Understanding Electric Current

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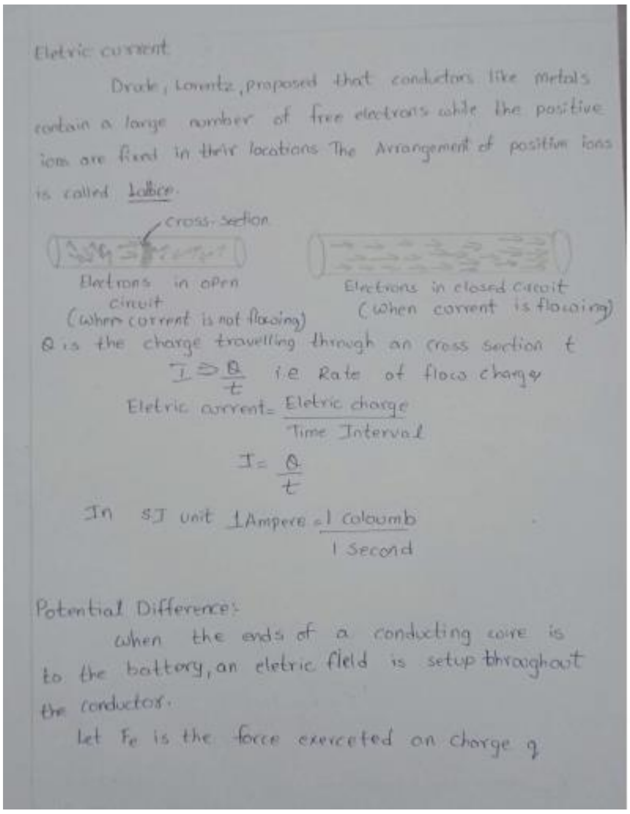


Eletric current

Drude, Lorentz, proposed that conductors like metals contain a large number of free electrons while the positive ions are fixed in their locations The Arrangement of positive ions is called lattice.

Q is the charge travelling through an cross section t

$I = \frac{Q}{t}$ i.e Rate of flow charge

Eletric current = $\frac{\text{Eletric charge}}{\text{Time Interval}}$

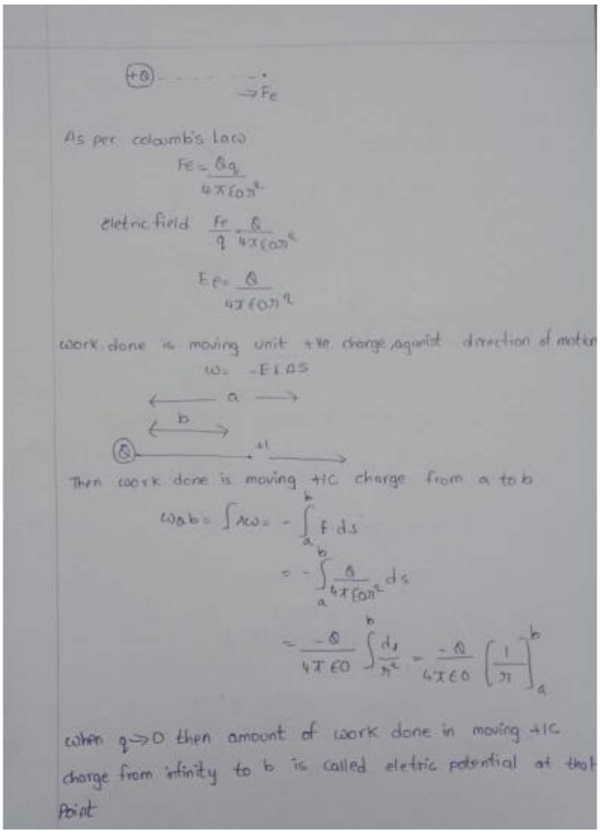
$$I = \frac{Q}{t}$$

In SI unit 1 Ampere = $\frac{1 \text{ Coloumb}}{1 \text{ Second}}$

Potential Difference:

when the ends of a conducting wire is to the battery, an eletric field is setup throughout the conductor.

