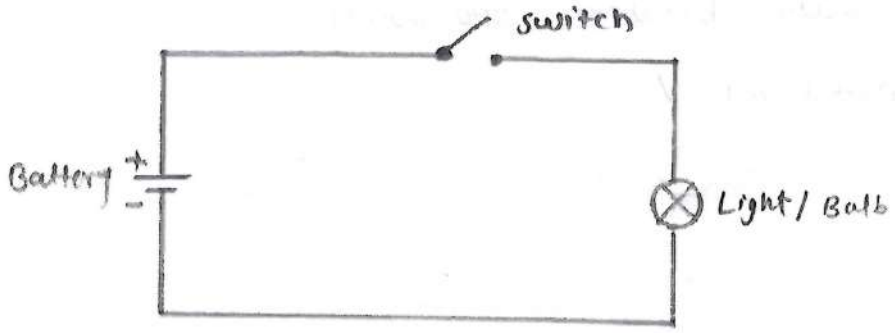
# Unit-I :- Electric and Magnetic circuit.

## * Electric Circuit :-

The electric circuit can be define as closed loop or path, forming a network of electrical components, where electrons can flow. This path is made using electrical wires & it is powered by source like battery




(Simple electric circuit)

## * Current :-

Electric current can be define as movement or flow of electrons (charge) in a conductor. The magnitude of electric current is measured in ~~coulom~~ coulombs per second.

The SI unit of current is 'Ampere' & denoted by 'A'

The relation bet^n charge and current is

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

where; $I$ = Current in Ampere

$Q$ = Charge

$t$ = time in sec.

## * Electromotive force (EMF)

- The electrical force or pressure that causes the electrons to move in perticular direction is called as electromotive force.
- An electromotive force is work done on unit electric charge
- The unit of EMF is Volts & denoted by E
- The formula of EMF =

$$E = \frac{W}{Q}$$

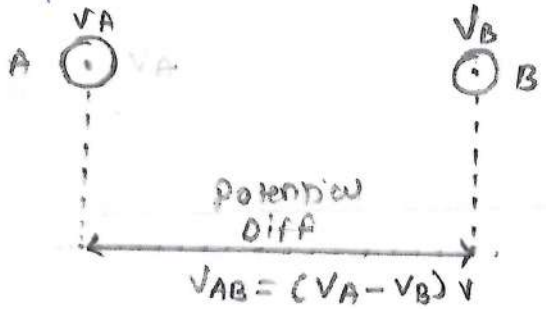
where; $E$ = EMF in volts

$W$ = work done in joules

$Q$ = charge in coulombs.

## * Potential Difference (Voltage)

- It can be define as 'difference bet$^n$ any two points in the electric field is defined as the amount of work done in moving unit positive charge without acceleration from one point to another along any path between two points.
- It is denoted by 'V'




- SI Unit = Volt.

The potential difference between points A & B is

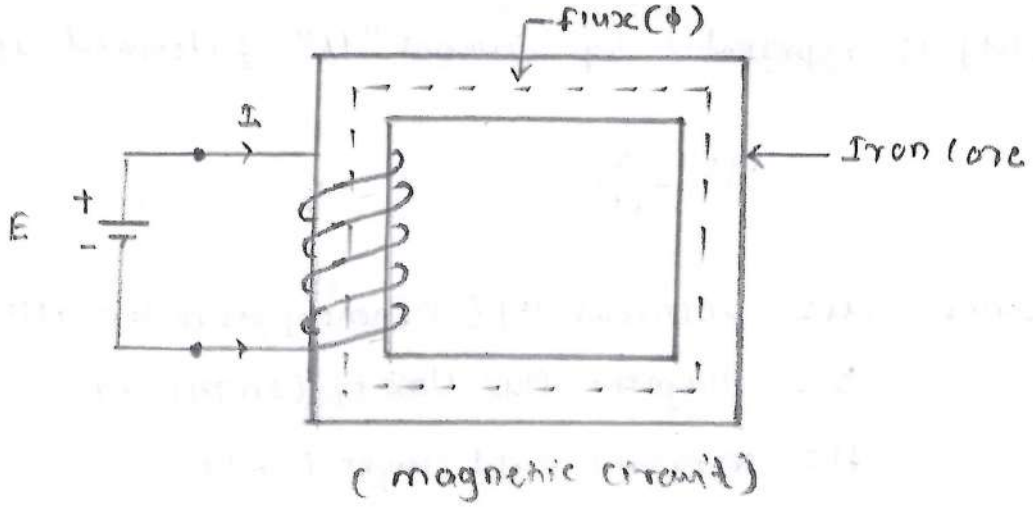
$$V_{AB} = (V_A - V_B) \text{ volts}$$

## * Power :-

- The electric power is the rate at which work is done or energy is transformed into an electrical circuit
- It is product of voltage & current
- The unit of power is "Watt" & denoted by "P".
- Formula fo power = $\boxed{P = V \times I}$

