

Electricity

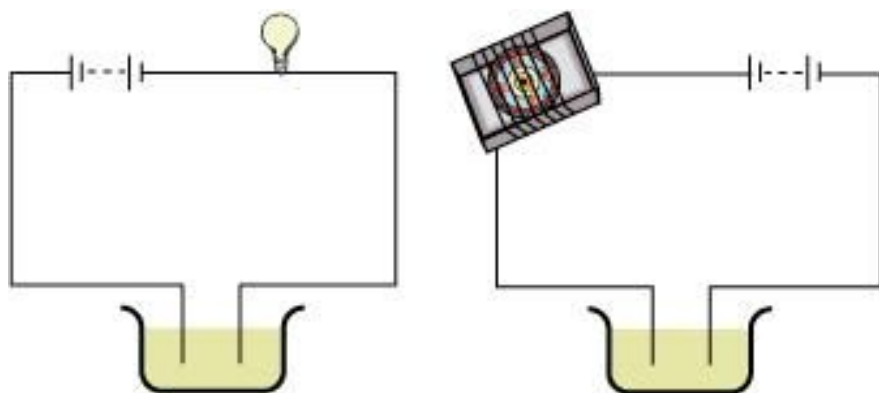
- Electric potential: The Electric potential of a point in an electric field is defined as the work to be done to move a unit positive charge from infinity to that point.
- Potential difference: The potential difference between two separate points is defined as the work done to move a unit positive charge from one point to another.

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

Unit: Volt

$$1 \text{ Volt} = \frac{1 \text{ joule}}{1 \text{ coulomb}}$$

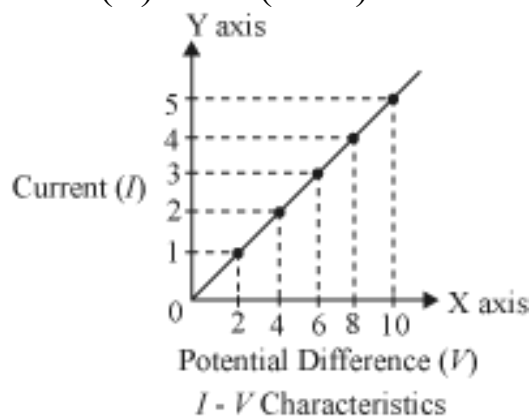
$$1 \text{ V} = 1 \text{ J C}^{-1}$$



- The bulb will glow or the magnetic needle will show deflection if the liquid in the beaker is a good conductor of electricity.
- Greater the deflection of needle or brighter the light, better is the conductivity of the liquid.

| Good conductor | Poor conductor |
|-----------------------|-----------------------|
| Lemon Juice | Coal tar |
| Vinegar | Distilled water |
| Acid solutions | Honey |
| Basic solutions | Vegetable oil |
| Salty water | Kerosene |

- Conducting liquids are also called electrolytes.
- The electric current passing through a conducting liquid (electrolyte) causes chemical reactions (electrolysis).
- **Ohm' law:** Under constant physical conditions (i.e., constant temperature, pressure etc.), the current flowing through a conductor is directly proportional to the potential difference across the conductor.
- $V \propto I$
- $V = IR$ ($R =$ resistance)
- **Unit** (R) $\rightarrow \Omega$ (Ohm)



$$1\Omega = \frac{1V}{1A}$$

- **Ohmic resistors:**

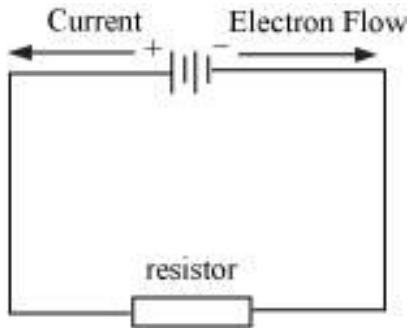
Conductors which follow the ohm's law at constant temperature are called ohmic resistors. Examples: All metallic conductors (Copper, Aluminium, silver etc.), copper sulphate solution with copper electrodes, and dilute sulphuric acid etc.

