ELECTRICAL CURRENT & OHMS LAW

By virtue of the fact that charge is conserved current is also conserved. Again using the analogy of water flowing through a pipe - what flows in must flow out. However, charges do not flow the same way in all materials. Some materials are insulators - they act like a plugged up hose. Examples are wood, glass, plastic etc. Others such as copper, aluminum, steel etc. let electrons pass thru them - they are more like big fat hoses. However, even with a fat hose we need some pressure to send the water across from one end to the other. The equivalent of pressure in the case of electrical flow is "voltage" or "potential difference".

The Unit of Voltage is a 'Volt' ! The typical dry cell battery of everyday use has a potential difference of 1.5 V across the + and - terminals.

In order to drive water through a pipe the pressure we apply helps to overcome the resistance of water to flow through the pipe. Similarly the effect of the applied voltage is to overcome an inherent property of all materials to conduct electrons - which we also call as 'resistance'. If we made the resistance of a certain piece of wire larger then we can guess that we will need a correspondingly larger voltage in order to get same current through the wire. Thus we can write:

$$\mathbf{I = V/R}$$

This is the statement of Ohms Law. It may also be rewritten as **V = I R.**

Geometry Dependence of Resistance: The resistance R of a wire is proportional to its length.

$$R \sim \text{length}$$

It is also inversely proportional to the cross sectional area of the wire.

$$R \sim 1/\text{Area}$$

Putting both the above facts together we have:

$R = \rho\, l / A$; where þ is called the resistivity of the material which the wire is made of.

Table : Typical Values for ρ

System	Resistivity (ohm-cm)
Metals	10^{-6}
Alloys	10^{-4}
Semiconductor	1
Insulator	10^{10}
Superconductor	0

Conductance - is the inverse of resistance. Therefore conductivity is the inverse of resistivity.

$$\sigma = 1/\rho$$

The resistivity of most materials depend on temperature. This dependence is parametrized by another constant of the material called "the coefficient of reistivity". It is denoted by the symbol æ and the governing equation is:

$$\rho = \rho_0 [1 + æ (T-T_0)]$$

Application: Resistance thermometry - Calibrate Platinum wire as a function of temperature. Knowing resistance we can deduce temperature. This can be done for example with a "carbon resistor". Note that only certain materials are fit to be used as thermometers. Different materials behave in different ways when chilled. Compare a High Tc wire and a regular metal for example. This is because there are different mechanisms that occur inside these materials that inhibit or facilitate the motion of electrons. In metals the vibrations of atoms hinder the motion of electrons in a process much like good defence in the game of basketball.