let F_e is the force exerceted on charge q



As per coloumb's Law

$$F_e = \frac{Qq}{4\pi\epsilon_0 r^2}$$

eletric field $\frac{F_e}{q} = \frac{Q}{4\pi\epsilon_0 r^2}$

$$E_e = \frac{Q}{4\pi\epsilon_0 r^2}$$

work done is moving unit +ve charge, against direction of motion

$$W = -E \, \Delta S$$

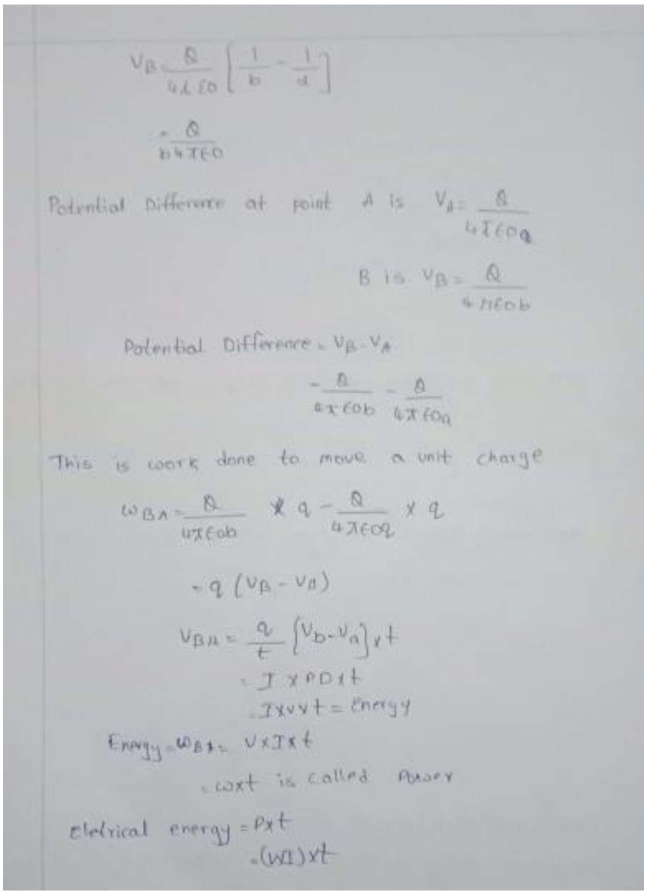
Then work done is moving +1C charge from a to b

$$W_{ab} = \int \Delta W = -\int_a^b F \cdot ds$$

$$= -\int_a^b \frac{Q}{4\pi\epsilon_0 r^2} ds$$

$$= \frac{-Q}{4\pi\epsilon_0} \int \frac{dr}{r^2} = \frac{-Q}{4\pi\epsilon_0} \left[\frac{1}{r}\right]_a^b$$

when $q \to 0$ then amount of work done in moving +1C charge from infinity to b is called eletric potential at that Point



$$V_B = \frac{Q}{4\pi\epsilon_0} \left[\frac{1}{b} - \frac{1}{a}\right]$$

$$= \frac{Q}{b \, 4\pi\epsilon_0}$$

Potential Difference at point A is $V_A = \frac{Q}{4\pi\epsilon_0 a}$

B is $V_B = \frac{Q}{4\pi\epsilon_0 b}$

Potential Difference = $V_B - V_A$

$$= \frac{Q}{4\pi\epsilon_0 b} - \frac{Q}{4\pi\epsilon_0 a}$$

This is work done to move a unit charge

$$W_{BA} = \frac{Q}{4\pi\epsilon_0 b} \times q - \frac{Q}{4\pi\epsilon_0 a} \times q$$

