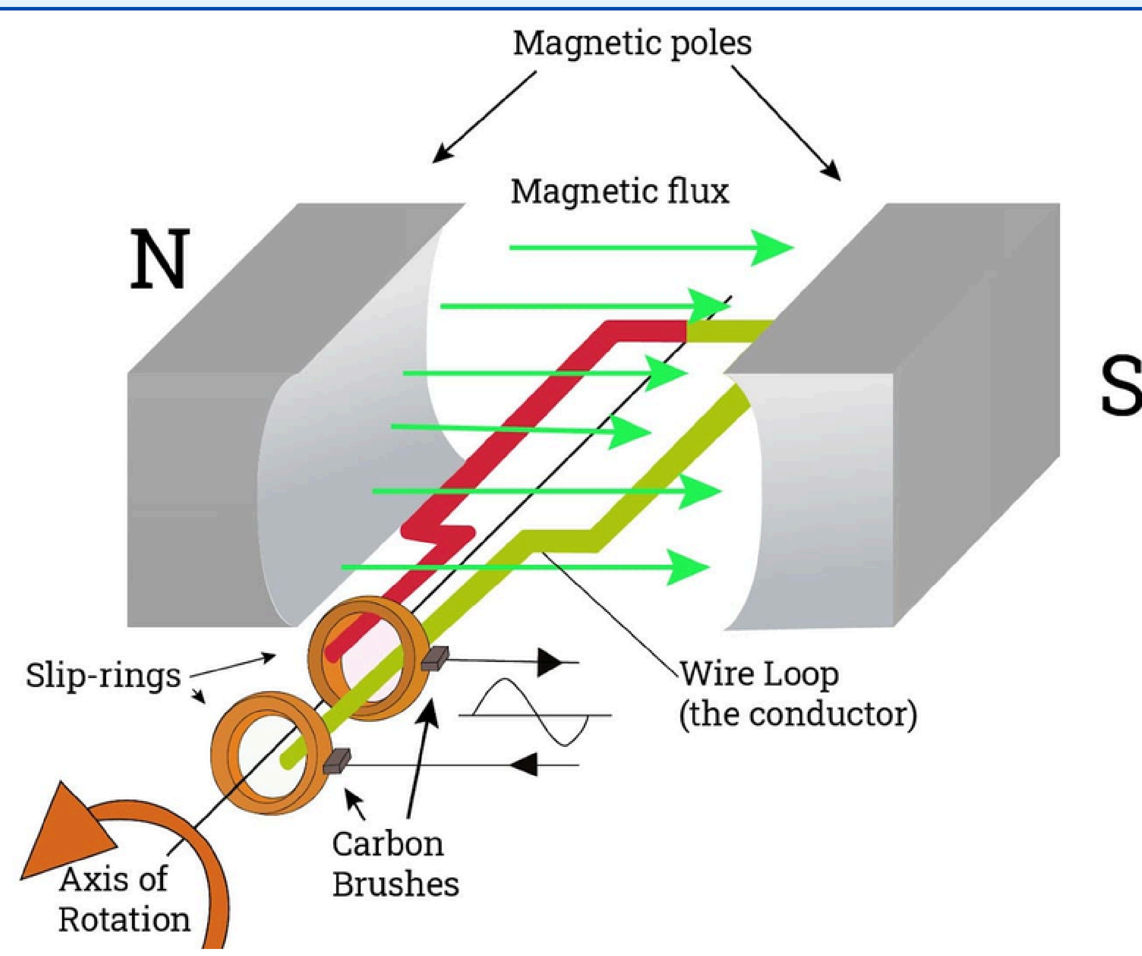
- Direct Current (DC) is an electric current that flows in a constant direction. The current does not reverse its flow, from the positive to the negative terminal (e.g., a battery).
- The voltage in DC circuits is constant and does not change direction, meaning it remains positive or negative.
- Commonly used in battery-powered devices, such as mobile phones, flashlights, and laptops.

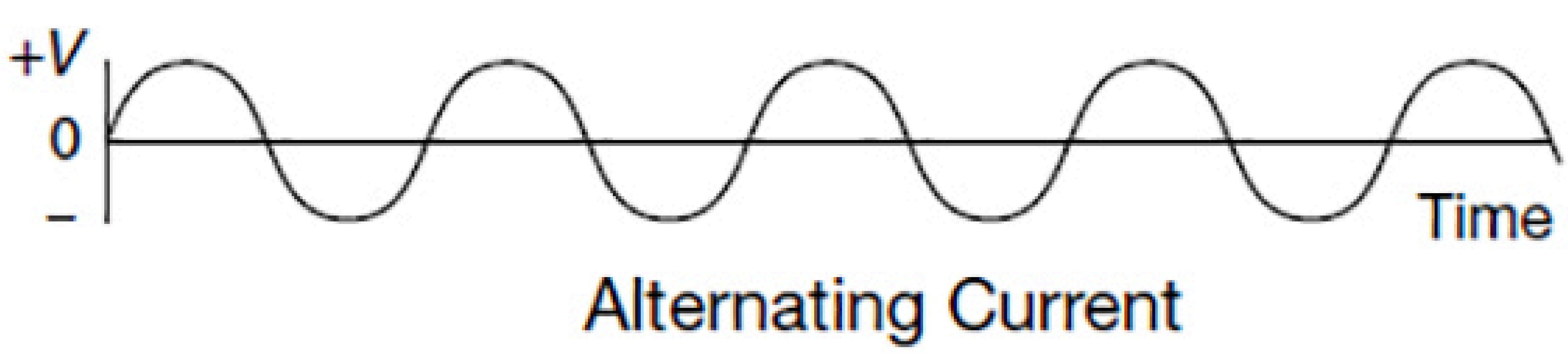




ALTERNATING CURRENT (DC)

- Alternating Current (AC) is an electric current that reverses direction periodically.
- The current reverses its flow, typically following a sine wave pattern.
- The voltage in AC circuits alternates between positive and negative values, allowing for efficient power transmission over long distances.
- AC is used in the National Grid to power homes and industries because it is easy to transform to higher or lower voltages for transmission.