## * Magnetic Circuit :-

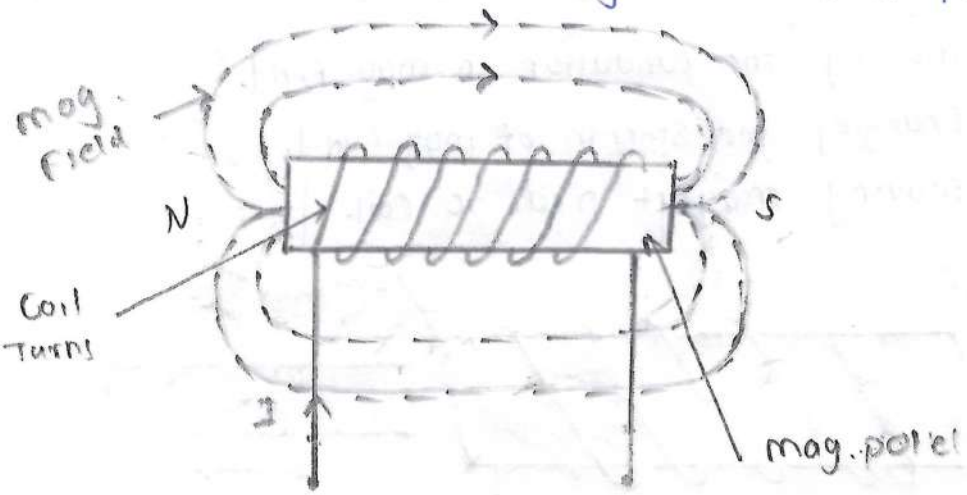
- A magnetic circuit is a closed loop or path through which magnetic flux flows.
- This flux is generated by magnetomotive force (MMF), usually
- created by current passing through a coil of wire wound around a magnetic material (like iron).




( magnetic circuit )

## * Magnetomotive Force (MMF)

- Magnetomotive force (MMF) is the force that drives magnetic flux through a magnetic circuit
- It is created by pussing an electric current through a coil of wire and acts as a source of magnetic field strength in circuit




MMF Depends on :-

- Amount of electric current (in amperes) flowing through coil.
- The numbers of turns of the coil.

formula = MMF = N x I

where ; N = Number of coil turns

I = Current through coil

## * Permeability :-

- It is define as ability of material to allow magnetic flux (magnetic lines) to pass through it.
- It shows how easily a material can be magnetized when placed in magnetic field.

- Permeability is represented by symbol "$\mu$" & defined as

$$\mu = \frac{B}{H}$$

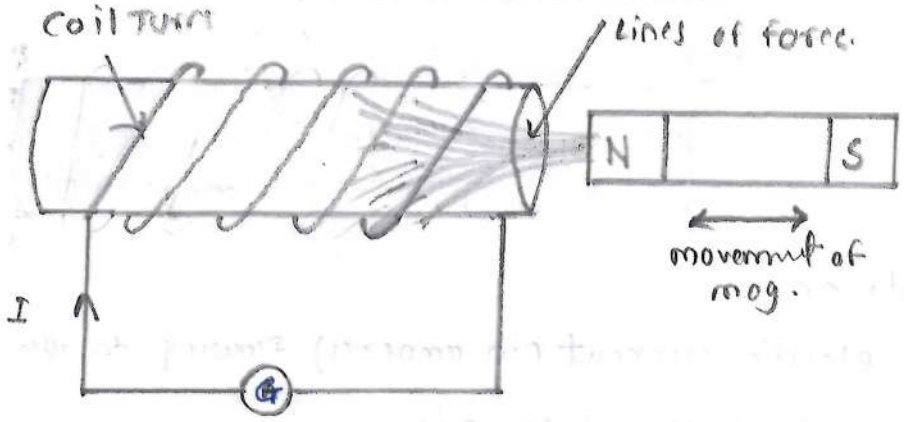
where; $\mu$ = permeability (in henery per meter, H/m)

B = Magnetic flux density (In Tesla (T)

H = Magnetic field strength. ( A/m)

## * Electromagnetic Induction:-

- It can be defined as process by which an electric current is generated in a conductor, when it is exposed to changing magnetic field.
- when a magnetic field passing through a coil or conductor changes either by
  - moving the conductor in mag. field.
  - Changing the strength of mag. field.
  - moving magnet near to coil.




This phenomenon was discovered by Michael faraday in 1831 and is basic principle behind the devices like generators, transformers, and Inductors.

## * Faraday's first law of Electromagnetic Induction.

- Whenever a conductor is placed in varying mag. field, ane (EMF) electromotive force is induced.
- If the conductor circuit is closed, a current is induced, which is called induced current.
- Such an EMF is present as long as change is taking place.

## * faraday's second law of ~~EM~~ electromagnetic Induction

- Whenever conductor cuts by magnetic flux, an emf is induced in the conductor. ~~The magnetude of~~
- The magnetude of which is directly proportional to rate at which the conductor cuts by magnetic field.
- In short second law ~~sett~~ stated that magnetude of induced emf is directly proportional to rate of change of flux linkage.

