Electricity and circuit – GCSE Physics

CONTENTS:

1. Introduction

- An **Electrical circuit** is a closed path that allows electric current to flow through it.
- It connects electrical components using conductors to perform a specific function using electricity.
- Electrical circuits make it possible to control and distribute electrical energy safely and efficiently.

Where it is used:


Home Appliances

Electronics

Transportation

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2. What is an Electrical Circuit?

- An **Electrical circuit** is a closed loop path that allows electric current to flow, allowing energy to power devices and systems.
- It connects some components so that electricity can do useful work.
- Without electrical circuits, we could not use electricity to light our homes, charge devices, run machines, or operate communication systems.
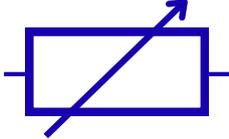
Basic Electric circuit:
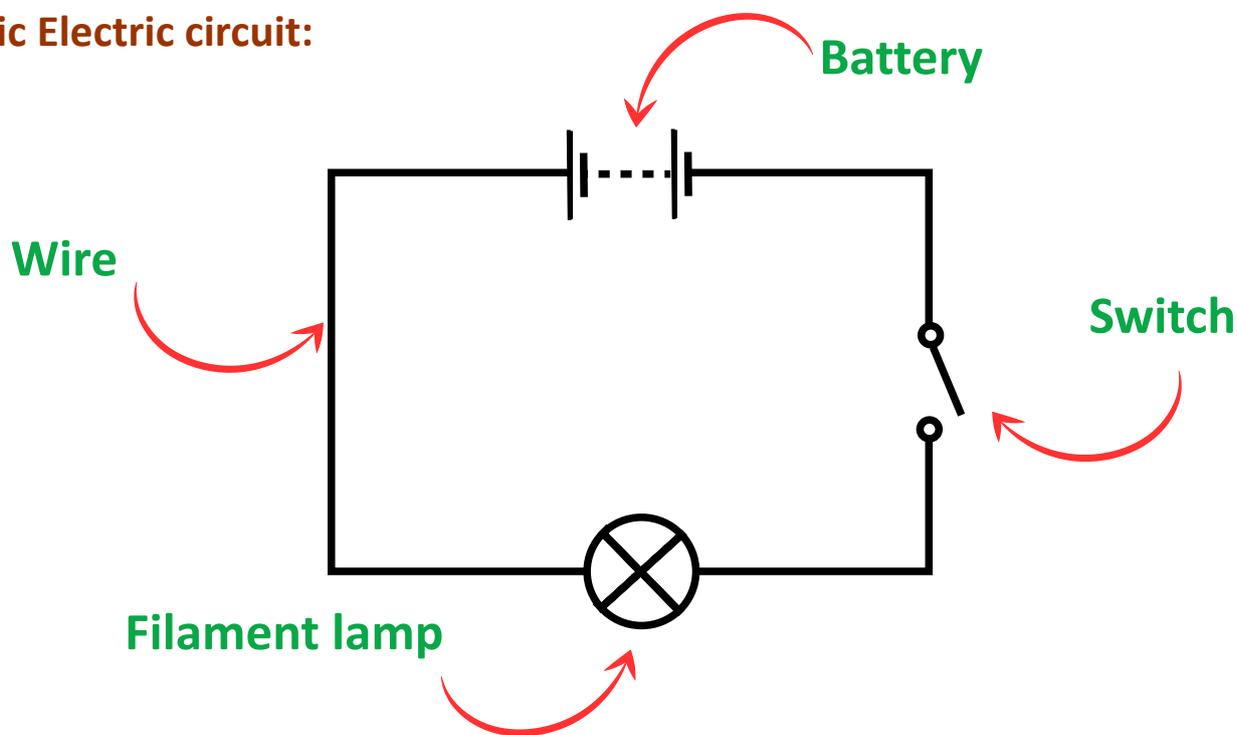
Components used in an electrical circuit with their symbols:

Components	Use	Symbol
Cell	To provide electric power	
Battery	To supply more electrical power.	