COMPARISON BETWEEN AC AND DC

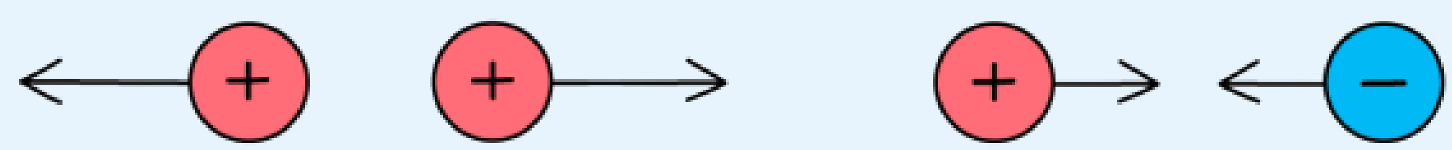
Alternating Current	Direct Current
You can transmit AC electrical energy over long distances without significant power losses.	DC loses electrical power if you transmit it over extensive distances.
It features a changing magnetic field which, in turn, changes the electric flow direction.	It has a stable magnetism. Hence current travels unidirectionally.
AC frequency is different from one country to the other. But, on average, most nations use 50 Hz or 60 Hz frequencies.	It features no frequency since it's steady.
There is a constant forward and backward periodic shifting of AC flow direction as it travels.	Contrastingly, DC power steadily travels in one order throughout.
Lastly, the electrons will move forward and backward during AC transmission.	The electrons move steadily in one direction like a stream of water.

ATTRACTION & REPULSION

Charged objects exert forces on each other even without touching.

- Like charges repel
- (+ repels +), (− repels −)
- Opposite charges attract
- (+ attracts −)

These forces happen through electric fields — invisible regions around a charge where a force is felt.



<u>Why objects attract even if only one is charged</u>

A neutral object has equal positive and negative charges.

When a charged object is brought near it:

- The charged object pushes/pulls electrons inside the neutral object.
- This creates charge separation → positive becomes closer, negative farther.
- Attraction occurs.

So even neutral objects can be attracted to charged ones

ATTRACTION & REPULSION

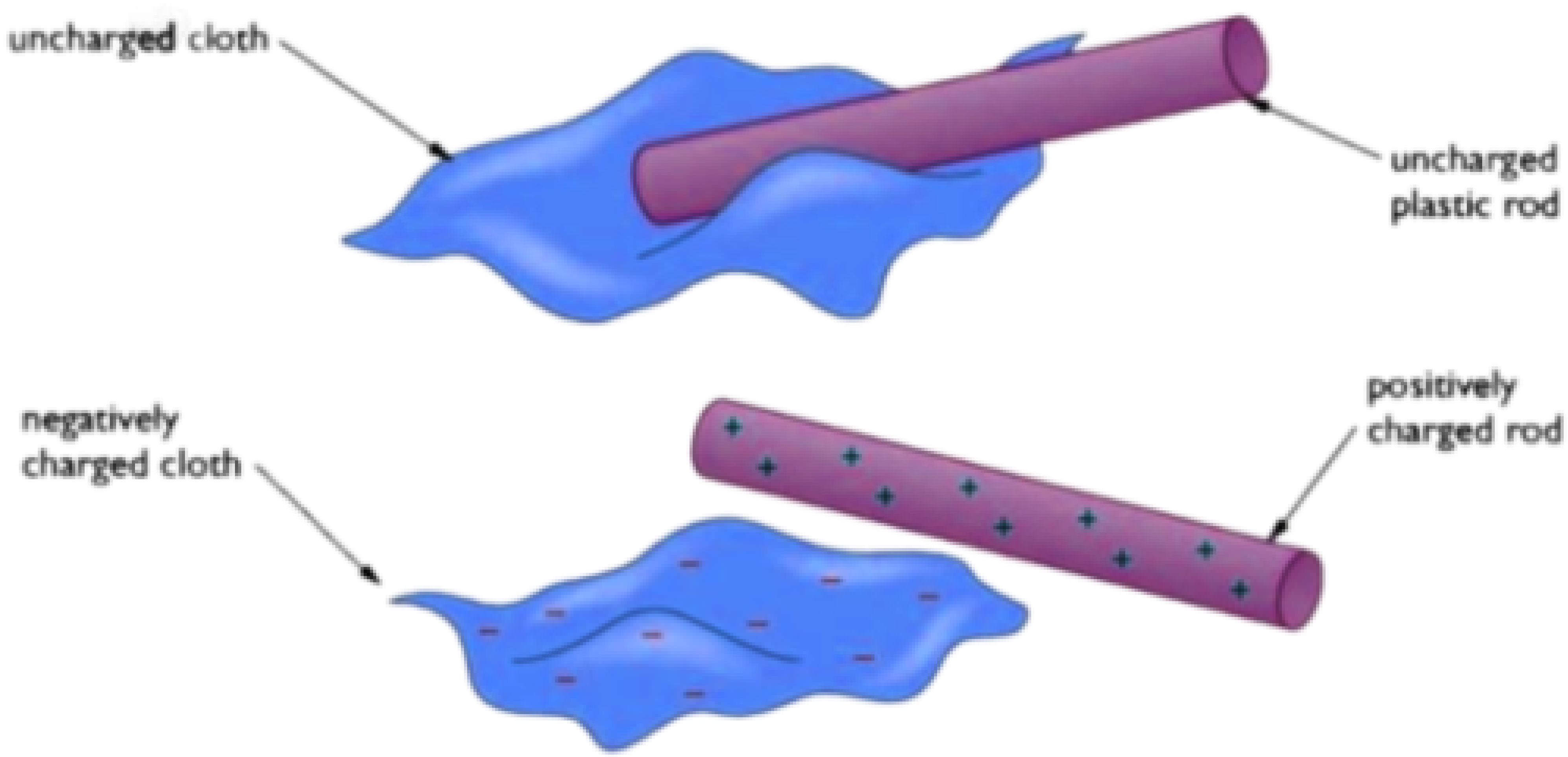
Attraction or Repulsion Summary Table

Charge of Object 1	Charge of Object 2	Attract or repel?
Positive	Positive	Repel
Positive	Negative	Attract
Negative	Positive	Attract
Negative	Negative	Repel