* **formula:-**

$$EMF = -N\frac{d\phi}{dt}$$

where; EMF = Induced EMF. in V.

N = No. of coil turns.

$\phi$ = Magnetic flux in (Weber)

$\frac{d\phi}{dt}$ = Rate of change of mag. flux.

## * Lenz's law:-

- It state that direction of electric current induced in a circuit by changing mag. field. is such a that magnetic field created by induced current opposes changes in flux
- It can be expressed by eqn

$$EMF = -N\frac{d\phi}{dt}$$

where; EMF = ~~Induced~~ electromotive force ~~in~~ (V.)

N = No. of coil turns

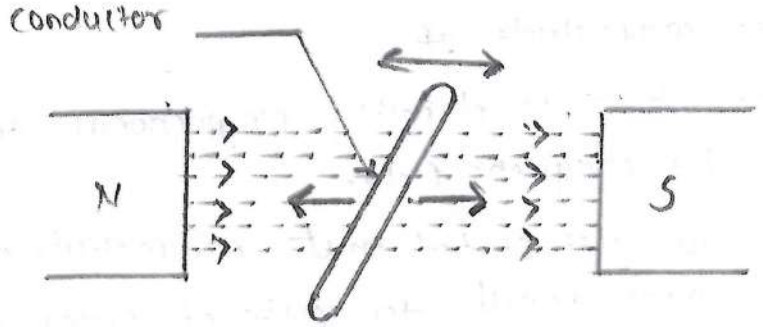
$\phi$ = mag. flux (Wb)

$d\phi/dt$ = rate of change of mag. flux.

(-ve) sign = induced emf opposes the change in mag. flux (by Lenz's law)

## * Dynamically Induced Emf:-

- It is governed by faraday's law of electromgnetic Induction.
- It is generated when current carrying conducter cuts by mag. flux using relative motion.
- It having rotating parts on it which inducing an emf w.r.t. moving parts is known as dynamically induced EMF
- The magnetic field is stationary while conducter moves thrgh it.
- Ex:- generator works on production of dynamically induced Emf




- formula :-

$$EMF = BlV \sin\theta$$

where; B = mag. flux density (Tesla)

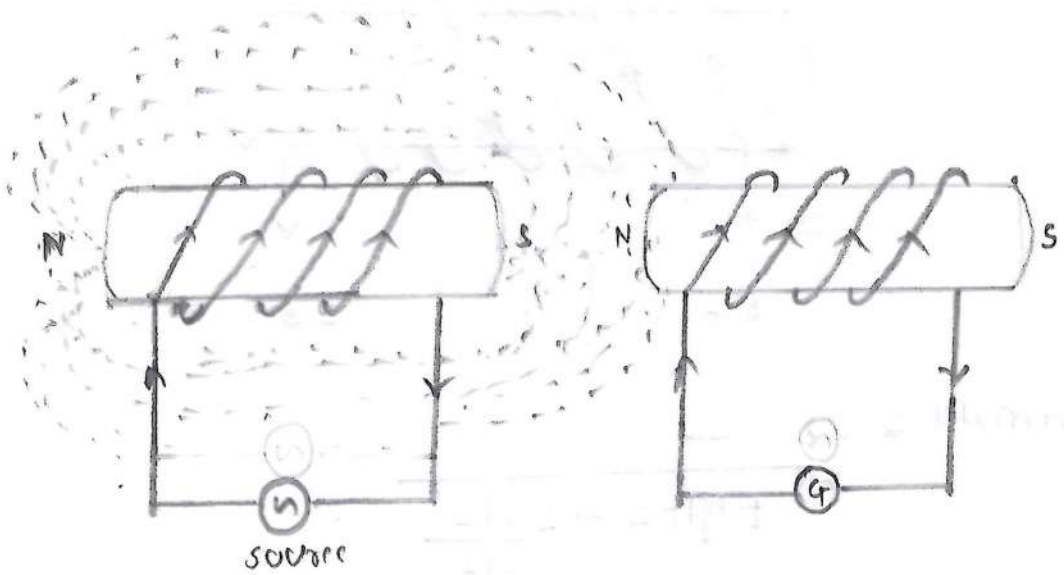
l = length of conducter (M)

V = velocity of conducter (M/s)

$\theta$ = angle betn field and motion of conducter.