- **Non-ohmic resistors:**

Conductors which do not follow the ohm's law are called non-ohmic resistors. Examples: LED, solar cell, junction diode, transistor, bulb filament etc.

- Potential difference (which is measured in Voltage) is the cause of current (which is measured in Ampere).
- In conductors, flow of electrons constitutes the current. In a circuit current flow from the positive terminal of the battery to the negative terminal, but electrons travel from negative terminal to the positive terminal. The negative terminal of

a battery is said to be at lower potential and the positive terminal is said to be at higher potential.



- When a battery is not connected to any circuit, the potential difference across the terminals of the battery is equal to the EMF of the battery. (EMF = Electro Motive Force).
- The more the number of collisions of electron with the atoms, the more is the resistance offered by a conductor.
- Electric resistance can be defined as the obstruction or opposition to the drifting electrons.
- Electric resistance completely depends on the nature of a conductor.
- **Units of Resistance:**

Resistance is measured in ohms (Ω).

Emf (E): The amount of work done (W) per unit charge in taking a positive charge around the complete circuit of a cell. Its SI unit is volt (V).

$$E = Wq$$

Factors affecting emf of a cell

- the material of the electrolyte
- the electrolyte used in the cell

Terminal voltage of a cell (V): The amount of work done (W') per unit charge in taking a positive charge around the circuit connected across the terminals of a cell. Its SI unit is volt (V).

$$V = W'q$$

Voltage drop in a cell (v): The amount of work done (w) in taking a unit positive charge through the electrolyte inside a cell. Its SI unit is volt (V).

$$V = wq$$

Relation between emf (E), terminal voltage (V) and internal resistance (r)

$$E = V + v$$

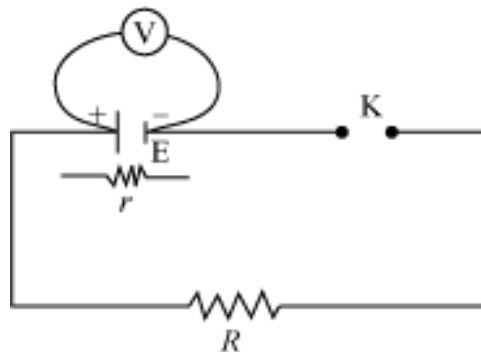
Internal resistance (r) of cell: The resistance offered by the electrolyte of a cell to the flow of electric current through it.

$$v = Ir$$

Factors affecting internal resistance of a cell

- The surface area of electrodes
- The distance between the electrodes
- The temperature of the electrolyte
- The concentration of the electrolyte
- The nature of the electrolyte

Relation between emf (E), terminal voltage (V) and internal resistance (r)