CHARGING BY FRICTION

Static electricity is most often produced by friction, especially between two insulators.
When rubbed together:

- Electrons move from one material to the other.
- One material becomes electron-rich (negative).
- The other becomes electron-deficient (positive).



Why only insulators?
In conductors, electrons flow away instantly.
Insulators trap electrons, so charge builds up and stays.

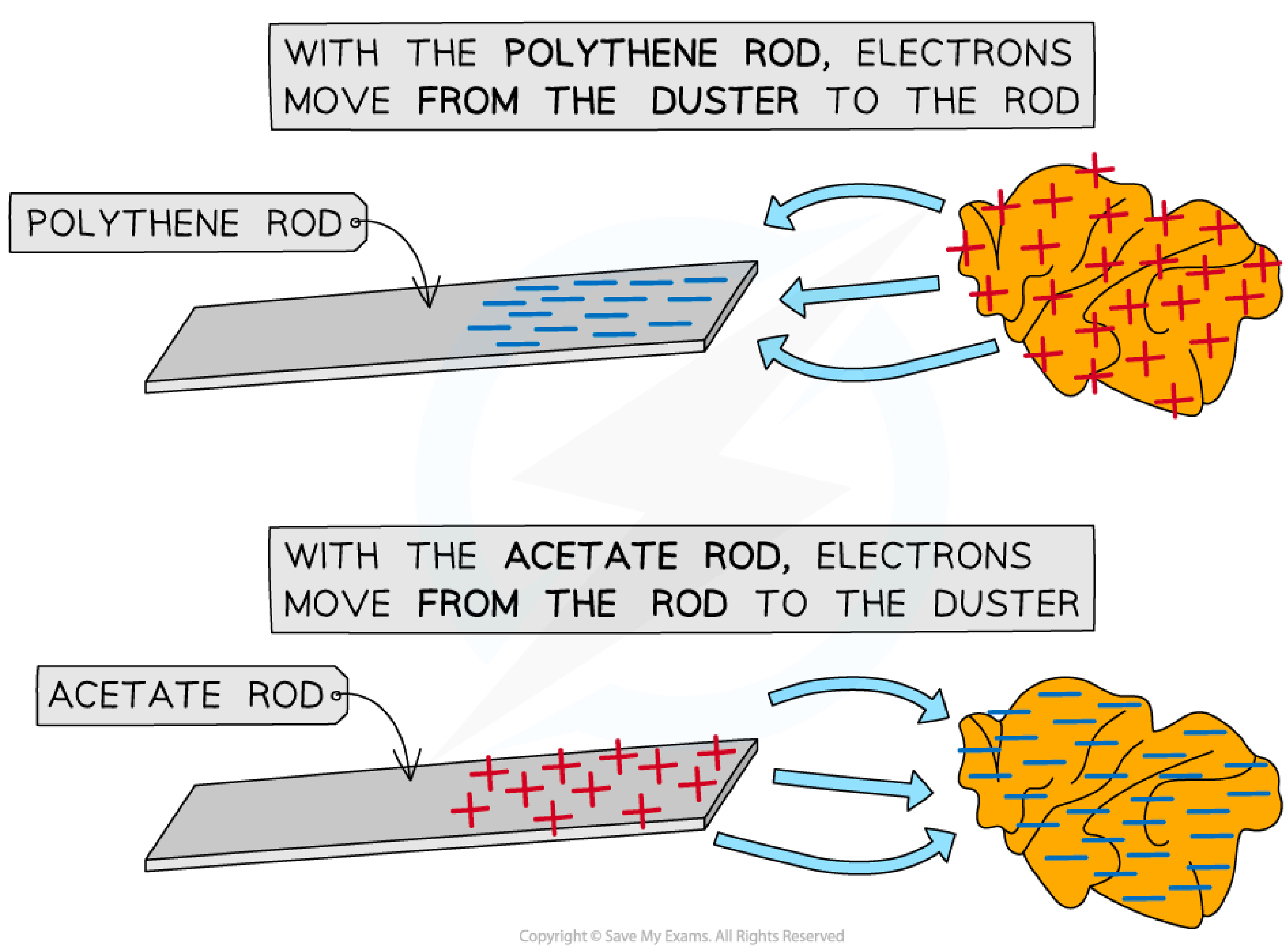
CHARGING BY FRICTION

Acetate Rod Example:

- Rub acetate rod with cloth.
- Electrons transfer FROM rod TO cloth.
- Rod loses electrons → positive.
- Cloth gains electrons → negative.

