# Vikash Polytechnic, Bargarh

Vikash Polytechnic
Campus: Vikash Knowledge Hub, Barahaguda Canal Chowk, NH6
PO/DIST: Bargarh-768028, Odisha

# Lecture Note
# on
# Applied Physics-II

## Diploma 2nd Semester


**Submitted By:-** *Mr. Rupesh Ku. Pradhan*

# UNIT 6 : OSCILLATIONS AND WAVE

Q What is wave?

Ans - **Wave**

* It is a disturbance which carries energy.

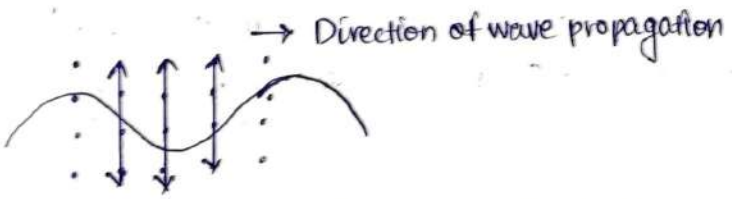
Waves

- **Mechanical waves**
  (They need a medium for their propagation)
  Ex - Sound waves
- **Non-mechanical waves**
  (They don't need any medium for their propagation)
  Ex - light wave, Radio signal

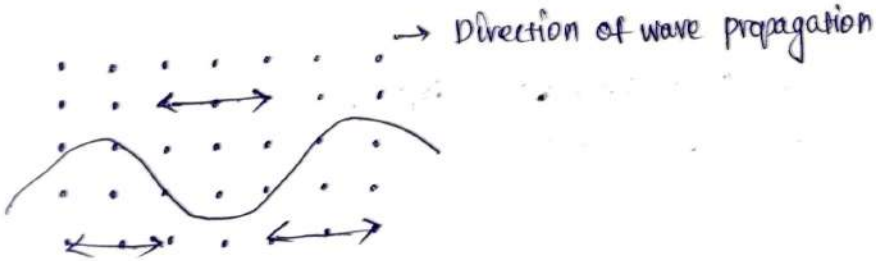
1. **Mechanical wave**: A mechanical wave propagates due to vibration / oscillation of particles or molecules of the medium.

Mechanical wave

- Transverse waves
- Longitudinal waves



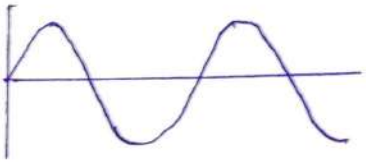
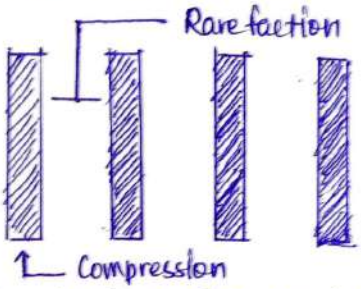

Transverse waves (perpendicular)




Longitudinal waves (Parallel)

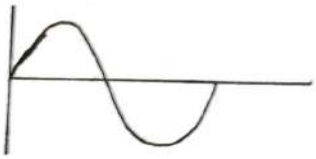
Q. Distinguish between transverse wave and longitudinal waves?

Ans-

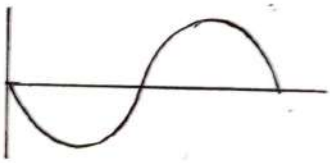
| Transverse wave | Longitudinal Waves |
|---|---|
| (i) Particles of the medium are vibrating perpendicular to the wave propagation. | (i) Particles of the medium are vibrating parallel to the wave propagation. |
| (ii) Example: water wave | (ii) Example: Sound wave |
| (iii)  | (iii)   |
| (iv) Transverse wave consists of Crests and troughs. | (iv) Longitudinal wave consists of compression and rarefaction. |

Wave parameters

(i) Wave cycle

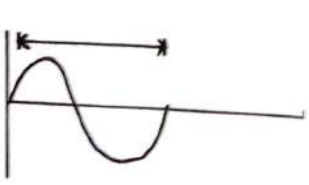


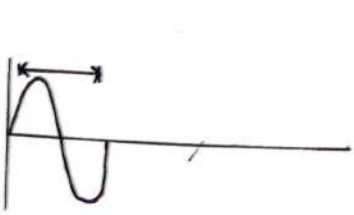
or



* A wave cycle consists of a crest and a trough, in case of a transverse wave
* A wave cycle consists of a compression and a rarefaction in case of a longitudinal wave.