## * Statically Induced Emf:-

- It can be defined as EMF generated when a conducter is stationary but magnetic field around it changes or varies.
- which is similar to faraday's law of electromagnetic induction
- when a conducter is placed in a varying magnetic field an emf is induced.
- Ex:- Transformer is example of statically induced emf.




formula :- (by faraday's law)

$$\text{EMF} = -N\frac{d\phi}{dt}$$

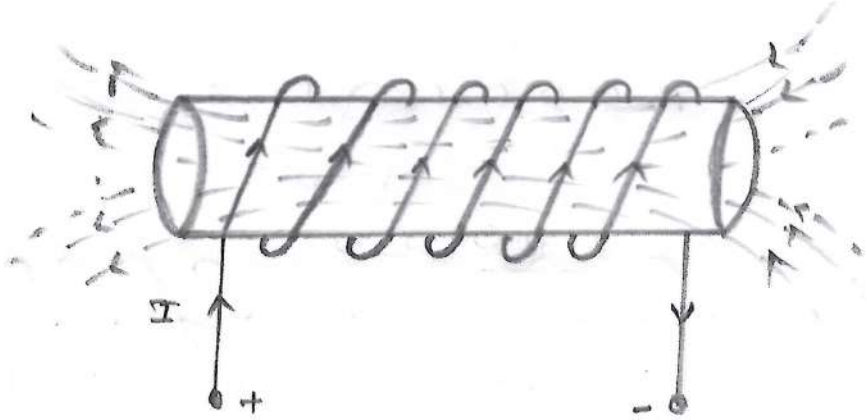
where:- N = no. of coil turns

$\frac{d\phi}{dt}$ = rate of change of mag flux

(−ve) sign = direction of induced emf opposes the cause by (Lenz's law)

## * Self Induced Emf :-

- Self Induced emf is the electromotive force induced in a coil due to change in it's own current.
- when current in a coil changes. magnetic field around it also changes.
- This changing magnetic field links back to the coil itself inducing an EMF in the same coil.
- This is a form of statically induced emf and it is governed by faraday's law and Lenz's law.
- diagram :-




formula =

$$\text{EMF} = -L\frac{dI}{dt}$$

where ;, EMF = self induced emf (V)

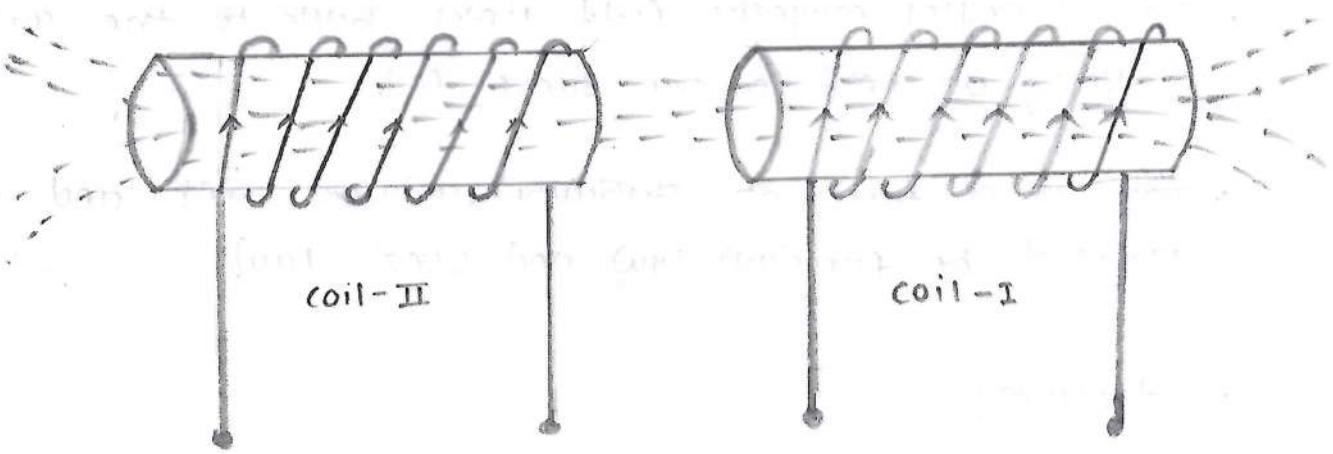
L = self Inductance (H)

$\frac{dI}{dt}$ = rate of change of current w.r.t. time

(-ve) sign show ~~(-ve) sign~~ = opposition to change in current (Lenz law)

## * Mutually Induced EMF :-

- Mutually induced emf is the electromotive force induced in a ~~coil~~ one coil due to changing current in a nearby second coil.
- This occurs through principle of mutual inductance.
- when the mag. field created by one coil links with another coil inducing EMF in it as mag. flux changes.



formula:-

$$\text{EMF(mutual)} = -M\frac{dI}{dt}$$

where; M = Mutual Inductance (H)

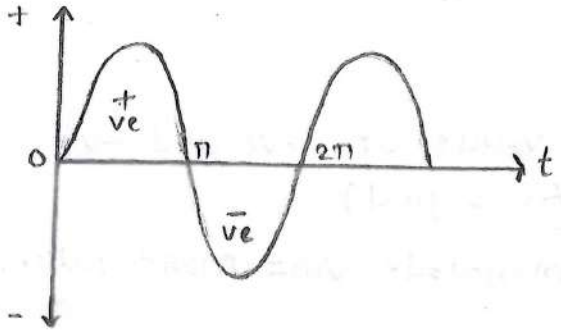
$\frac{dI}{dt}$ = rate of change of current in primary coil.

