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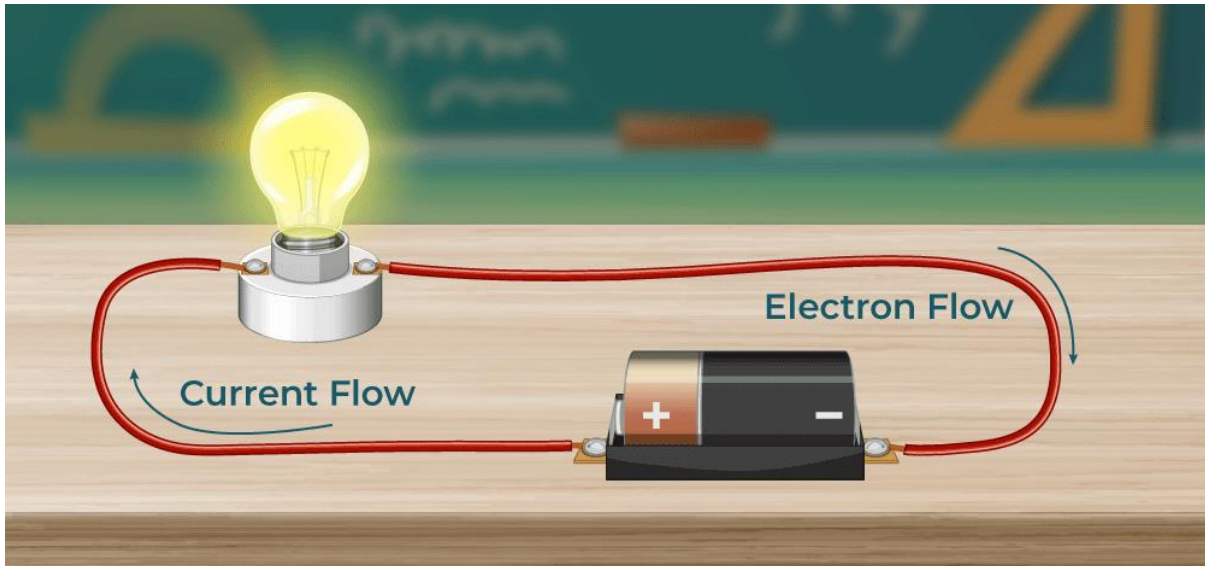


Nurture your dreams

S4 New Curriculum Physics

Theme: Electricity

Chapter 1 – Introduction to current electricity



Importance of electricity

Electricity is woven into nearly every part of our day—it's one of the silent forces that keeps modern life humming.

- Used for lighting of homes, hospitals, industries and streets
- Powers heat and cooling devices such as fans
- Powers appliances (refrigerators, microwaves, washing machines)
- Powering computers, televisions, and phones
- Charging electric vehicles
- Provides light and Powers Medical equipment such as X-ray machines and ultrasound equipment
- Public transportation systems
- Communication, entertainment

Electromotive force (emf)

Electromotive force, or **emf**, is a term used in physics to describe the energy provided by a power source, like a battery or generator, per unit charge as it moves through a circuit. It represents the potential energy that drives electric current around a circuit.

In simple terms, **emf is the “push” that gets electrons moving.**

It’s measured in volts (V), and here’s a basic example: if a battery has an emf of 1.5 volts, it means that it provides 1.5 joules of energy for every coulomb of charge it moves through the circuit.

Sources of electromagnetic force (emf)

Electromotive force (emf) originates from any device or system that supplies electrical energy by converting another form of energy.

1. **Batteries:** These convert chemical energy into electrical energy. Inside, chemical reactions generate an emf that pushes electrons through a circuit—powering everything from flashlights to phones.
2. **Bicycle dynamo:** Changes kinetic energy into electricity
3. **Generators:** Generators convert mechanical energy into electrical energy using electromagnetic induction.
4. **Solar Cells (Photovoltaic Cells):** They use light energy from the sun and convert it directly into electrical energy.
5. **Thermocouples:** These generate emf based on the temperature difference between two dissimilar metals.
6. **Fuel Cells:** Fuel cells also rely on chemical reactions—typically involving hydrogen and oxygen—to continuously generate emf, often used in advanced energy systems like spacecraft.
7. **Piezoelectric Materials:** When these materials are compressed or stretched, they produce emf. You’ll find them in sensors, lighters, or even medical ultrasound devices.