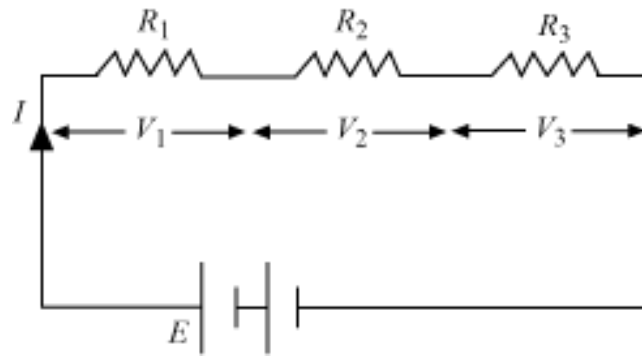


$$\therefore V = \frac{E}{r + R} R$$

$$r = \left(\frac{E}{V} - 1 \right) R$$

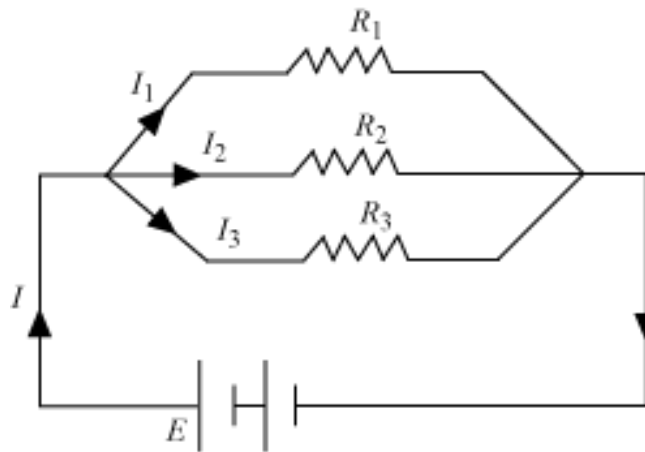
Combination of resistors

Resistors in series



- Equivalent resistance, $R_S = R_1 + R_2 + R_3$
- Equivalent resistance is always greater than the largest resistance present in the combination
- $E = V_1 + V_2 + V_3$

Resistors in parallel



- Equivalent resistance (R_p), $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
- Equivalent resistance is always less than the smallest resistance present in the combination
- $I = I_1 + I_2 + I_3$
- **Electric power:** Electric power is defined as the rate of consumption of energy or simply the rate of doing work.

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

- **SI unit of power is watts (W)**
- **1 kWh is the commercial unit of electric energy.**

- **1 Unit** – 1 kWh = 3.6×10^6 J
- $1 \text{ W} = 1 \text{ V} \times 1 \text{ A}$
- **Joule's heating** law suggests that heat produced in a resistor is directly proportional to the
 1. square of the current flowing through the resistor i.e., $H \propto I^2$
 2. resistance of the resistor i.e., $H \propto R$
 3. time for which the current flows through the resistor i.e., $H \propto t$
- Electric energy = VIt

$$\begin{aligned} \text{Heat, } H &= VIt \\ &= I^2 R t \end{aligned}$$

- **Application:**

Electric iron, toaster, fused wire, bulb

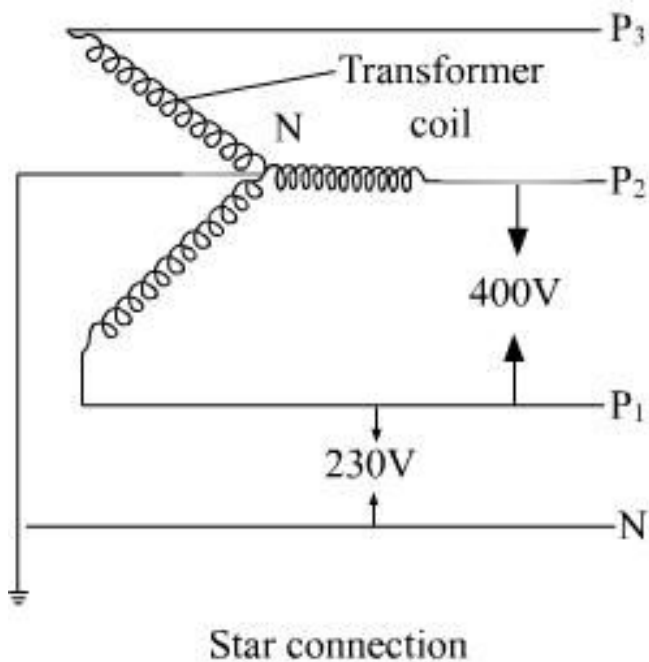
- **Fused wire:** a low-melting point wire connected in series with electric devices for safety.

1. Electricity produced in a power station is transmitted for industrial and domestic uses with the help of transformers, wires, towers, etc.
2. After generating electricity, a power transformer is used, at heavy load, for its transmission.
3. At the initial stage of power transmission a step-down transformer is used to step-down (decrease) the voltage of electricity.
4. In an electric line, energy is lost in the form of heat. This loss is known as **transmission loss**.
5. Energy loss in the form of heat, during the transmission of electricity is minimal when the electricity is transmitted at a high voltage for a given power. This is because at high voltage, the current flowing through the wire is minimal.
6. Heat loss in the transmission network depends on the following three factors:
 - (i) Magnitude of the electric current flowing through the wires
 - (ii) Resistance of the wires

(iii) Time for which current is flowing

7. At the last stage of transmission, a distribution transformer is used for the distribution of electricity at low voltage. This voltage is less than 33 kilo volts for industrial purposes and around 220V for domestic purposes.