(-ve) sign shows opposition to cause by (Lenz's law)

## * A. C. signal terms

## * Cycle:-

- A cycle is one complete wave of an alternating quantity
- It includes +ve and -ve half cycle of the waveform.

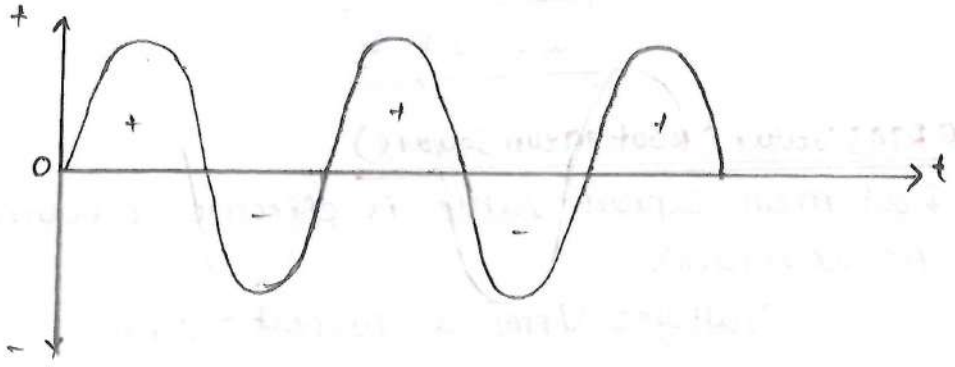



## * Frequency:-

- Frequency can be defined as numbe of cycles per second. in AC waveform.
- Measured in Hz. (Hertz) Denoted by f.

$$f = \frac{\text{cycles}}{\text{seconds}} = \frac{1}{\text{second/cycle}} = \frac{1}{T}$$

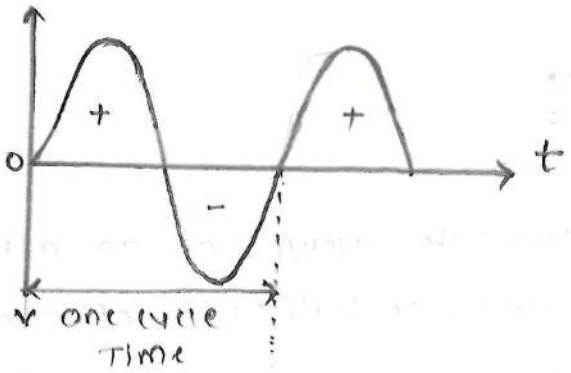
$$\therefore f = \frac{1}{T} \text{ in (Hz)}$$



## *Time Period (T)

- The Time taken to complete one full cycle of an AC signal is known as Time period.
- Measured in Seconds (s)

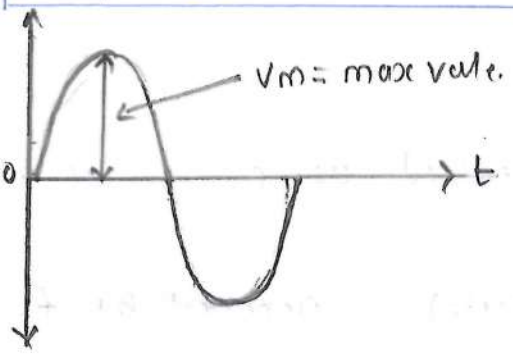
$$\therefore \boxed{T = \frac{1}{f}}$$




## * Amplitude :-

The maximum value of +ve and -ve cycle of alternating quantity of (AC signal)

$$\therefore \boxed{\text{Amplitude } V_m = \text{max}^m \text{ value.}}$$




## * Angular Velocity :- (ω)

- angular velocity can be define as rate of change of angle with rest. to time
- In turms of radians per seconds.

$$\therefore \boxed{\omega = 2\pi f}$$

## * RMS Value (Root Mean Square)

Root mean square value is effective or equivalent DC value of an AC waveform.

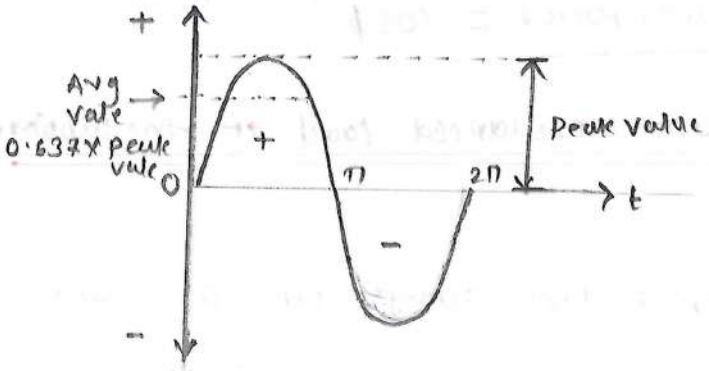
Voltage = Vrms & current = Irms

$$\boxed{\text{RMS} = 0.707 \times \text{Peak value}}$$

## * Average Value :- (sine wave)

An AC quantity is equal to avrage of all instantenious value over one half cycle of waveform.