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Components	Use	Symbol
Switch	Control the flow of electricity.	Closed switch / Open switch
Filament Lamp (Bulb)	To convert electrical energy into light energy.	⊗
Diode	To control the direction of current in a circuit.	
Ammeter	To monitor the amount of current flowing through the circuit.	Ⓐ
Voltmeter	To check the voltage supplied or dropped across circuit components.	Ⓥ
Fixed Resistor	To control the current in a circuit to a fixed value.	
Variable Resistor	To change the current in a circuit as needed.	
Thermistor	To detect to temperature changes in a circuit	
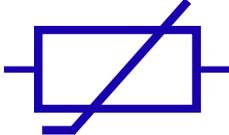
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3. What are series and parallel circuits?

Series Circuit:

- In **Series circuit**, the components are connected end-to-end in a single path, so the same current flows through all of them.
- **Example:** A simple flashlight with two batteries.
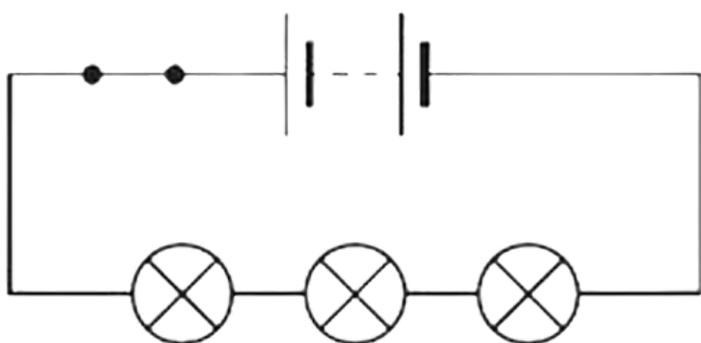
Total Potential Difference

$$V_{total} = V_1 + V_2 + V_3 + ...$$

Total Current

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

Parallel Circuit:

- In **Parallel circuit**, the components are connected across multiple paths, so voltage is the same across each branch, but current can vary.
- **Example:** Home appliances (lights, fans, etc.) wired separately to the mains.
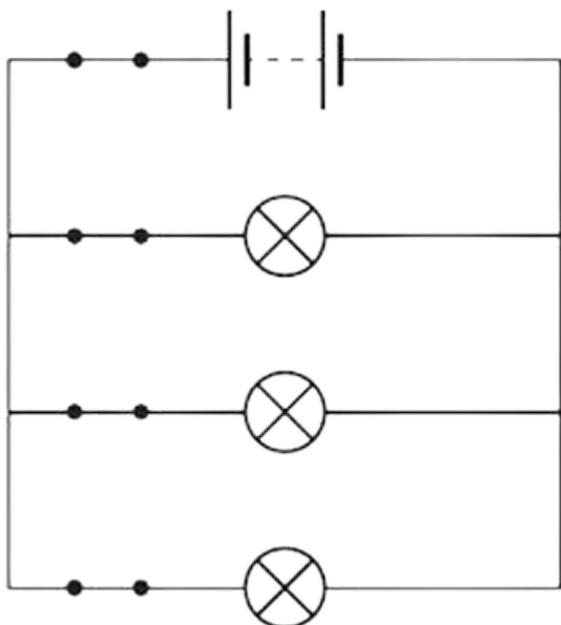
Total Potential Difference

$$V_{total} = V_1 = V_2 = V_3 = ...$$

Total Current

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

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4. What is potential difference, current, and resistance?

Potential difference:

- **Definition:** The force required for the flow of electrons in a circuit is called potential difference.
- **Unit:** Volts (**V**)
- **Provided by:** A cell or battery.

Current:

- **Definition:** The flow of electric charge (usually electrons) through a conductor is called current.
- **Unit:** Amperes (**A**)
- **Provided by:** A cell or battery pushing charges through the circuit.

Potential difference:

- **Definition:** The property of a material that opposes the flow of electric current.
- **Unit:** Ohms(**Ω**)
- **Provided by:** Resistors and the materials of wires/components in the circuit.

5. What is Ohm's Law?

- **Ohm's Law** states that the current through a conductor is directly proportional to the potential difference across it, if the temperature remains constant.
- It is written as:

$$V = I \times R$$

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Where:

- **V** = Potential difference
- **I** = Current
- **R** = Resistance

Example: If a circuit has a current of 3 A and a resistance of 3 Ω, find the voltage across it.

Solution:

Given:

- **A** = 3A
- **R** = 3Ω

Using formula:

$$V = I \times R$$

Plug the values:

$$V = 3A \times 3Ω$$

$$V = 9V$$

Therefore, the voltage across the circuit is **9 V**.

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6. How are Charge, Current, and Time Related?