(ii) Wavelength

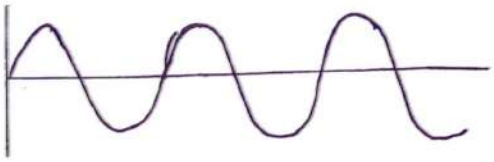


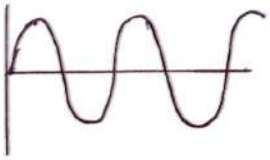


It is the length of a wave~~length~~ cycle.

* It's symbol is 'λ'. (lambda)
* It's S.I unit is meter (m).

(iii) Time period

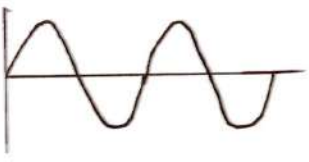




It is the time taken by a wave to complete the wave cycle.

* It's symbol is 'T'.
* It's S.I unit is second 's'.

(iv) Frequency



2Hz

4Hz

It is the number of wave cycles completed by a wave in one second.

* It is denoted by 'f' or 'n'.
* It's S.I unit is $\frac{1}{\text{Second}}$ or $s^{-1}$ or Hertz (Hz).

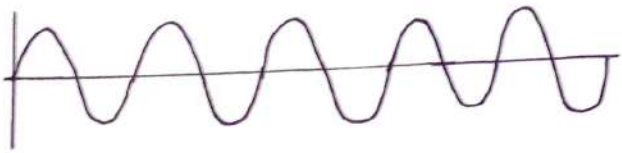
$$1\,Hz = 1\,s^{-1}$$

(v) Wave velocity (v)

It is the velocity with which the waves travels or propagate.

* It's symbol is 'v'.
* It's S.I unit is meter/second or m/s or $ms^{-1}$

Relation between time period and frequency



$f = 5Hz$

1 sec $\Rightarrow$ 5 (no. of wave cycle completes)

$\Rightarrow$ 5 wave cycle complete = 1 sec

$\Rightarrow$ 1 wave cycle complete = $\frac{1}{5}$ sec

$\Rightarrow$ $\boxed{T = \frac{1}{f}}$ or $\boxed{f = \frac{1}{T}}$

Q. Derive the relation between wavelength, frequency and wave velocity of a wave.

Ans - Relation between wavelength, frequency and wave velocity

We have, $\lambda$ = wave length

$f$ = frequency

$V$ = wave velocity

$T$ = time period

By defination,

$$V = \frac{\text{length}}{\text{time}} = \frac{\lambda}{T}$$

$$V = \frac{\lambda}{T}$$

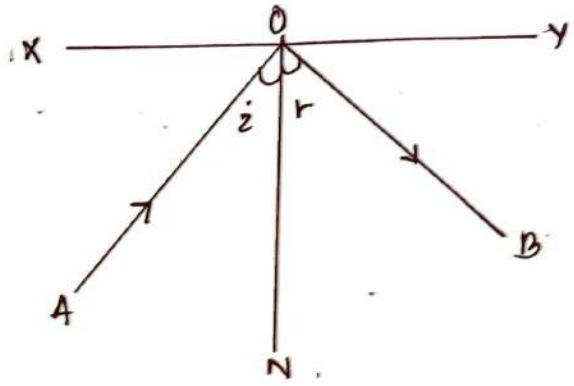
$$\Rightarrow V = \lambda \times \frac{1}{T}$$

$$\boxed{V = \lambda \times f = f\lambda}$$

velocity = frequency x wavelength

This is the required relation.

# UNIT 8 : OPTICS




AO → Incident Ray

OB → Reflected Ray

XY → Reflecting surface

O → Point of reflection

ON → Normal to XY

$i$ → Angle of incidence

$r$ → Angle of reflection

Q. Write laws of reflection?

Ans – Laws of reflection

(i) Angle of incidence is equal to angle of reflection.