$$= q(V_B - V_A)$$

$$V_{BA} = \frac{q}{t} [V_b - V_a] \times t$$

$$= I \times PD \times t$$

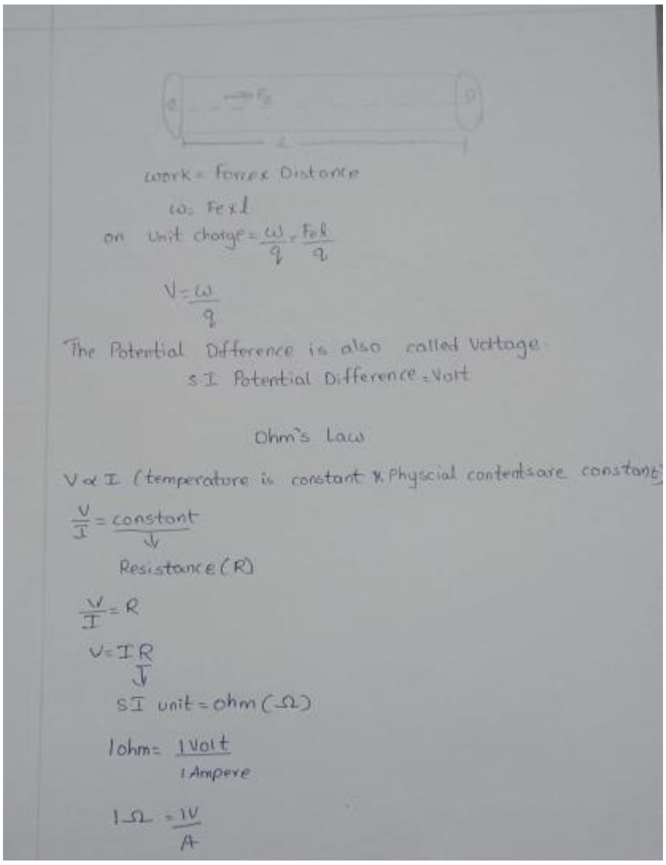
$$= I \times V \times t = \text{Energy}$$

Energy = W_{BA} = $V \times I \times t$

= $W \times t$ is called Power

Electrical energy = $P \times t$

= $(VI) \times t$



work = Force × Distance

$W = F_e \times l$

on Unit charge = $\frac{W}{q} = \frac{F_e l}{q}$

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

The Potential Difference is also called Voltage

S.I Potential Difference = Volt

Ohm's Law

$V \propto I$ (temperature is constant & Physcial contents are constant)

$\frac{V}{I}$ = constant
↓
Resistance (R)

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

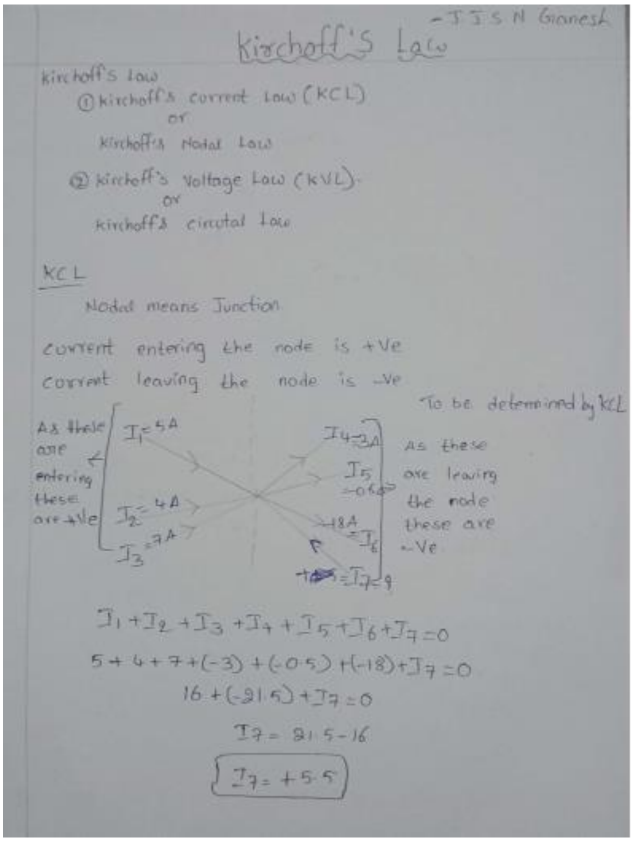
$$V = IR$$

↓

SI unit = ohm (Ω)

1 ohm = $\frac{1 \text{ Volt}}{1 \text{ Ampere}}$

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



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Kirchoff's Law

Kirchoff's Law

1. Kirchoff's current Law (KCL)
   or
   Kirchoff's Nodal Law
2. Kirchoff's Voltage Law (KVL)
   or
   Kirchoff's circutal Law