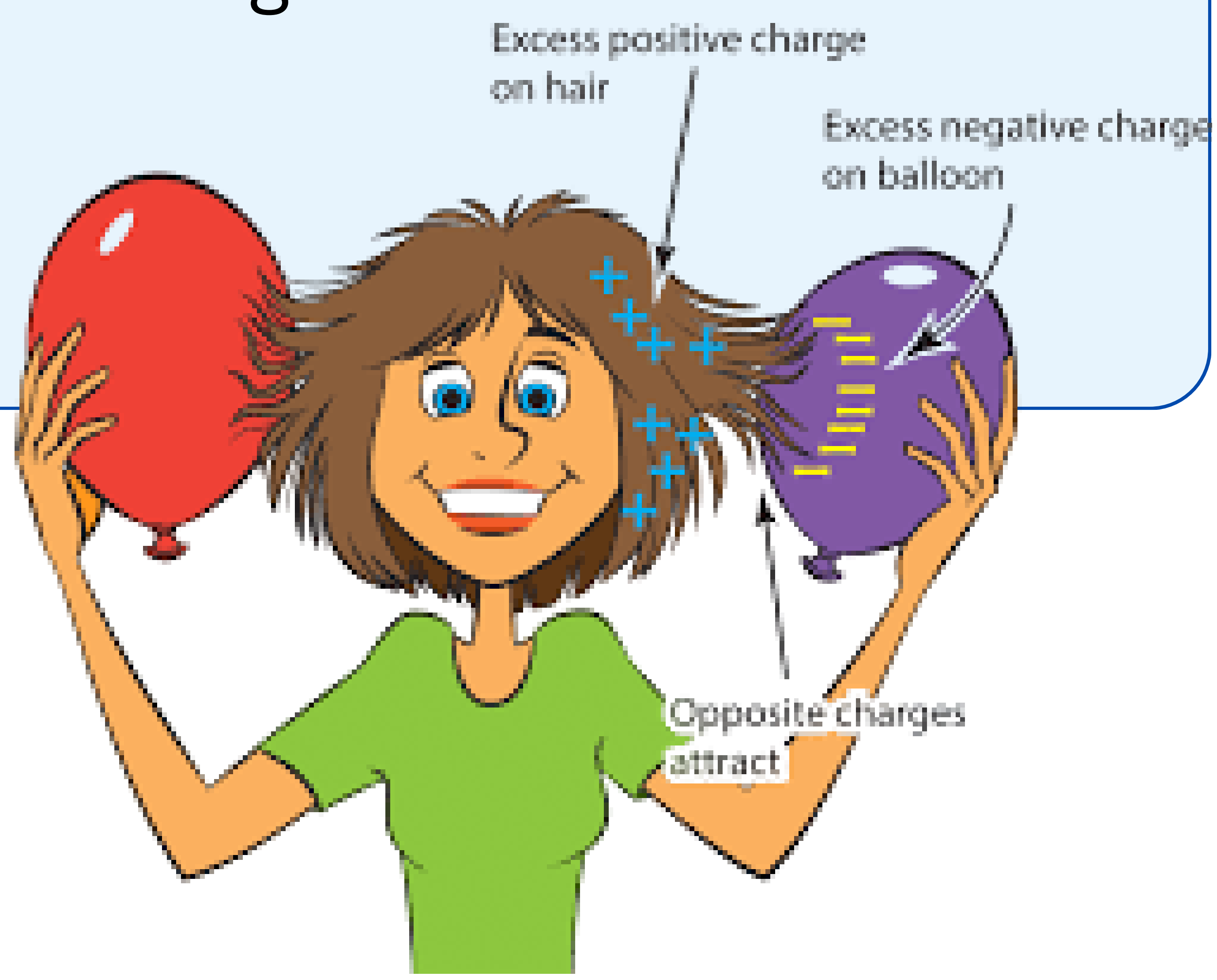
Polythene Rod Example:

- Rub polythene rod with cloth.
- Electrons transfer FROM cloth TO rod.
- Rod gains electrons → negative.
- Cloth loses electrons → positive.