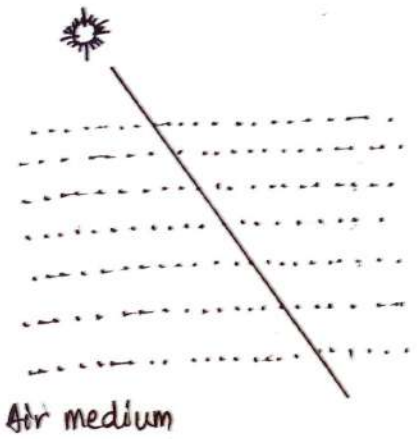
$$\angle i = \angle r$$

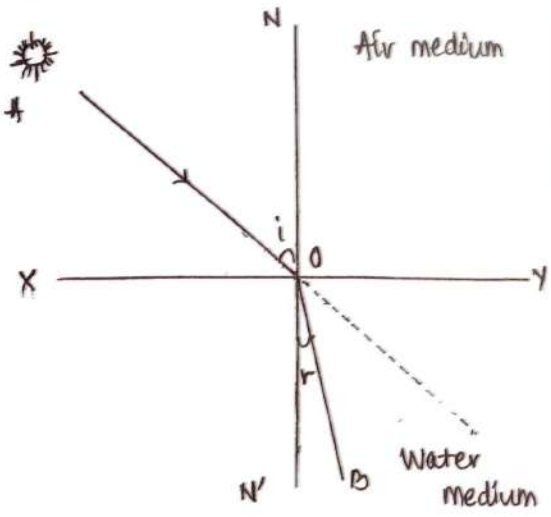
(ii) The incident ray, reflected ray and normal all lies on one plane and the plane is perpendicular to the reflecting surface.

Q. What is refraction?

Ans – Refraction

It is the property of light in which a ray of light travelling from one medium to another undergoes a change in it's speed and direction.




AO → Incident Ray

OB → Refracted Ray

O → Point of refraction

XY → Interface

NN' → Normal to XY at point 'O'

$i$ → Angle of incidence

$r$ → Angle of refraction

Q. Write laws of refraction.

Ans - laws of refraction

(i) $\frac{\sin i}{\sin r}$ = Constant

Constant is called refractive index of the medium (M).

(ii) The incident ray, refracted ray and the normal all lies in one plane and the plane is perpendicular to the interface.

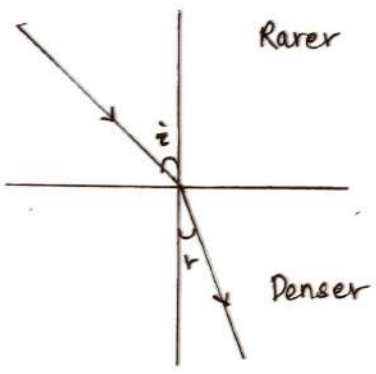
Note

Medium

Rarer medium
Air & water
Air → Rarer
Water → Denser

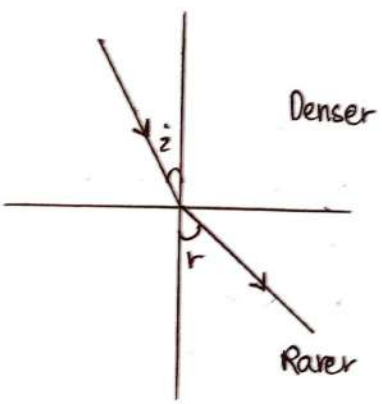
Denser medium
Water & glass
Water → Rarer
glass → Denser

Case 1



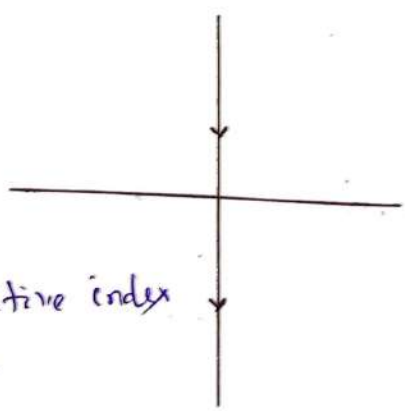

$i > r$

Case 2




$i < r$

Case 3



Q'. What is refractive index of a medium.

Refractive Index

It is defined as. $\mu = \frac{c}{v}$

$c \rightarrow$ Speed of the light in vacuum

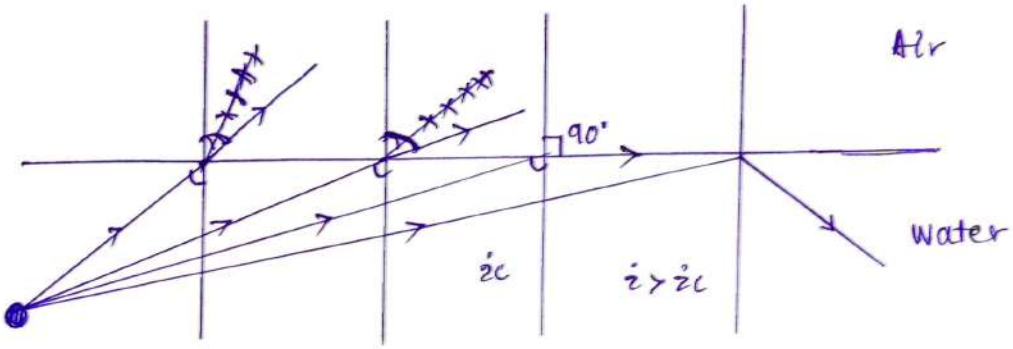
$v \rightarrow$ Speed of the light in the given medium

Q. What is critical angle and total internal reflection (TIR) ?

Ans - Critical angle

It is the angle of incidence for which angle of refraction is 90°

i.e $\angle i = \angle i_c$ when $\angle r = 90°$




Total internal reflection

Total internal reflection occurs.

