Current Electricity - I

Current: Rate of flow of charfe;

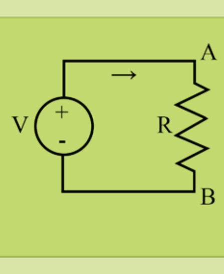
$I = \frac{Q}{t}$ $\quad 1A = \frac{1C}{1s} = 1\ Cs^{-1}$

Instantaneous Current

$I_{inst} = \lim_{\Delta t \to 0} \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}$

If n electrons pass through the cross section of a conductor in time t, then total **charge** passed through the conductor is **Q = n x e**

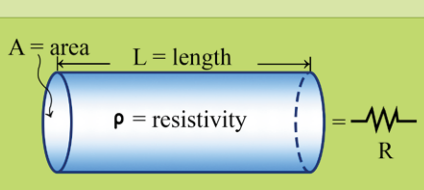
$\boxed{\text{Current } I = \frac{ne}{t}}$



Ohm's Law : $V = IR \Rightarrow R = \frac{V}{I}$

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

Resistance (R) : Obstruction offered to the flow of current by the conductor.



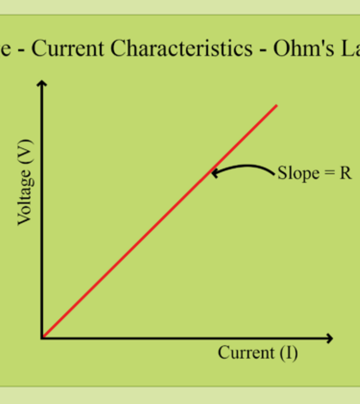
$R = \rho \frac{L}{A}$

For a Cylindrical Wire

$\rho = \frac{1}{\sigma} = \frac{(\pi r^2) R}{l}\ \Omega m$

Current Density $j = \frac{I}{A} = \sigma E$

Voltage - Current Characteristics - Ohm's Law Graph



Drift Velocity & Mobility

$\vec{V}_d = -\left(\frac{e\tau}{m}\right)\vec{E}$

$|V_d| = \left(\frac{e\tau}{m}\right) E = \frac{I}{neA}$

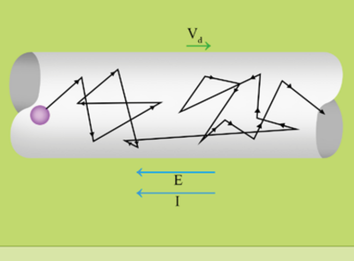
V_d = drift velocity of free electrons

τ = average relaxation time

n = number of free electrons

Mobility $(\mu) = \frac{|v_d|}{E} = \frac{e\tau}{m}$

S. I unit of μ is $\frac{m^2}{V.s}$



Limitations of Ohm's Laws

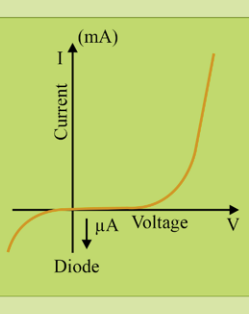
Ohm's Law is NOT applicable to

a) Unilateral Networks: Diodes, Transistors

b) Non - linear elements: Thyristors

For Non - Ohmic Conductors:

V is not proportional to I



Current Electricity - II

Resistivities of Various Materials

Resistivity of

Metals - Lowest

Semiconductors - Moderate

Insulators - Highest

Temperature Dependence Of Resistivity

$\rho_t = \rho_0 [1 + \alpha (T - T_0)]$

ρ_t - Resistivity at a temperature T.

ρ_0 - Resistivity at a reference temperature T_0.

α - temperature coefficient of resitivity

(α >1 for Metals or Conductors)

Note : With increase in temperature,

Resistance of Conductors Increase (&

Resistance of Semiconductors and Insulators decrease

Colour Coding of Resistor

	First Digit	Second Digit	Multiplier	Tolerance
Black	Nil	0	1	Nil
Brown	1	1	10	± 1%
Red	2	2	100	± 2%
Orange	3	3	1000	± 3%
Yellow	4	4	10000	± 4%
Green	5	5	100000	± 0.5%
Blue	6	6	1M	± 0.25%
Violet	7	7	10M	± 0.10%
Grey	8	8	100M	± 0.05%
White	8	9	1G	Nil
Gold	Nil	Nil	÷10	± 5%
Silver	Nil	Nil	÷100	± 10%

Energy and Power

Power dissipated in a resistor $P = I^2R = V^2/R = IV$

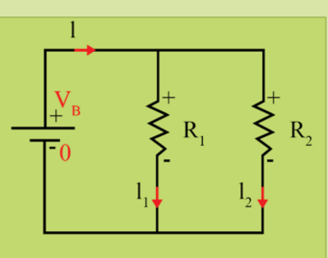
Energy dissipated in a resistor in a time interval Δt is

$\Delta W = IV.\Delta t = I^2R.\Delta t$

(SI unit of Power is Watt & Energy is Joule)

Power dissipated in the transmission wires $P_c = \frac{P^2R_c}{V^2}$

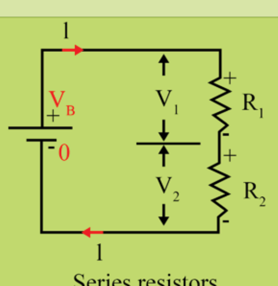
Combination of Resistors



Parallel resistors

$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2}$

In Parallel : The Voltage drop across each of the branches is the same



Series resistors

$R_{equivalent} = R_1 + R_2$

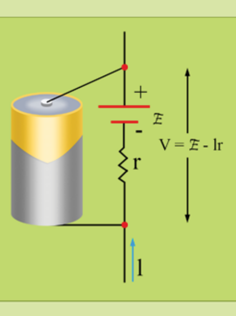
In Series : The current is the same at each resistor