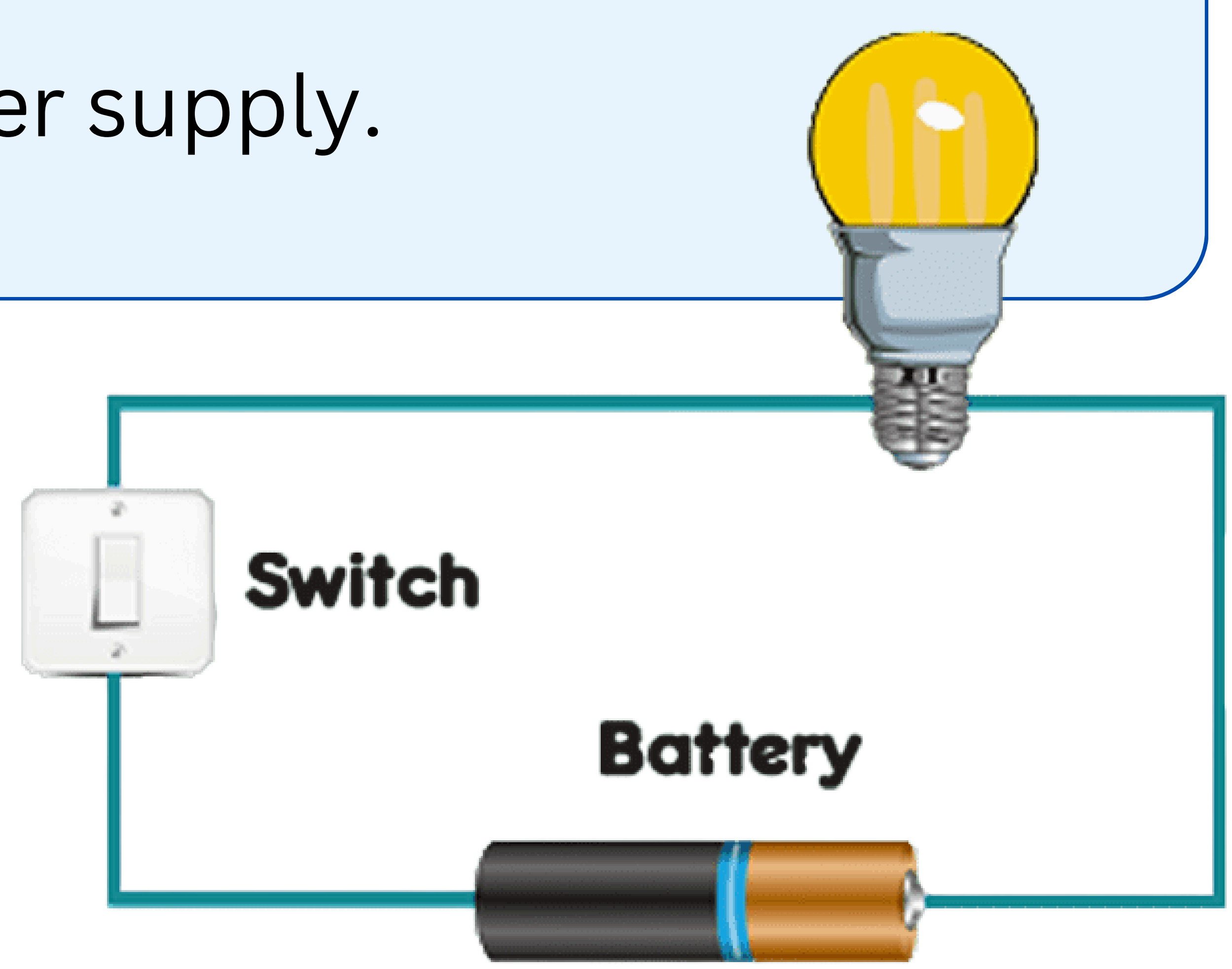


STATIC VS CURRENT ELECTRICITY

Static Electricity (Electrostatics):
- Charge is "stuck" on a surface.
- No continuous movement of charge.
- Found in insulators.
- Produced by friction.



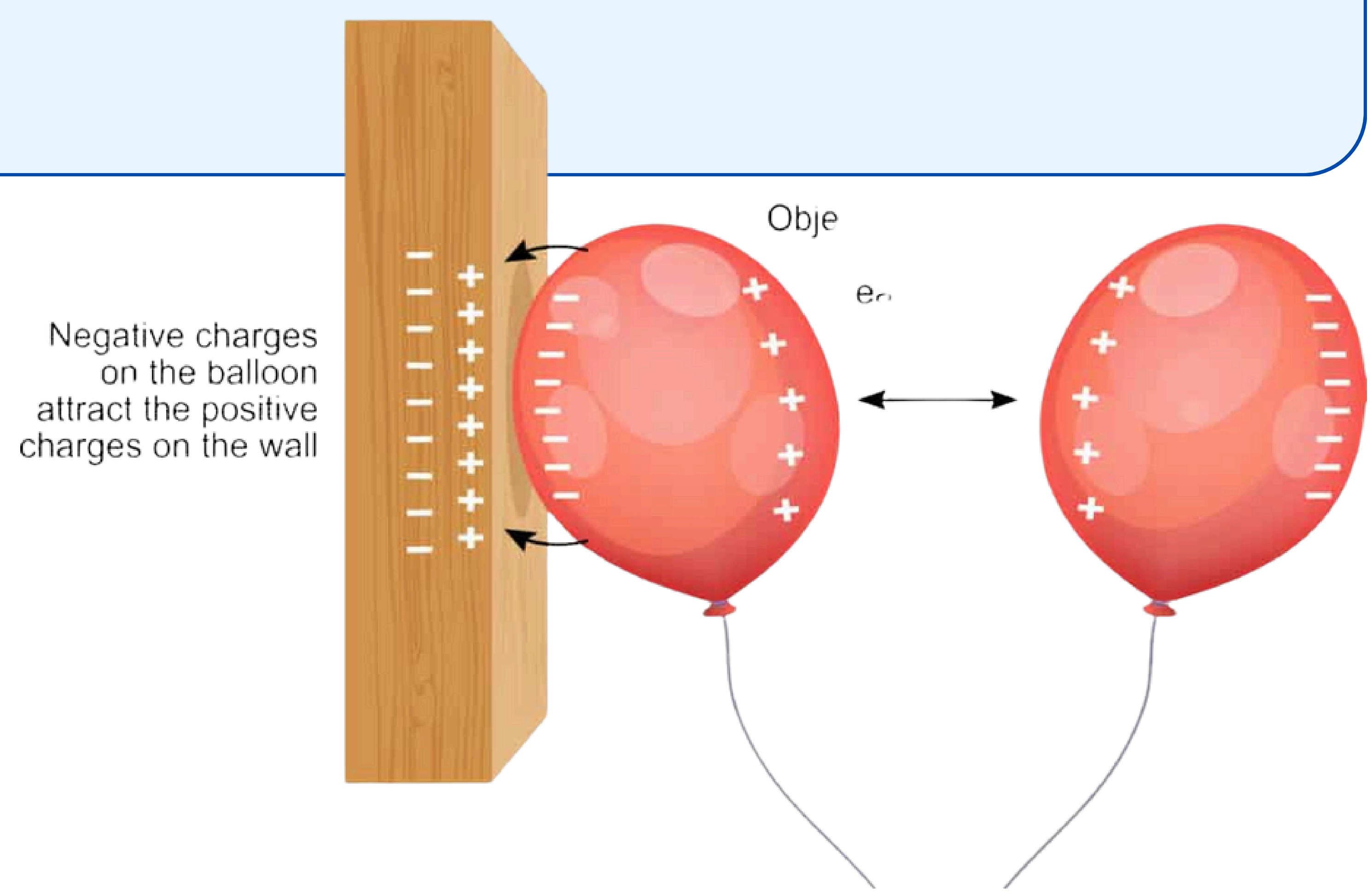
Current Electricity:
- Continuous flow of electrons.
- Needs a complete circuit.
- Usually in metals.
- Produced by a battery or power supply.