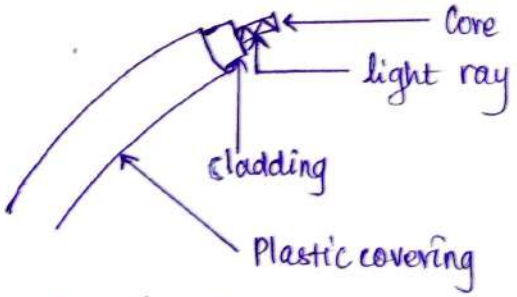
(i) When $i > i_c$ (Angle of incidence is greater than critical angle).

(ii) Ray must travel from denser medium to rarer medium.

Q. What is optical fiber ?

Ans - Optical fiber

Optical fiber is a wave guide which transmits light along it's axis through the process of total internal reflection.




Q. Write uses of optical fiber ?

Ans - Uses of optical fiber

(i) Medical Industry

(ii) Communication

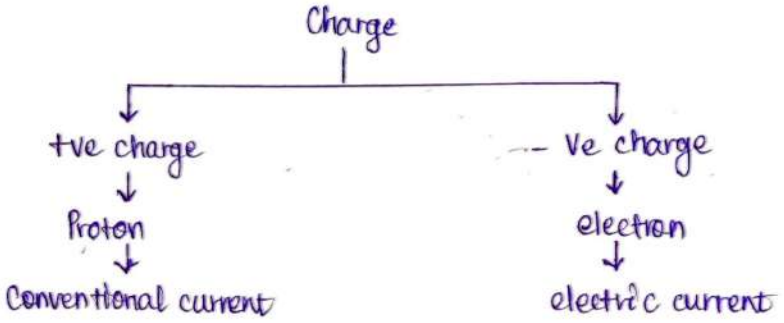
(iii) Lighting & Decoration

(iv) Broadcasting

# UNIT 9 : ELECTROSTATICS & MAGINETOSTATICS

Electro static — Charge at rest

Magnetostatic — Magnet at rest




**Note**

→ Symbol of charge is $q$ or $Q$.

→ SI unit of charge is coulomb (C).

**Electric force**

→ force between two charges.

→ Two type - (i) Attractive (ii) Repulsive

Q. State and explain coulomb law in electrostatic.

Ans - **Coulomb's law**

Consider two charges : $q_1$ & $q_2$


$r$ → Distance between $q_1$ and $q_2$

Let, $F$ → Electric force between $q_1$ and $q_2$

**Statement**

(i) Electric force is proportional to the product of two charges.

(ii) Electric force is inversely proportional to the square of distance between two charges.

**Explanation**

(i) $F \propto q_1 q_2$ — (1)

(ii) $F \propto \frac{1}{r^2}$ — (2)

Combining eqn (1) & eqn (2)

$$F \propto \frac{q_1 q_2}{r^2}$$

$$\Rightarrow F = K \frac{q_1 q_2}{r^2}$$

Where K is a constant and $K = \frac{1}{4\pi\varepsilon_0}$

$$= 9 \times 10^9 \frac{Nm^2}{C^2}$$

$\varepsilon_0$ → Permitivity of the free space

$$\boxed{F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}} \quad -(3)$$

In SI units

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$$

$$\boxed{F = 9 \times 10^9 \frac{q_1 q_2}{r^2}} \quad -(4)$$

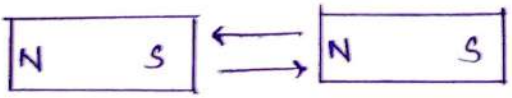
Magnetostatic

It deals with magnet.

Magnetic force

Force between two magnets or magnetic pole.

Attractive

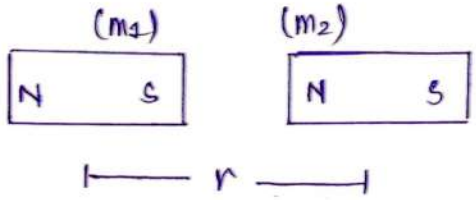




Repulsive.