Avrage value = 0.637 X peak value.




## * Form Factor :-

form factor is a ratio of RMS value to avrage value of AC waveform.

$$FF = \frac{RMS}{Peak\ value} = \frac{0.707 \times V_{max}}{0.637 \times V_{max}} =$$

$$\therefore \boxed{\text{form factor} = 1.11}$$

## * Peak Factor (crest factor)

Peak factor is a ratio of peak (maxm) value to RMS value

$$\boxed{\text{Peak factor} = \frac{Peak}{RMS} = 1.414 \text{ (for sine wave)}}$$

## * Impedance :-

- Impedance can be defined as Total opposition to the flow of AC alternating current in a circuit.
- Include resistance (R) & reactance (X)

$$\therefore \boxed{Z = \sqrt{R^2 + X^2}}$$

## * Phase Angle ($\phi$) :-

phase angle is angular difference bet two waveforms tipically for voltage and current in AC quantity. is know as phase angle

## * power factor :- (PF)

- It is measure of how effectively electrical power is used in AC system
- It is ratio of real working power to apperent power.

$$\text{power factor} = \cos\phi$$

## * Balance load :- and unbalanced load of the supply.

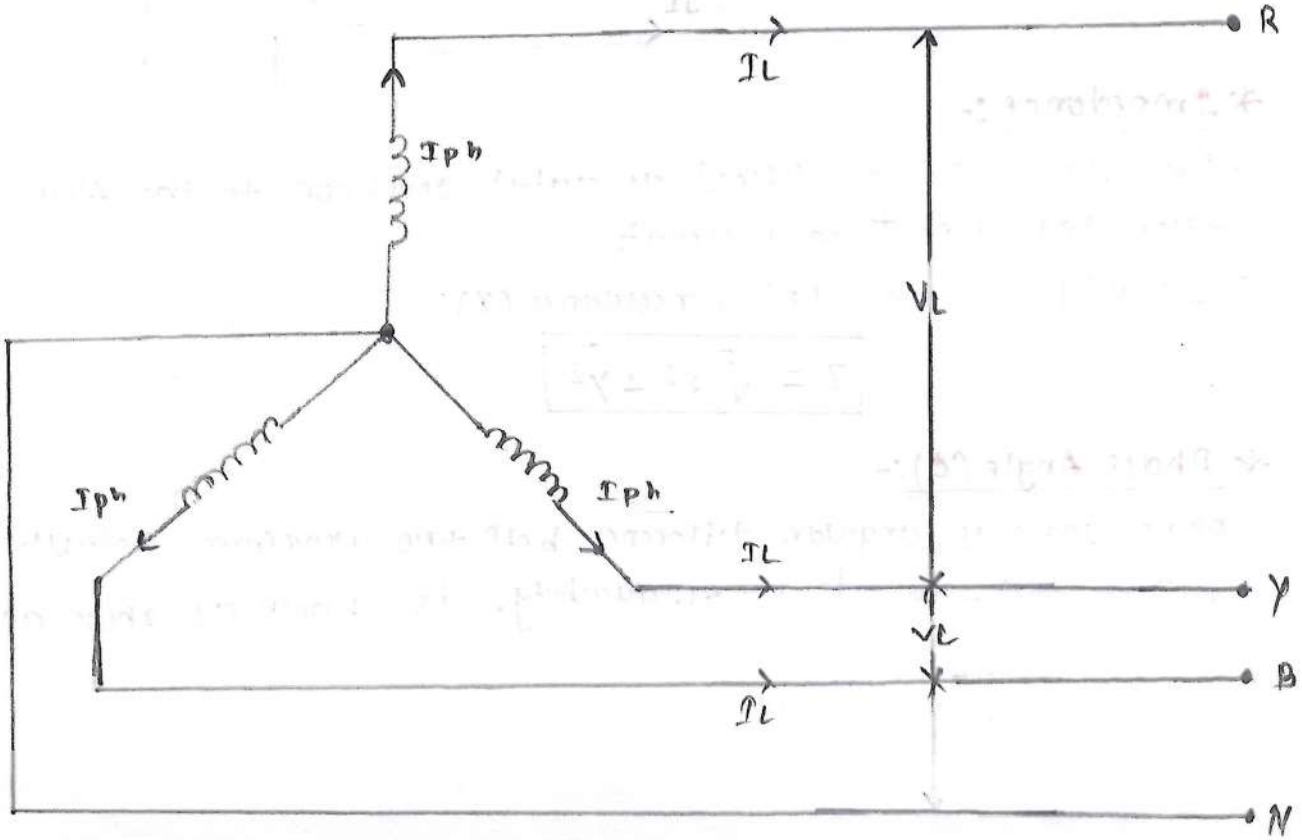
### 1) Balance load. :-

- when equal current flows trough each phase wire is known as Balanced load.
- In balance load magnitude of all impedance are equal.
- phase angle is equal for all.
- phase shift is 120°.

