Ohm’s Law

It is the most fundamental Law of electricity and was given by George Simon Ohm in 1828.
"It states that if the Physical condition like, temperature, remains unchanged, then the current (I) flowing through a conductor is always directly proportional to the potential difference (V) across its two ends."
Mathematically,

$$V \propto I$$

$$V = RI .$$

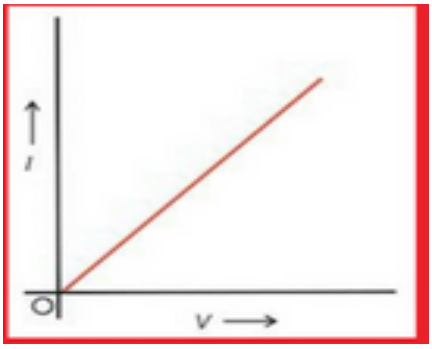
Where R is constant of proportionality and here R is known as electrical resistance of conductor.
The value of resistance (R) depends upon the nature of conductor, its dimensions and physical conditions.
The value of resistance (R) independent of the value of V and I.

A conducting device obeys Ohm’s law when the resistance of the device is independent of the magnitude and polarity of the applied potential difference.
A conducting material obeys Ohm’s law when the resistivity of the material is independent of the magnitude and direction of the applied electric field.

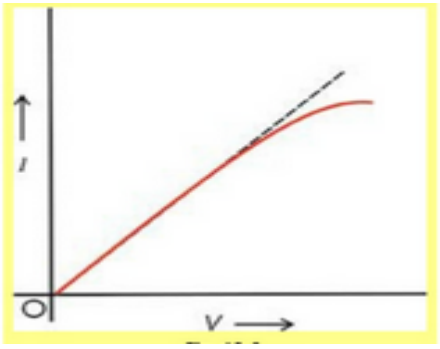
How does Ohm’s Law work?

Ohm’s Law describes the current flow through a resistance when different electric potentials (voltage) are applied at each end of the resistance. Since we can’t see electrons, the model or an analogy of electric circuits used to help us understand circuits better is the water-pipe analogy. Water flowing through pipes is a good mechanical system that is analogous to an electrical circuit. Here, the voltage is analogous to water pressure, the current is the amount of water flowing through the pipe, and the resistance is the size of the pipe. More water will flow through the pipe (current) when more pressure is applied (voltage) and the bigger the pipe, (lower the resistance).

The materials which obey Ohm's law are called Ohmic conductors.



The materials which don't obey Ohm's law are called non-Ohmic conductors.



Different Applications of Ohm's Law

The main applications of Ohm's law are:

1. To determine the voltage, resistance or current of an electric circuit.
2. Ohm's law is used to maintain the desired voltage drop across the electronic components.
3. Ohm's law is also used in dc ammeter and other dc shunts to divert the current.

Examples Of Ohm's Law In Everyday Life

1. Conventional domestic fans
2. Electric heaters
3. Electrical kettles and irons
4. Design of electric devices
5. Fuse design
6. Mobile or laptop charger

Limitations of Ohm's Law

Following are the limitations of Ohm's law:

1. Ohm's law is not applicable for unilateral electrical elements like diodes and transistors as they allow the current to flow through in one direction only.
2. For non-linear electrical elements with parameters like capacitance, resistance etc the voltage and current won't be constant with respect to time making it difficult to use Ohm's law.

Electrical Resistance

"Electrical resistance may be defined as the force which opposes the flow of electric current through it."

According to Ohm's law, V = IR

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

from this equation,*"Resistance of a conductor is also defined as the ratio of Potential difference (V) across the ends to of the conductor to the current (I) flowing through it."*

Unit: S.I. Unit of resistance is Ohm. It is denoted by **Ω** known as Omega.

"Resistance of a conductor is said to be one Ohm, if one Ampere of current flows through it, when a potential difference of one Volt is applied across the conductor."

$$1 \text{ ohm } (\Omega) = \frac{1 \text{Volt (V)}}{1 \text{ Ampere (A)}} = 1VA^{-1}$$

Resistivity

The resistance of a conductor depends upon the following factors :-

i. It is directly proportional to the length of conductor, i.e.,

$$R \alpha l$$

ii. It is inversly proportional to the area of cross - section of the conductor. i.e.,

$$R \alpha \frac{l}{A}$$

iii. The resistance of condutor also depends upon the nature of material and temperature of the conductor.

By combining above equations we get,

$$R = \rho \frac{l}{A}$$

Where ρ is constant of proportionality and is known as specific resistance or electrical resistivity of the material of the conductor.

If I = 1, A = 1

Then **R = ρ**

Hence Resistivity or specific resistance of the material of a conductor is the resistance offered by a wire of this material of unit length and unit area of cross-section.

(or)

It is also defined as the resistance of unit cube of a material of given conductor.

Unit of Resistivity

$$\rho = R. \frac{A}{l}$$

In S.I. Unit of resistivity,

$$\rho = \frac{ohm \times m^2}{m} = \text{Ohm - m or } \Omega\text{ - m}$$

Conductivity

The reciprocal of resistivity of the material of a conductor is called conductivity. It is denoted by σ

$$\sigma = \frac{1}{\rho}$$

The S.I unit of conductivity is $ohm^{-1}m^{-1}$ ($\Omega^{-1}m^{-1}$) or mho $meter^{-1}$ or simen $meter^{-1}$ (Sm^{-1}).