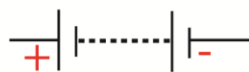
Symbols for emf sources



1 electric cell



2 batteries



many batteries

Trial 1

1. A thermopile is an instrument which converts
 - A. heat energy to electrical energy
 - B. electrical energy to light energy
 - C. light energy to electrical energy
 - D. chemical energy to heat energy [A]

Example 2

Calculate the current produced when a truck battery causes 480C of charge to flow past a point in a circuit in 4s while starting the engine?

$Q = 480\text{s}$ and $t = 4\text{s}$

$$\text{Current, } I = \frac{Q}{t} = \frac{480}{4} = 120A$$

Trial 2

- (a) How long does it take 1.5C of charge to flow through a calculator if a 0.30A current is flowing? [5s]
- (b) Calculate the charge passing when a current of 6A flows through a lamp 2s. [12C]
- (c) A current of 5 A flows through a given point in a circuit of 2 minutes. Calculate the quantity of charge that passes the point. [600C]

Form of charge carrier

They are:

- (a) **Negative ions:** These are from atoms or molecules which have gained electrons.
- (b) **Positive ions:** These are from atoms or molecules which have lost electrons.
- (c) **Free electrons:** Like those in metallic condition.

Note:

The strength of electric current depends on

- (i). the size of charge on each carrier that pass a fixed point per second
- (ii). the number of carriers of charge that pass a fixed point per second

Effects of a current

An electric current has three effects that reveal its existence. These are:

(a) Heating and lighting

This can be shown by the bulb filament where it's heated white hot by current.

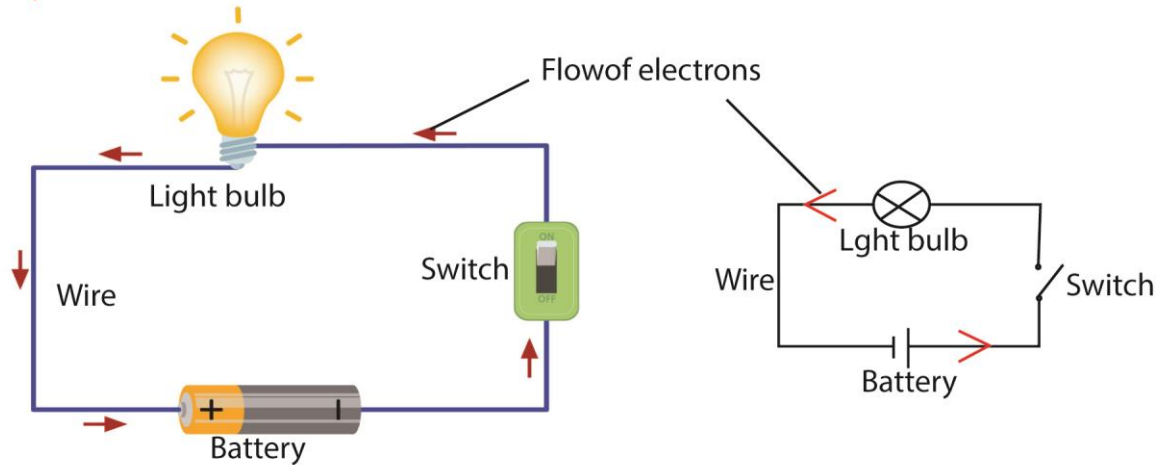
(b) Magnetic

Plotting compass is deflected when placed in field produced by a wire carrying current.

(c) Chemical

Bubbles of gas are given off at the wire carrying current in the acid because of the chemical action of the current.

Simple electric circuit



Conductors and insulators

A **conductor** is any material that allows electric current to flow through it easily. That's because conductors have free-moving charged particles—usually electrons—that can carry electricity. E.g. copper wires, aluminium wire, etc.

Application of conductors in electricity

- **Electrical Wiring:** Copper and aluminum are the go-to materials for wiring in homes, buildings, and power grids.
- **Electronic Devices:** Inside gadgets like smartphones, laptops, and TVs, conductors (often copper, gold, or silver) form intricate circuits that carry signals and power between components.
- **Power Transmission Lines:** High-voltage transmission lines use conductors—usually aluminum reinforced with steel—to carry electricity over long distances from power plants to cities.
- **Electric Motors and Generators:** Conductors wound into coils create magnetic fields when current flows through them—this principle powers motors and generates electricity in turbines.

An **insulator** is a material that resists the flow of electric current. E.g. rubber, wood, glass, plastic.