### 2) Unbalanced load :-

- when different current flows trough each phase wire known as Unbalanced load.
- In unbalanced load magnitude of all impedance are not equal.
- phase angle beth all of them are not same as 120° phaseshift.

## * star connection :-



* For star connection:-

$I_L = I_{ph}$

Line current = Phase current

$V_L = \sqrt{3}\, V_{ph}$

Line voltage = $\sqrt{3}$ phase voltage.

1) Line voltage:-

The voltage between any two phase is called as line voltage.

2) phase voltage:-

The voltage between any phase and nutral is ~~the~~ called as phase voltage.

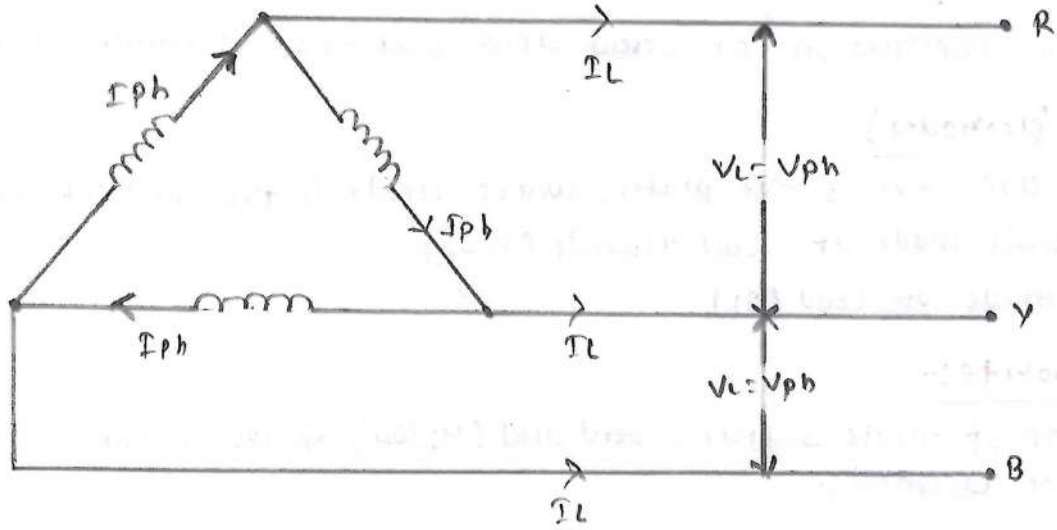
3) Line current:-

The current in any line is called as line current

4) phase current:-

The current in any phase is called as phase current.

* Delta connection (Δ)




$I_L = \sqrt{3}\, I_{ph}$

Line current = $\sqrt{3}$ phase current

$V_L = V_{ph}$

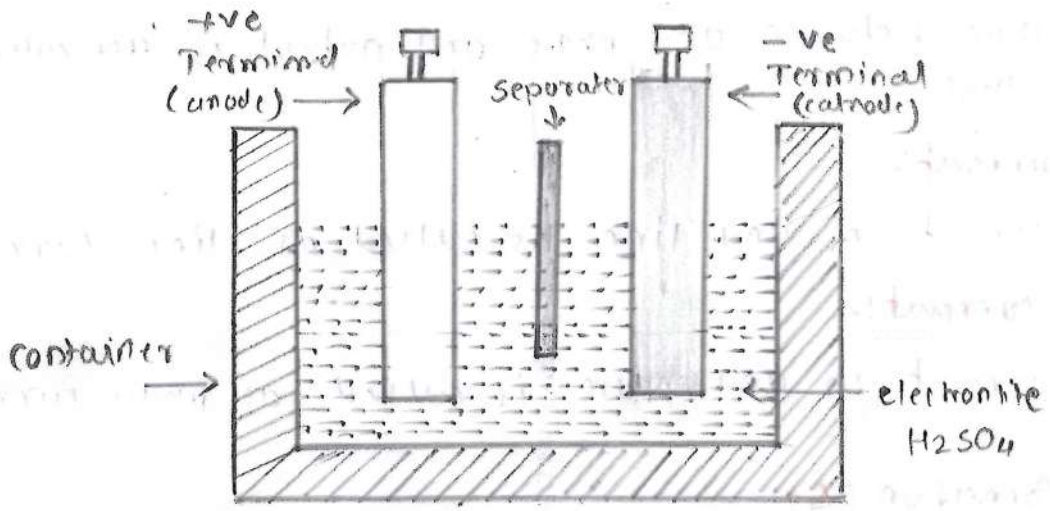
Line voltage = Phase voltage.