KCL

Nodal means Junction

current entering the node is +Ve

current leaving the node is -Ve

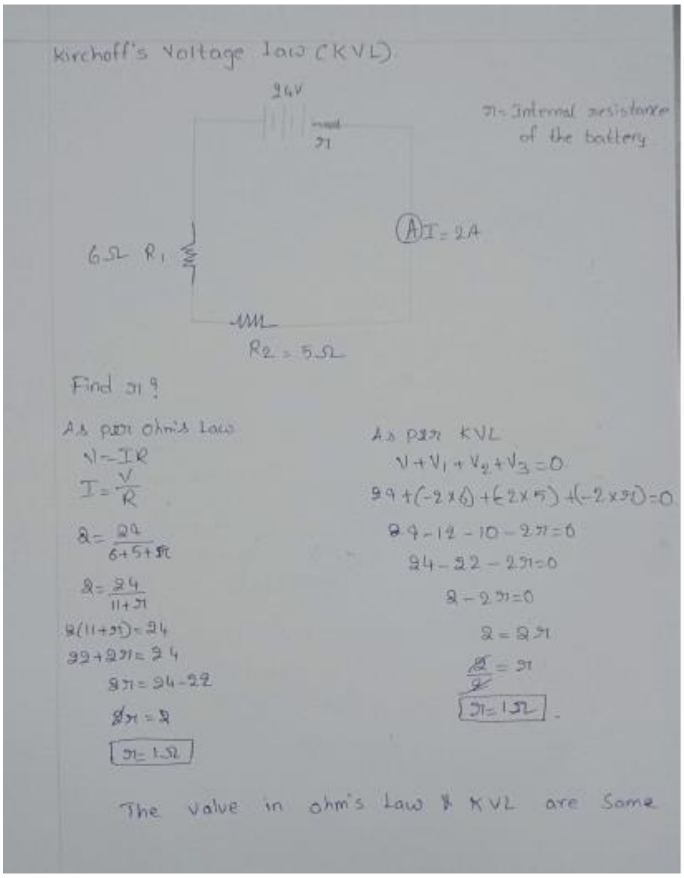
$$I_1 + I_2 + I_3 + I_4 + I_5 + I_6 + I_7 = 0$$

$$5 + 4 + 7 + (-3) + (-0.5) + (-18) + I_7 = 0$$

$$16 + (-21.5) + I_7 = 0$$

$$I_7 = 21.5 - 16$$

$$\boxed{I_7 = +5.5}$$



Kirchoff's Voltage Law (KVL)

Find r?