Application of insulators in electricity

- Socket covers
- Insulate connecting wire at home
- Electric device covers protect from electric shocks

Trial 3

Metals are good conductors of heat because

- A. they are ductile
- B. they contain free protons
- C. they contain loose electrons
- D. their atoms can be easily displaced [C]

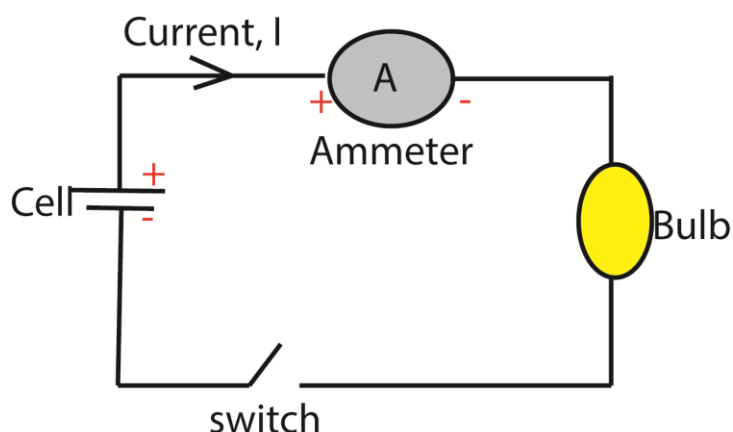
Measuring current

Current is measured by an ammeter



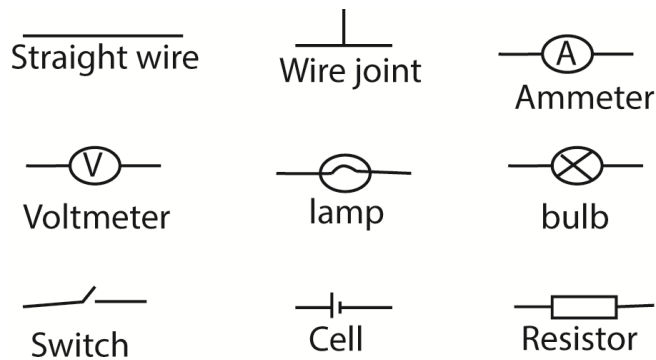
Connecting the Ammeter

In the circuit the Ammeter should be connected in **series** with the part of the circuit for measuring current. Therefore Ammeter is connected such that current flows directly through it. The positive of the cell is connected to the positive of the Ammeter (red terminal in color), while the negative of the cell is connected to the negative of the Ammeter (black terminal in color). In case the ammeter reads in the reverse direction, interchange the conductors connected to the ammeter



Circuit diagram or electric symbols

Circuit is a complete path of a conductor in which current flows. Some of the symbols used for various parts of an electric circuit



Potential difference (p.d)

Potential difference between any two points in a circuit is the work done for a charge to move from one point to another.

The S.I unit of potential difference is a volt (V). The other units include

- mill volt (mV)

$$1V=1000mV$$

$$1mV = \frac{1}{1000}V$$

Example 3

Change 200mV to V

$$1mV = \frac{1}{1000}V$$

$$200mV = \frac{200}{1000} = 0.2V$$

Other large unit kV, MV.

$$1kV = 1000V = 10^3V.$$

$$1MV = 1000000V = 10^6V$$

Measuring electromotive force and potential difference

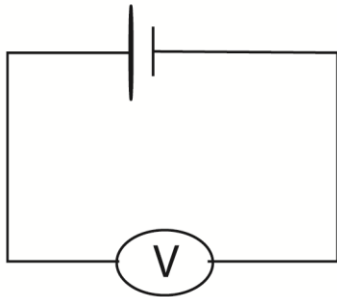
Electromotive force and potential difference are measured by voltmeter.



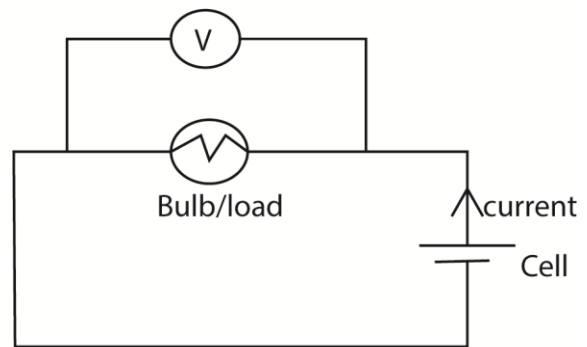
Connecting voltmeter

A voltmeter is connected across the load whose potential difference is required.

