Electric Current

Resistance depending on temperature

- Resistivity of conductor increase with increase in tempreature.
- Resistivity of semiconductor decreases with increases in temperature

Rate of flow

S.I. Unit Ampere (A) Coulomb Second

Instaneous, $i = \frac{d\theta}{dt}$ Average, $i = \frac{\Delta\theta}{\Delta t}$

By convection, direction of flow of positive charge is taken as direction of flow of current. Drift velocity (Vd)

Current, $I = \frac{q}{t} = \frac{ne}{t}$

- In case of electron revolving in a circle of radius r with speed V,
- Period of revolution, $T = \frac{2\pi r}{V}$
- Frequency of revolution, $f = \frac{V}{2\pi r}$
- Current at any point of orbit is $I = \frac{e}{T} = \frac{eV}{2\pi r}$

Kirchoff's laws

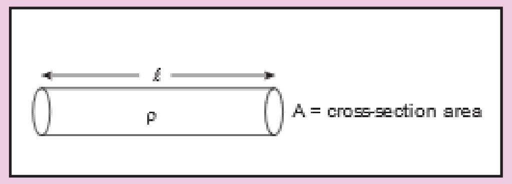
1st law/ Junction law

- Algebraic sum of all the current meeting at junction is zero. i.e., $\Sigma I = 0$

2nd law/loop rule

Algebraic sum in potential around any closed loop is zero

Resistance. (R)



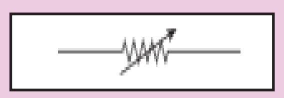
$R = \frac{\rho \ell}{A}$

- Unit of Resistance Ohm (Ω)
- Dependency of R on temperature (T)

  $R_2 = R_1(1 + \alpha (T_2 - T_1))$

  α = Temperature coefficient of resistance
- Symbol

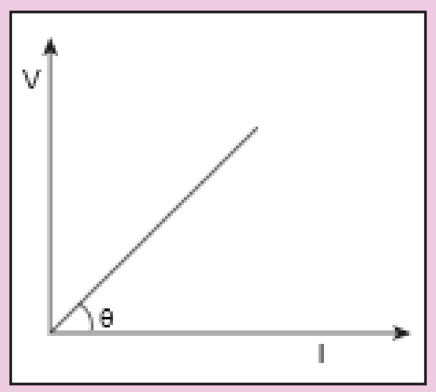
- Rheostate is variable resistance

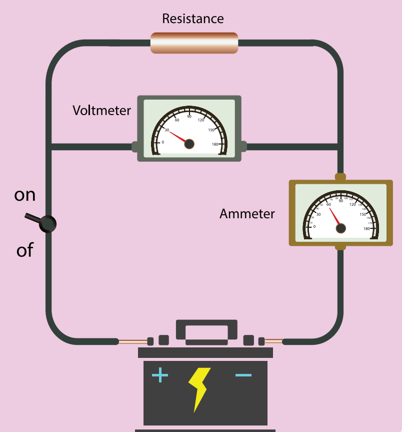


Resistance colour code
R = 1st digit – 2nd digit × 3rd digit + 4th digit%

Ohm's Law

- If physical condition remain same current $I \propto V \Rightarrow V = IR$
- R-electric resistance substances which obey Ohm's law called Ohmic and that do not obey called non-ohmic substances.
- Ohm's law is not valid for semi-conductor
- For Ohmic substances $\tan\theta = \frac{V}{I} = R$





Conductance.

$C = \frac{1}{\text{Resistance}} = \frac{1}{R}$

Unit is mho (Ω^{-1})

Conductivity (σ)

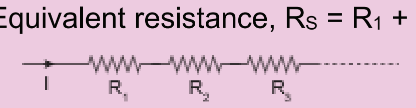
$\sigma = \frac{1}{\text{Resistivity}} = \frac{1}{\rho}$

Unit = $\frac{1}{\Omega m} = \frac{1}{\text{ohm} \cdot \text{m}}$ or $\frac{\text{mho}}{\text{m}}$

Grouping of Resistance

Series grouping of resnstance

- Equivalent resistance, $R_S = R_1 + R_2 + R_3$ .....