EVERYDAY STATIC ELECTRICITY EXAMPLES

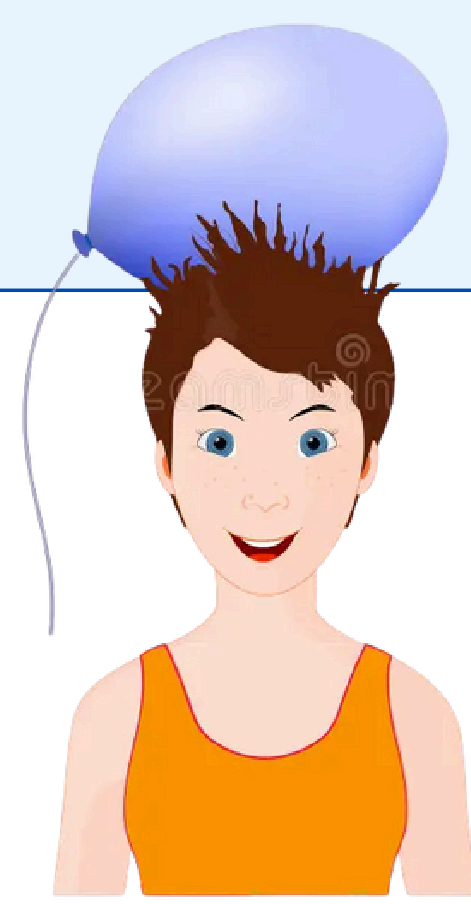
Balloon Sticking to Wall

- Balloon rubbed → becomes negative.
- Negative charges push electrons in wall deeper inside.
- Wall surface becomes temporarily positive.
- Opposite charges attract → balloon sticks.



Hair Standing Up

- Combing charges each strand the same way (usually positive).
- Like charges repel → hair strands push apart.

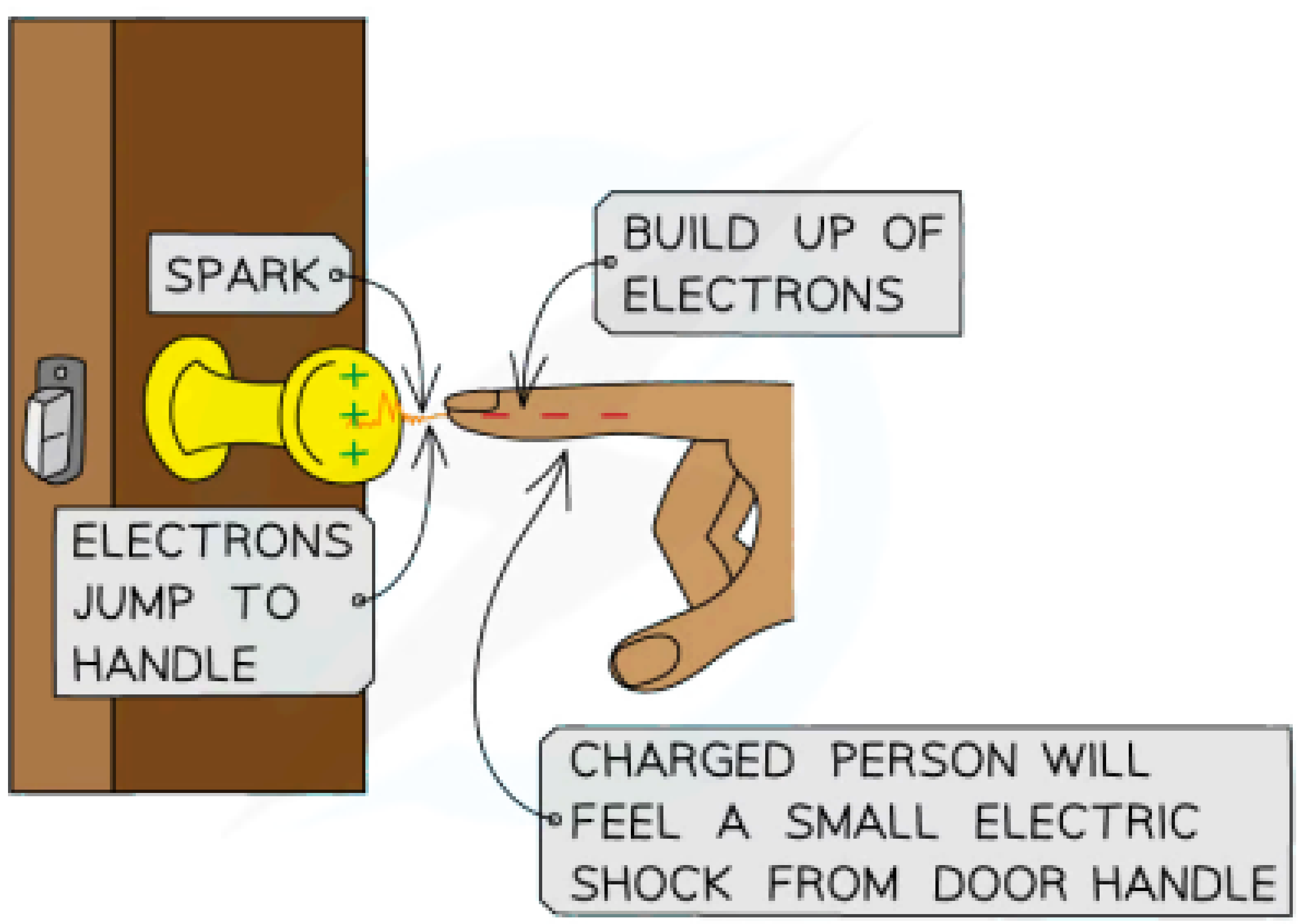


SPARKING

A spark is a sudden movement of electrons through the air.

Why sparks form:

- A large charge builds up.
- This creates a very strong electric field.
- The electric field forces electrons to rip through air molecules.
- Air becomes ionised — a path for electrons forms.
- Charge discharges rapidly → spark.



Examples:

- Static shock when touching metal.
- Taking off jumper in the dark (crackling sparks).
- Lightning.
- Sparks near petrol pumps (dangerous).