⚡ Charge ⚡

- **Definition:** A measure of the **total current** that flowed within a certain period of **time**. It is carried by particles like electrons and protons.
- **Symbol:** **Q** or **q**
- **Unit:** Coulomb (**C**)

How to Calculate Charge:

Formula:

$$Q = I \times t$$

Where:

- **Q** = Charge
- **I** = Current
- **t** = Time

Example: A current of **5 A** flows through a circuit for **6 seconds**. Calculate the charge that flows through the circuit.

Solution:

Given:

- **A** = 5A
- **t** = 6s

Using formula:

$$Q = I \times t$$

Plug the values:

$$Q = 5A \times 6s$$

$$Q = 30 \ C$$

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7. How are Energy, Voltage, and Charge Related?

⚡ Energy ⚡

- **Definition:** n electricity, energy is the work done when charge moves through a voltage.
- **Symbol:** E
- **Unit:** Joule (J)

How to Calculate Charge:

Formula:

$$E = V \times Q$$

Where:

- **Q** = Charge
- **E** = Energy
- **V** = Voltage

Example: A charge of **15 C** moves through a voltage of **9 V**. Calculate the energy transferred.

Solution:

Given:

- **Q** = 15Q
- **V** = 9V

Using formula:

$$E = V \times Q$$

Plug the values:

$$E = 9V \times 15Q$$

$$E = 135\ J$$

Therefore, **135 joules** of energy are transferred.

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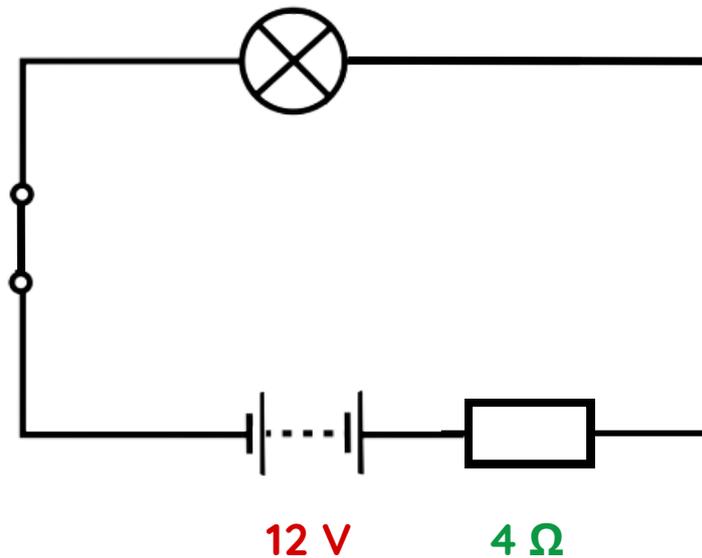## 8. Solving questions with circuit diagrams

Steps to solve question with circuit diagram

    Step#1: Identify given values in the circuit.

    Step#2: Choose the correct formula.

    Step#3: Substitute values and calculate the unknown.

Example: A circuit has a 12 V battery and a 4 Ω resistor in series. Find the current.

12 V   **4 Ω**

Solution:

Step#1: Identify given values in the circuit.

Given:

- **V** = 12 V
- **R** = 4Ω

Step#2: Choose the correct formula.

Using Ohm's Law:

$$V = I \times R \quad \text{or} \quad I = \frac{V}{R}$$

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Step#3: Substitute values and calculate the unknown.
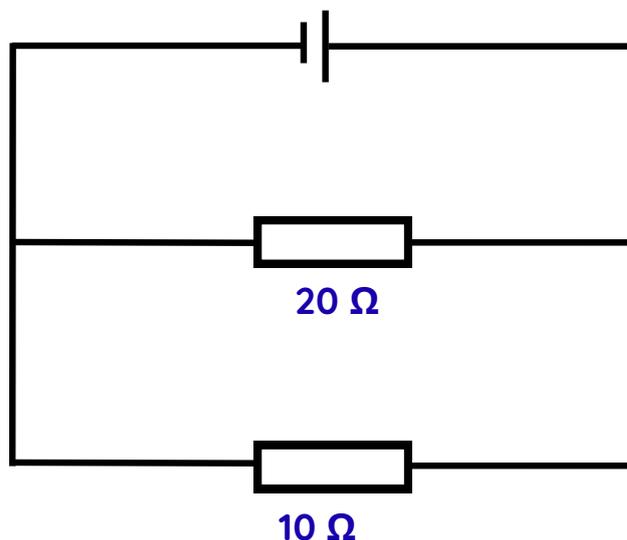
Substitute the values:

$$I = \frac{12V}{4\Omega}$$

$$I = 3\ A$$

Therefore, the current flowing in the circuit is 3 A.