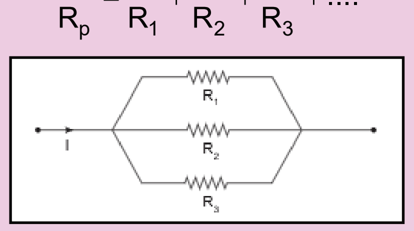


- Current flow through each resistance is same.
- Potential difference, $V \propto R$

Parallel grouping of resistance

- Equivalent resistance.

$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$



- Potential difference across each resistance same

current distribution. in each resistance. $I \propto \frac{1}{R}$

Some Important Formula

- After stretching, it length increases by n times then resistance will increase by n2 times i.e.,

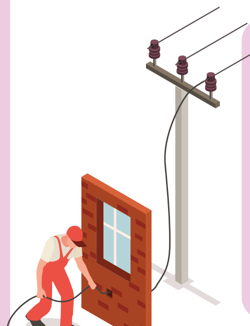
If radius be reduced to $\frac{1}{n}$ times then area of cross-section decreases $\frac{1}{n^2}$ time so the

- resistance become n^4 times i.e., $R_2 = n^4 R_1$

Using n conductors of equal resistance, the number of possible combination is 2^{n-1}.

If the resistance of n conductors are totally different, then the numbers of possible

- combination will be 2^n.



Electric Cell :

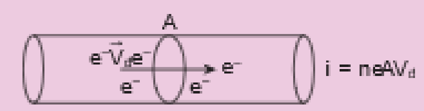
Source of energy that maintains continuous flow of charge in a circuit.

EMF of cell, $\varepsilon = \frac{W}{q}$

Cells in series and parallel

i.e., mixed current in the circuit, $I = \frac{n\varepsilon}{\frac{nr}{m} + R}$

Drift velocity (Vd)



$i = neAV_d = \frac{ne^2 A\tau E}{m} = neAl\mu_e E = neA\mu_e \frac{V}{\ell}$

Average uniform velocity acquired by free electron.

$V_d = \frac{i}{neA} = \frac{J}{ne} = \frac{V}{\rho \ell ne}$ or $\frac{eE}{m}\tau$

$V_d = \mu_e E$ (τ is avg. time between collisions)

mobility, $\mu_e = \frac{V_d}{E}$ (ρ is resistivity unit is Ω.m)

In terms of relaxation time τ_1

$R = \frac{ml}{ne^2 \tau A}$ and $\rho = \frac{m}{ne^2 \tau}$

n, τ, and ρ are properties of material.

Electric Energy and Power

Principle of bulb

- Resistance of bulb, $R = \frac{V^2}{P}$ or $R \propto \frac{1}{P}$ (V and P is rated value on bulb)
- In parallel, $P = P_1 + P_2$
- In Series, $\frac{1}{P} = \frac{1}{P_1} + \frac{1}{P_2}$
- In parallel a bulb having more rated power glows more brightly.
- In series a bulb having less rated power glows more brightly.

- Heat energy developed across a resistor

  $H = I^2Rt$; t = time
- Power, $P = I^2R = \frac{V^2}{R}$
- For transmission cable, power loss, $p_c = I^2R_c = \frac{P^2 R_c}{V_c^2}$, P = const.

Grouping of cells

Cell in Series.

Current in the circuits, $I = \frac{n\varepsilon}{R + nr}$

Cell in Parallel

Current in the circuit, $I = \frac{\varepsilon}{R + \frac{r}{m}}$

Current density. (J)

Current per unit cross-section area perpendicular to current flow.

$J = \frac{I}{A1} = \frac{E}{\rho}$

Meter bridge

Based on wheat stone bridge

$\frac{P}{Q} = \frac{R}{S} = \frac{\ell}{100 - \ell} = \frac{R}{S}$

Balanced Condition of wheat stone bridge

$\frac{P}{Q} = \frac{R}{S}$

Potentiometer

Used to

(i) compare emfs $\frac{E_1}{E_2} = \frac{\ell_1}{\ell_2}$

(ii) final internal resistance of cell $r = \left(\frac{E}{V} - 1\right)S$

Potential gradient (x)