## * Working of Battery:- (Lead Acid Battery)

### Definition of Battery:-

- A Battery is a device that stores chemical energy and converts it into electrical energy through chemical reaction.
- It involves the flow of electrons from one material to another (electrode).
- The flow of electrons provides an electric current that can be used to do work.

## * Construction of Lead Acid Battery




(Lead Acid Battery)

- In the construction of Lead acid battery is made using following:

- **Plate (Electrodes)**
  There are +ve & -ve plate, where anode is +ve and cathode is -ve
  +ve plate made of lead dioxide ($PbO_2$)
  -ve made of lead ($Pb$).

- **Electrolyte:-**
  Solution of dilute sulfuric ~~acid~~ acid ($H_2SO_4$), helps in chemical reaction to produce electricity.

- **Separator:-**
  A thin non conductive sheet that keeps a plate apart and prevent short circuit betn +ve & -ve terminals.

- **Container:-**
  A strong plastic box that holds all parts inside.

- **Terminals:-**
  +ve & -ve ends of battery. where wire is connected to use batterys power.

## * working of Lead acid Battery:-

- A Lead acid battery works by chemical reaction between Lead plates and sulfuric acid ($H_2SO_4$) in charging and discharging manner.

### * Discharge:-

when the battery discharges the -ve plate (lead) $(Pb)$ reacts and form ($PbSO_4$) lead sulfate. releasing electrons.

- this electrons flows through circuit to +ve plate (lead dioxide ($PbO$) where another reaction forms lead sulfate and water.
- this flow of electron creats an electric current to power devices.

### * Charge:-

- During charging the reaction reverse turning lead sulphate back into lead and lead dioxide & resorting the battery.
- The electrolyte (sulfuric acid) helps in flow of ions to keep reaction going
- In Sealed batteries the acid is fixed inside, making them safe and low maintanance for consumers.

## * Wring Specifications:-

### 1) Standards and codes:-

- NEC (National Electrical code) used in U.S. to make sure wiring is safe.
- IEC [International electrotechnical commision], which prepares and published international standards ~~for~~.

### 2) Wire types and size:-

- Material mostly copper for better conductor or aluminium because it is lighter and cheaper.
- wring size is mentioned in $mm^2$
  size of wire directly affects to current carrying capacity.
- Insulation:- wire must be covered like PVC or other suitable insulation material based on heat water and chemical condition. (IS 694)

### 3) Voltage and current rating.

for howehold purpose voltage rating is 230 V & ~~for~~

current rating of wires are determined by there cross sectional area in ($mm^2$) & tipically listed on wire itself.

Voltage not exceeding than 250 V for single phase AC & for 3Φ 415 V.

4) * Colour coding (US. standard)

- Black or Red :- mostly used fo live or hot wire.
- white :- mostly used for Nutral wire.
- Gree / Yellow Green :- must be used for Ground or earthing wires

5) Installation Rules :-

- Use of pipes for wiring :- wires are must be placed inside in a plastic pipe for protection.
- Do not bend wire to sharply to avoid short circuit
- Supports :- wire must be fixed at interves to avoid sagging or tangling.

6) Invironmental safety :

- Temp. rating :- wire should handle the heat in the area they installed.
- weather protection :- for outdoor use wires need to be water and sun resistance. to avoid short circuit.

7) Safety Devices :-

- Use of Circuit Breaker :- are the safty tool for avoid. over current.
- must be chosen upon circuit size and use.
- Must provide earthing system for over current pass safly in ground.

8) Testing and verification :-

- Continuity test :- It checks that wire is continew or not damage or brake from inside.
- Ensure the insulation (covering) material must be in good condition & not damage.
- Load test :-

make sure that the circuit can safely handle the electrical load it's meant for that.

## * I.S. Electrical standards

- The (BIS) Bureau of Indian standards creats and maintains electrical safety rules in India.
- This standards make sure electrical appliances and systems are safe reliable and in good quality.

## * General Electrical safety standards.

### 1) IS 732 :-

- Rule for safely designing, installing, and maintaining electrical wiring system up to 650 volts.

### 2) IS 3043 :-

- Guidelines for earthing (grounding) electrical installation to keep the safe. and provide safety path for fault current.

### 3) IS 5216 (Part I, Part-II)

- Part I :- Includes basic safety rules for all electrical work.
- Part II :- Includes special safety rules for certain or special type of electrical jobs and places.

## * Standards for Electrical Appliances :-

### 1) IS 302

- That ensures the safety requirments for household electrical appliances.

### 2) IS 3854 :-

- It ensures that safety and performance rule for switches used in home and similar places.

### 3) IS 694 :-

- It includes specification for PVC insulated cables used in homes and industries for voltage up to 1100 V.

### 4) IS 12640 (Part I, Part-II)

Part I = Includes rule for recidual current circuit breakers without extra protection (RCCB)

Part-II = Rules for Circuit Breaker with Built-in overcurrent protection

5) IS 1293:-

- In IS 1293 Includes that safety standards for plugs and sockets rated upto 250 volts 16 amperes.
- mainly covers for household purpose.

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