LIGHTNING

Lightning is a huge natural spark.

How clouds become charged:

Inside thunderclouds:

- Ice and water droplets collide violently.
- This friction transfers electrons.
- Bottom of cloud becomes negatively charged.
- Top becomes positive.

Ground becomes charged too:

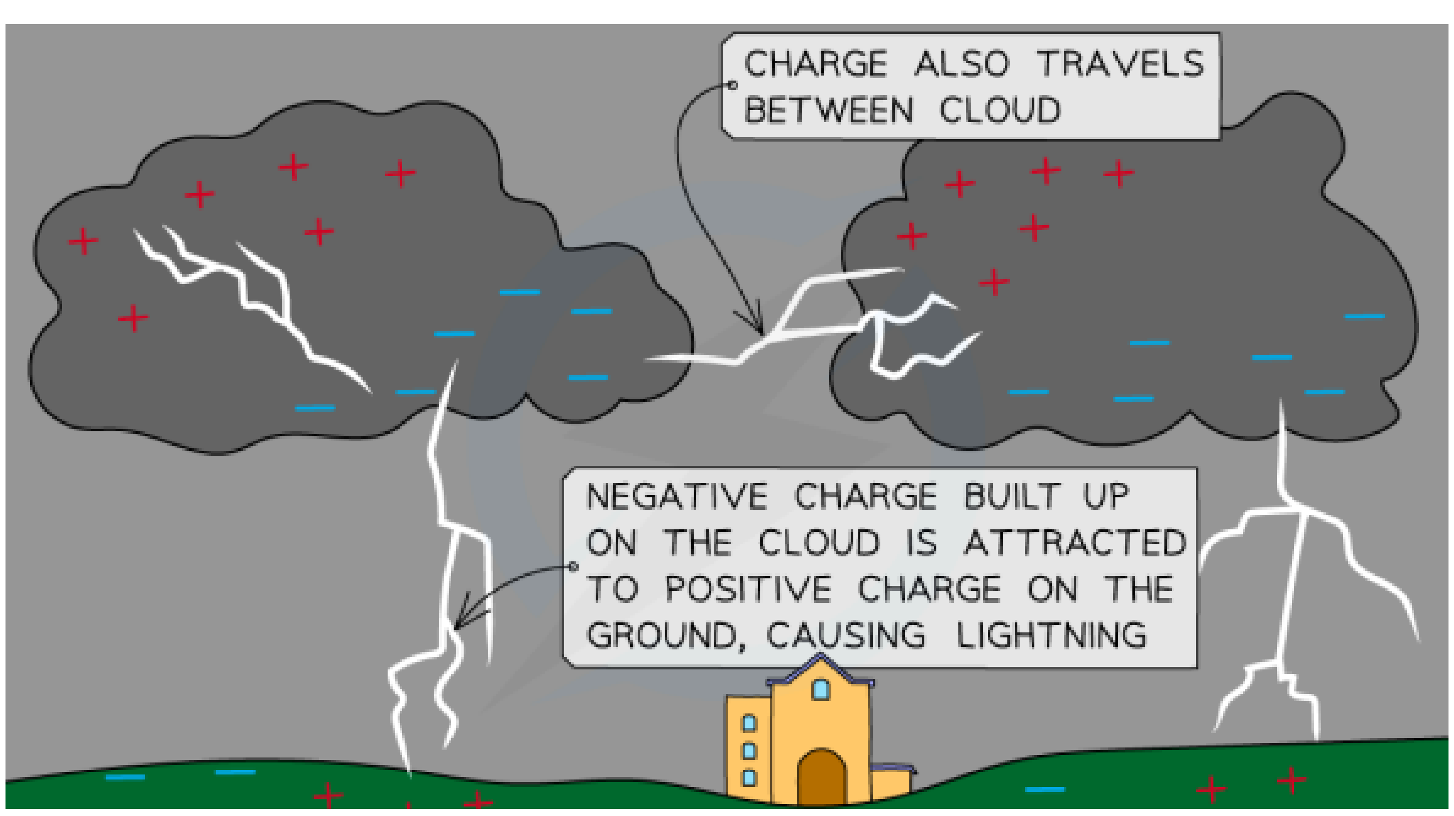
Negative cloud repels electrons on Earth's surface → ground becomes positive underneath the cloud.

What happens next:

- Potential difference becomes massive (millions of volts).
- Air breaks down (ionises).
- Gigantic discharge jumps between cloud and ground → lightning bolt.

Thunder:

Lightning superheats the air, air expands explosively → thunder.



DANGERS OF STATIC ELECTRICITY

Sparks can:

- Cause explosions (fuel vapours).
- Ignite gases (petrol stations).
- Damage electronics.

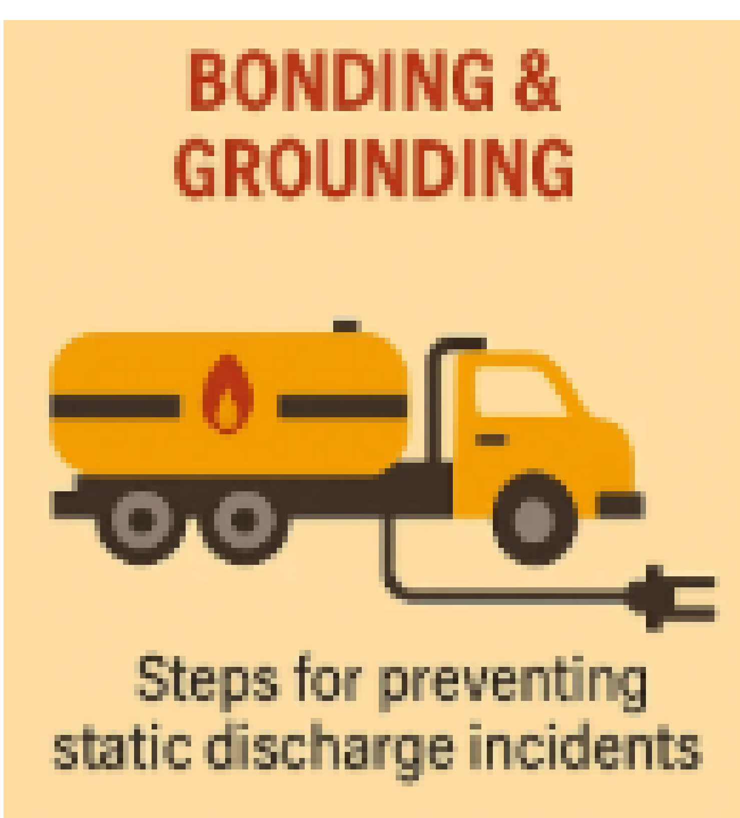
Refuelling Example:

When refuelling aircraft or tankers:

- Fuel rushing through pipes builds charge.
- A spark could ignite vapour → explosion.

How danger is reduced:

- A bonding/earthing cable connects the plane to ground.
- Charge flows safely into Earth.
- Prevents sparks.



ELECTRIC FIELDS

Single Positive Charge

- Lines radiate outward symmetrically.

Single Negative Charge

- Lines converge inward.

Opposite Charges (Dipole)

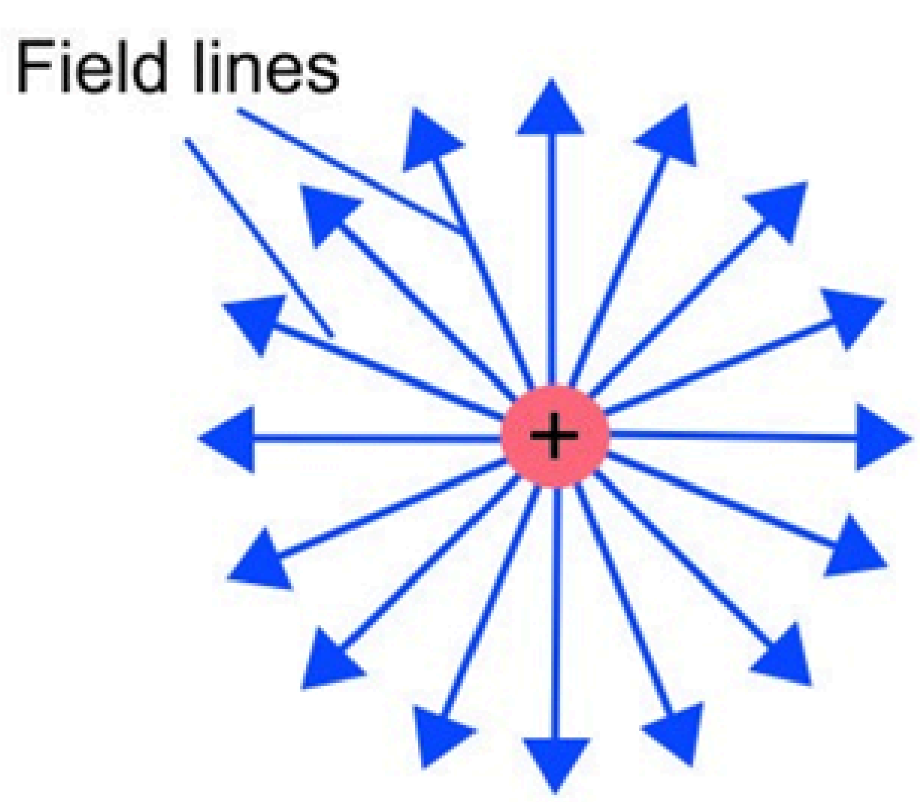
- Lines curve from + to −.
- Shows attraction.

Like Charges

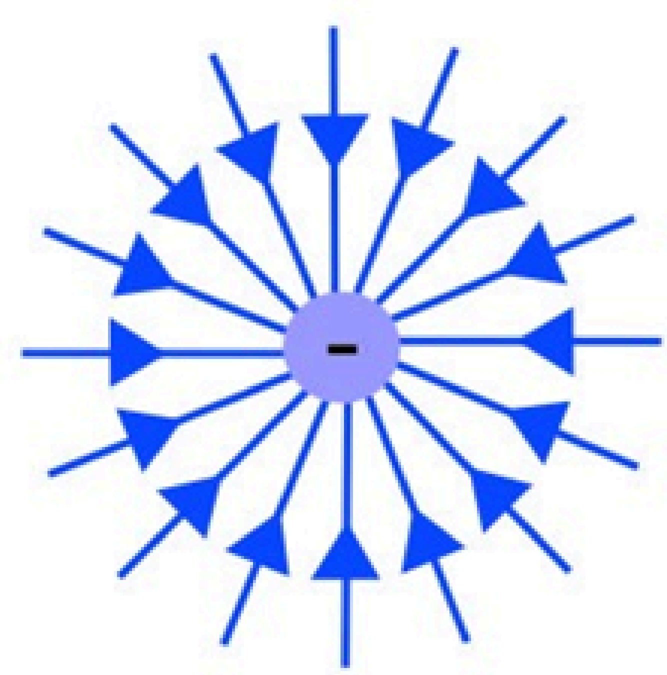
- Lines bend away → repulsion.

Uniform Field (Parallel Plates)

- Straight, evenly spaced lines.
- Same strength everywhere.



The electric field from an isolated positive charge



The electric field from an isolated negative charge

ELECTRIC FIELDS

Every charge creates an electric field (EF) around it.

What is an electric field?

A region in which a charged object experiences a force.

Field Line Rules:

- Lines point away from + charges.
- Lines point toward − charges.
- Closer lines → stronger field.
- Wider lines → weaker field.