Current Electricity - III

EMF (ε) - Work done per unit charge to take charge from one end (Lower Potential) to the other end (Higher Potential)

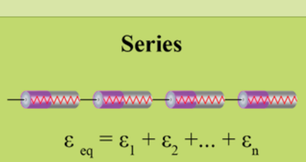
Or:

EMF (ε) - The potential difference between the positive And negative electrodes in an open circuit,



Combination of Cells

Series



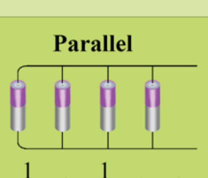
$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 + ... + \varepsilon_n$

$r_{eq} = r_1 + r_2 + ... + r_n$

If Cells are Identical :

$\varepsilon_{eq} = n\varepsilon\ \&\ r_{eq} = nr$

Parallel

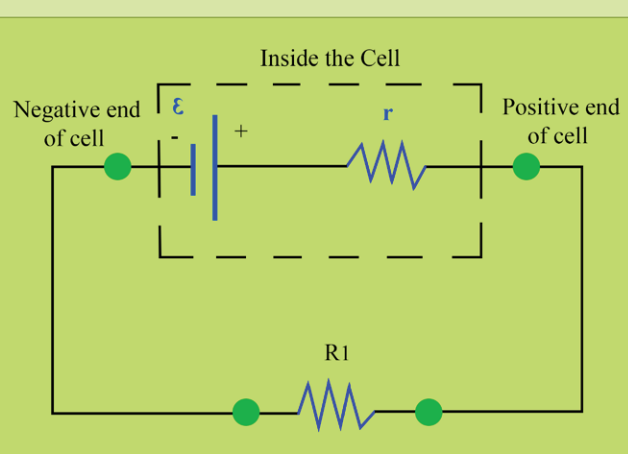


$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + .. + \frac{1}{r_n}$

$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + .. + \frac{\varepsilon_n}{r_n}$

If Cells are Identical :

$\varepsilon_n = \varepsilon\ \&\ r_n = \frac{r}{n}$

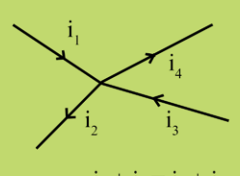


Current in the Circuit

$I = \frac{\varepsilon}{R + r}$

Kirchhoff's Laws

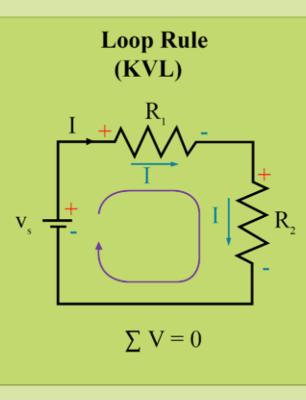
Junction Rule (KCL)



$\Sigma i = 0$

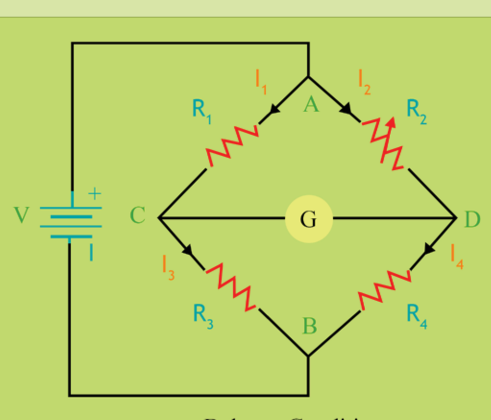
$i_1 + i_3 = i_2 + i_4$

Loop Rule (KVL)



$\Sigma V = 0$

Wheatstone Bridge

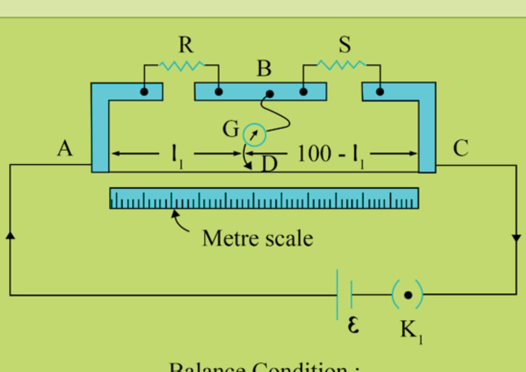


Balance Condition :

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$

Note : Galvanometer gives null deflection for the Balance Condition

Meter Bridge

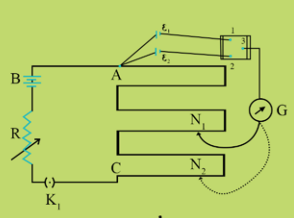


Balance Condition :

$\frac{R}{S} = \frac{l_1}{(100 - l_1)}$

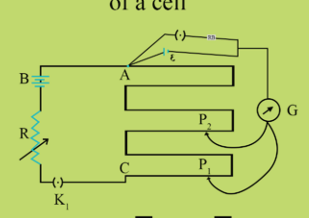
Potentiometer

Potentiometer Circuit for comparing emf 's of two sources



$\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$

Potentiometer Circuit for finding the internal resistance of a cell



$r = R\left[\frac{l_1}{l_2} - 1\right]$