Using a voltmeter



Voltmeter reads emf of cell



voltmeter potential difference across the bulb or load

Definition

A **volt** is the SI unit of electromotive force, the difference of potential that that carry one ampere of current against one ohm resistance.

Or

$$\text{Volt} = \frac{\text{workdone in moving a charge}}{\text{charge}}$$

But work done in moving a charge is the electrical energy

$$\therefore \text{Volt} = \frac{\text{Electrical energy}}{\text{charge}}$$

$$\text{Electrical energy} = \text{Volt} \times \text{charge}$$

$$\text{Electrical energy} = VQ$$

$$\text{But } Q = It$$

$$\text{Electrical energy} = VIt$$

Example 4

Calculate the potential difference across a device if 6J of electrical energy is changed by the device when 2C pass it.

$$\text{Electrical energy} = 6\text{J}$$

$$Q = 2\text{C}$$

$$\text{Electrical energy} = QV$$

$$6 = 2V$$

$$3V = V$$

Example 5

Calculate the energy supplied to a 240V lamp if 0.1A flows for 1s

$$I = 0.1\text{A} \quad t = 1\text{s} \quad V = 240$$

$$\begin{aligned} \text{Electrical energy} &= tIV \\ \text{Electrical energy} &= tIV \\ &= 1 \times 0.1 \times 240 \\ &= 24\text{J} \end{aligned}$$

Example 6

Calculate the energy supplied to a 0.24kV device in which 400mA flows for 2s.

$$V = 0.24\text{kV} = 0.24 \times 1000\text{V} = 240\text{V}. \quad t = 2\text{s}. \quad I = 400\text{mA} = \frac{400}{1000} = 0.4\text{A}.$$

$$\begin{aligned} \text{Energy supplied} &= VIt \\ &= 240 \times 0.4 \times 2 \\ &= 192\text{J} \end{aligned}$$

Trial 3

An electric heater is used to heat 0.2kg of water for 200s. find the p.d across the heater if the current through it is 0.5A and the temperature of the water rises by 25°C [210V]

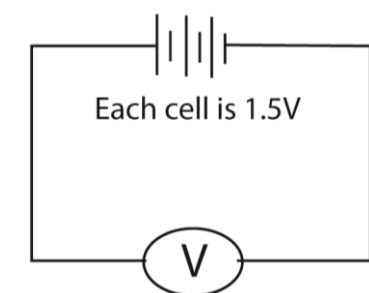
Arrangement of cells

Series arrangement of cells

When cells are arranged in **series**, they're connected end-to-end so that the voltage adds up. i.e., The **positive terminal** of the first cell is connected to the **negative terminal** of the second cell. This pattern continues for any additional cells. The **free terminals** at the ends (negative of the first and positive of the last) are connected to the rest of the circuit.

Example 7

Find the reading of the voltmeter below



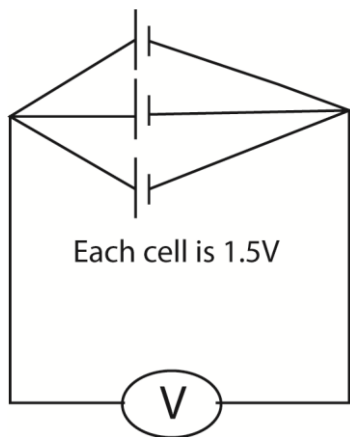
There 3 cells in series

$$\text{Reading of the voltmeter} = \text{Total voltage} = 1.5 + 1.5 + 1.5 = 4.5\text{V}$$

Parallel cell arrangement

When cells are arranged in **parallel**, all their **positive terminals are connected together**, and all their **negative terminals are connected together**. This setup keeps the voltage the same as a single cell, but it increases the total current the combination can supply.

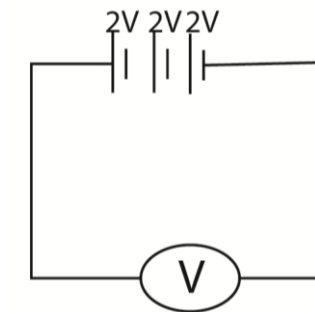
Example 8



There are 3 cells in parallel each 1.5V; hence the voltmeter reading is 1.5V

Trial 4

Find reading of the voltmeter below [6V]



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Thanks

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