As per ohm's Law

$V = IR$

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

$2 = \frac{24}{6+5+r}$

$2 = \frac{24}{11+r}$

$2(11+r) = 24$

$22 + 2r = 24$

$2r = 24 - 22$

$2r = 2$

$\boxed{r = 1\Omega}$

As per KVL

$V + V_1 + V_2 + V_3 = 0$

$24 + (-2\times6) + (-2\times5) + (-2\times r) = 0$

$24 - 12 - 10 - 2r = 0$

$24 - 22 - 2r = 0$

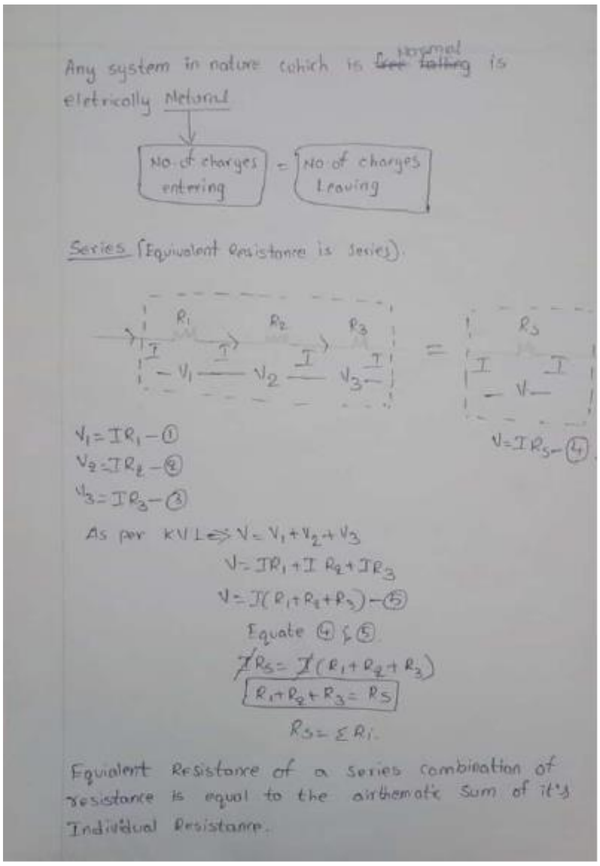
$2 - 2r = 0$

$2 = 2r$

$\frac{2}{2} = r$

$\boxed{r = 1\Omega}$.

The value in ohm's Law & KVL are Same



Any system in nature which is ~~free falling~~ normal is eletrically Netural

No. of charges entering = No. of charges Leaving

Series (Equivalent Resistance is series).

$V_1 = IR_1$ — (1)

$V_2 = IR_2$ — (2)

$V_3 = IR_3$ — (3)

$V = IR_s$ — (4)

As per KVL $\Rightarrow V = V_1 + V_2 + V_3$

$V = IR_1 + IR_2 + IR_3$

$V = I(R_1 + R_2 + R_3)$ — (5)

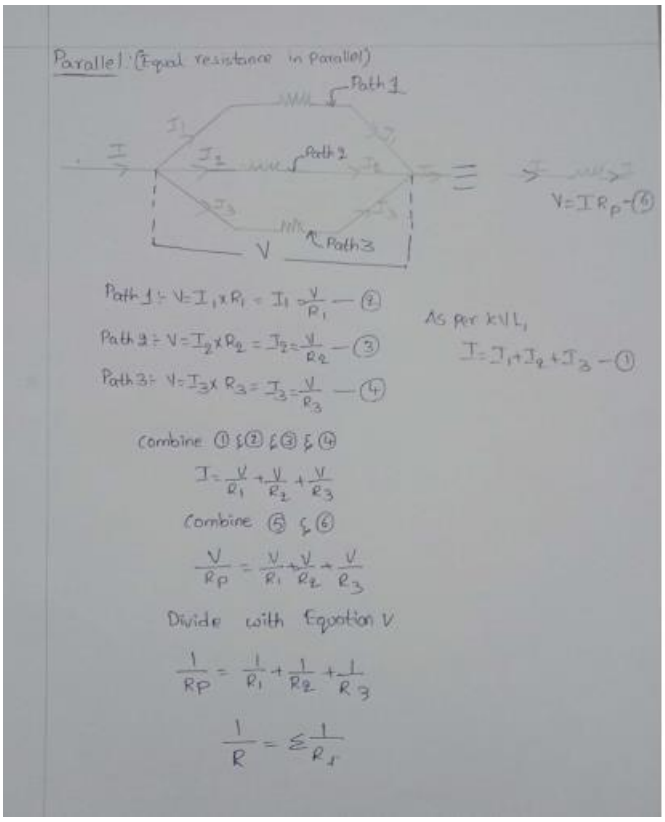
Equate (4) & (5)

$IR_s = I(R_1 + R_2 + R_3)$

$\boxed{R_1 + R_2 + R_3 = R_s}$

$R_s = \Sigma R_i$

Equivalent Resistance of a series combination of resistance is equal to the airthematic sum of it's Individual Resistance.



Parallel (Equal resistance in Parallel)

$V = IR_p$ — (5)

Path 1: $V = I_1 \times R_1 = I_1 = \frac{V}{R_1}$ — (2)

Path 2: $V = I_2 \times R_2 = I_2 = \frac{V}{R_2}$ — (3)

Path 3: $V = I_3 \times R_3 = I_3 = \frac{V}{R_3}$ — (4)

As per KVL,

$I = I_1 + I_2 + I_3$ — (1)

Combine (1) & (2) & (3) & (4)

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Combine (5) & (6)

$$\frac{V}{R_p} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

Divide with Equation V

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

$$\frac{1}{R} = \Sigma \frac{1}{R_r}$$