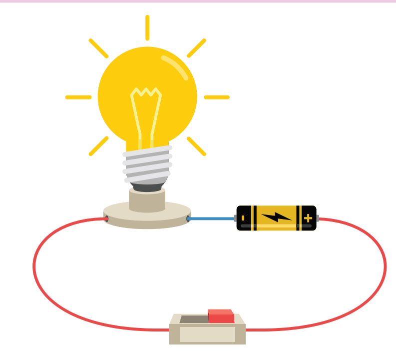
Potential difference per unit length of wire

$x = \frac{V}{L} = \frac{\text{Volt}}{\text{m}}$

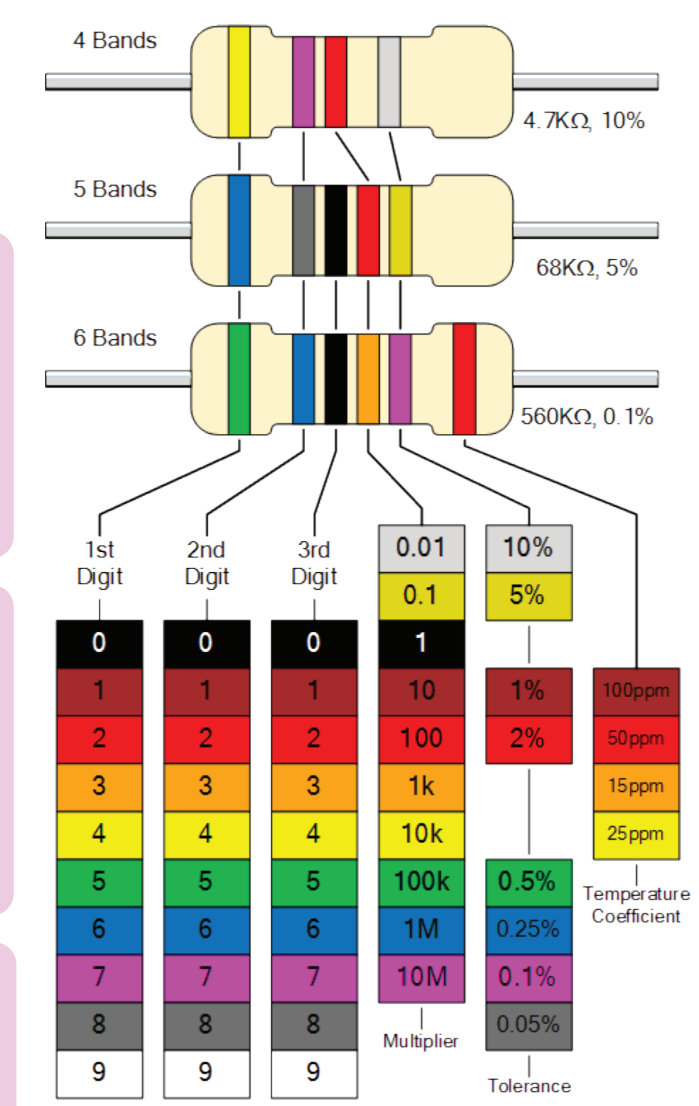
where, $V = iR = \left(\frac{e}{(R + R_n + r)}\right) \times \frac{R}{L}$

Sensitivity of potentiometer

- A potentiometer is more sensitive, if it measures a small potential difference more accurately.



Resistance colour code



When cell is discharging

when cell is discharging current inside the cell is from cathode to anode current $I = \frac{E}{r + R}$

or E = IR + Ir = V + Ir or V = E – Ir

When cell charging

when cell is charging current inside the cell is from anode to cathode.

Current, $I = \frac{V - E}{r}$ or V = E + Ir

When cell is open circuit

$R = \infty$

$I = \frac{E}{R + r} = 0$ and V = E

When cell is short circuited

R = 0 and $I = \frac{-E}{R + r}$ and V = IR = 0

Power transferred to load by cell

$P = I^2R = \frac{E^2R}{(r + R)^2}$ and $P = P_{max}$

if $\frac{dP}{dR}$ and $P = P_{max}$ if r = R

$P_{max} = \frac{E^2}{4r} = \frac{E^2}{4R}$