8. Wires are connected in star mode connection in the secondary coil of the distribution transformer for three phase line.

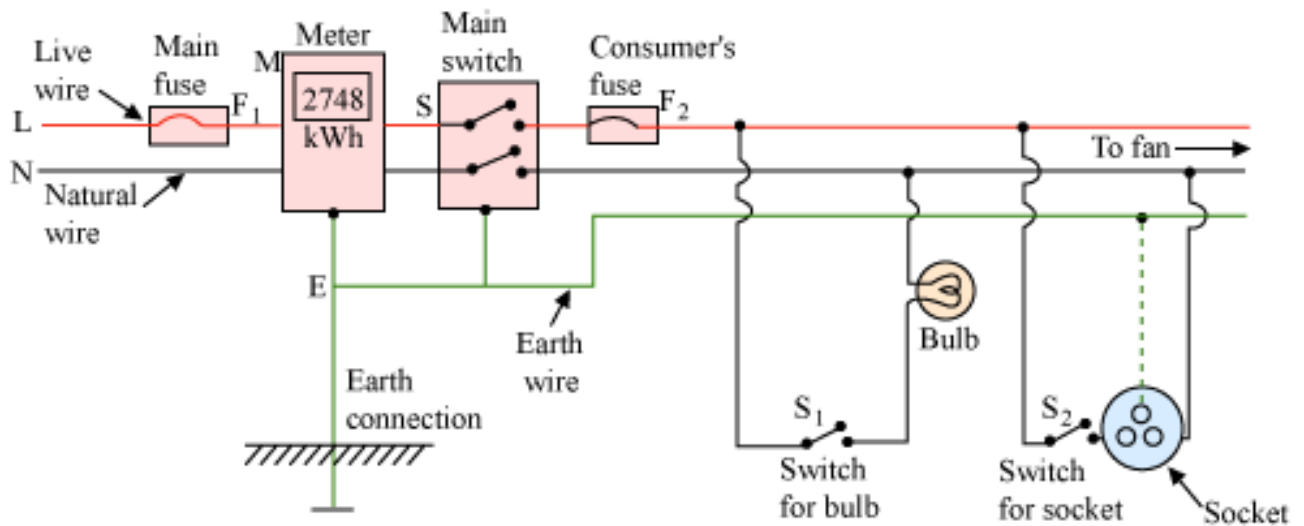


We get four lines out of the distribution transformer; three phase lines and one neutral line.

From this distribution system, we can see that P₃ and N line are used for the domestic purpose

- **Domestic wiring**

Electricity is transferred to our homes through a pair of wires consists of a red colour wire (called **live wire, L**), and a black colour wire (called **neutral wire, N**). In addition to these wires, a green colour wire known as the **Earth wire, E** is also connected with the circuit. In India, 220 V potential is supplied through live wire, while neutral wire has ground potential of zero volts.



- **Switches:** It is a device which is connected in the live wire so as to turn 'ON' or 'OFF' the current in the circuit.

Types of switches:

- 1) Single pole switch:
 - 2) Double pole switch:
- Fuse is the most important safety device, used for protecting the circuit due to short-circuiting or overloading of the circuit.

Characteristic of electric fuse

- Fuse wire has low melting point. It is generally made up of an alloy of lead and tin.
- Fuse wire is always connected in the series with the live wire. Its resistance is higher than that of the copper wires. So it gets heated up much faster than the copper wire when excessive current flows through it.
- Current rating of the fuse wire decides its thickness. More the current rating of the fuse wire, more will be its thickness.