9. Solved Examples

Problem1: A parallel circuit has a 10 Ω resistor and a 20 Ω resistor. The current through the 20 Ω resistor is 0.6 A.
Calculate: 1. The current through the 10 Ω resistor, and
              2. The total voltage of the cell.

Solution:

Step#1: Identify given values in the circuit.

Given:
- R_1 = 10Ω
- R_2 = 20Ω
- I_2 = 0.6 A

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Step#2: Choose the correct formula.

In parallel circuits,

Voltage across each branch is the same:

$$V = I \times R$$

Step#3: Substitute and calculate.

- **The voltage across the resistors:**

Using,

$$V = I_2 \times R_2$$

$$V = 0.6A \times 20\Omega$$

$$V = 12V$$

The voltage across the 10 Ω resistor is also **12 V**.

- **The current through the 10 Ω resistor:**

Using,

$$I_1 = \frac{V}{R_1}$$

$$I_1 = \frac{12V}{10\Omega}$$

$$I_1 = 1.2A$$

The current through the 10 Ω resistor is **1.2 A**.

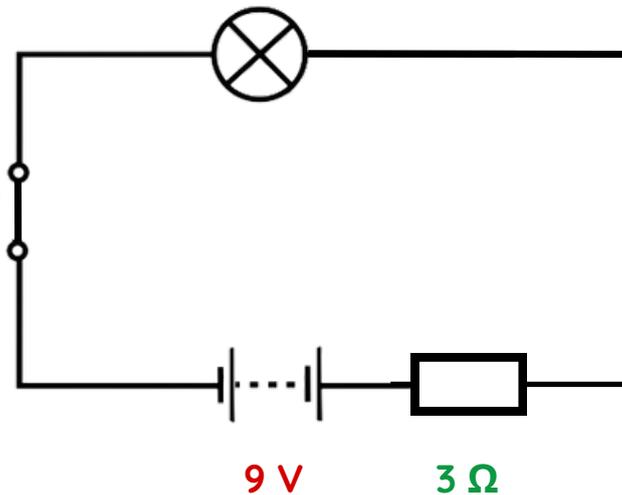- **The total current from the cell:**

In parallel:

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

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$$I_{total} = 1.2 \text{ A} + 0.6 \text{ A}$$

$$I_{total} = 1.8 \text{ A}$$

The total current from the cell is **1.8 A**.

Problem2: A battery of 9 V is connected in series with a 3 Ω resistor. Calculate the charge flowing through the circuit in 4 seconds.

9 V   3 Ω

Solution:

Step#1: Identify given values in the circuit.

Given:
- **V** = 12 V
- **R** = 4Ω
- **t** = 4 s

Step#2: Choose the correct formula.

To find charge (Q), use:

$$Q = I \times t$$

First, find current (**I**) using Ohm's Law:

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

Step#3: Substitute and calculate.

- **Find the current:**

$$I = \frac{9V}{3\Omega}$$

$$I = 3\ A$$

- **Find the charge:**

$$Q = I \times t$$

$$Q = 3A \times 4s$$

$$Q = 12C$$

The charge flowing through the circuit in 4 seconds is **12 C**.

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10. FAQs

1.What is an electric circuit?

It is a closed path that allows electric current to flow.

2. What does Ohm's Law state?

Ohm's Law states that:

$$V = I \times R$$

3. What is electric charge?

Electric charge is a property of particles like electrons and protons that causes them to experience a force in an electric field.

4. What is potential difference?

It is the work done to move unit charge between two points. Measured in volts (**V**) using a voltmeter.

5. What is resistance?

It is the opposition to the flow of electric current. Measured in ohms (**Ω**) using an ohmmeter.

6. What happens to current in a series circuit?

Current stays the same in all parts of the circuit. It has only one path to flow.

Total Potential Difference

$$V_{total} = V_1 + V_2 + V_3 + \ldots$$

Total Current

$$I_{total} = I_1 = I_2 = I_3 = \ldots$$