Q. State and explain coulomb's law in magneto statte?

Ans - Coulomb's law in magneto static




Consider two poles of strength $m_1$ & $m_2$
Let, 'r' be the distance between two poles.
'f' be the force between two poles.

Statement

(i) Magnetic force between two poles is directly proportional to product of two poles.

(ii) Magnetic force is inversely proportional to the square of distance between two poles.

Explanation

$$F \propto m_1 m_2 \quad \text{---(1)}$$

$$F \propto \frac{1}{r^2} \quad \text{---(2)}$$

Combining eqn(1) & eqn(2)

$$F \propto \frac{m_1 m_2}{r^2}$$

$$\Rightarrow F = K \frac{m_1 m_2}{r^2}$$

Where K is a constant and $K = \frac{\mu_0}{4\pi}$

$\mu_0 \rightarrow$ permiability of free space

$$\therefore \boxed{F = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{r^2}} \quad -(3)$$

$$\Rightarrow \boxed{F = 10^{-7} \frac{m_1 m_2}{r^2}} \quad -(4)$$

In SI unit,

$$\frac{\mu_0}{4\pi} = 10^{-7} \frac{Wb}{Am}$$

Q. Define unit charge?

Ans - Unit charge

when, $F = 9 \times 10^9$ N

$r = 1$ meter

$q_1 = q_2 = q$

$$\therefore 9 \times 10^9 = 9 \times 10^9 \times \frac{q_1 q_2}{1^2}$$

$$\Rightarrow \frac{9 \times 10^9}{9 \times 10^9} = \frac{q^2}{1}$$

$$\Rightarrow 1 = q^2$$

$$\Rightarrow q = \sqrt{1} = \pm 1$$

Defination

Unit charge is that amount of charge when placed in air at a distance of one meter from another charge experience a force of $9 \times 10^9$ N.

Q. Define unit pole.

Ans - Unit pole

Unit pole is that pole when placed in air at a distance of one meter from another pole experience a force of $10^{-7}$ N.

# UNIT 10: ELECTRIC CURRENT

**Q. What is current?**

Ans - Flow of charge.

Current due to positive charge → conventional current

Current due to negative charge → electric current

→ Symbol of current → $i$ or $I$

S.I unit of current → Ampere (A)

$$\text{Current} = \frac{\text{charge}}{\text{time}}$$

$$\Rightarrow i = \frac{q}{t}$$

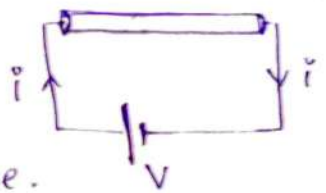
**Q. What is Ohm's law?**

Ans - It states that at constant temperature current flowing through a conductor is directly proportional to the potential difference between the two ends of the conductor.

Mathematically, we have

$$V \propto i$$

$$\Rightarrow V = Ri$$




R is a constant and is called resistance.

$$\Rightarrow \frac{V}{R} = i$$

**Resistor** ( —wwww— )

→ It oppose the flow of current.

**Resistance**

→ The property of resistor to oppose the current is called resistance.

→ SI unit : Ohm ( $\Omega$ )

Other unit : milli ohm ( $m\Omega$ )

micro ohm ( $N\Omega$ )

$$1\ \Omega = 1000\ m\Omega = 10^3\ m\Omega$$

$$1\ \Omega = 1000000\ N\Omega = 10^6\ N\Omega$$

## Capacitor

→ It stores charge.

## Capacitance

The capacity of a capacitor is called capacitance.

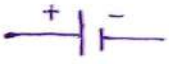
→ Symbol : C

→ SI unit : Farad (F)

→ Other unit : milliFarad (mF)
Microfarad (μF)

$1F = 10^3 mF$

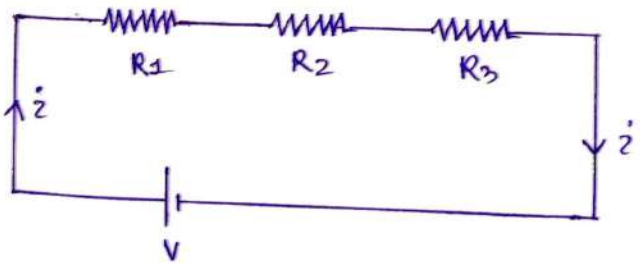
$1F = 10^6 \mu F$

| Equipment | symbol |
|---|---|
| Battery |  |
| Resistor |  |
| Capacitor |  |

## Grouping of resistors

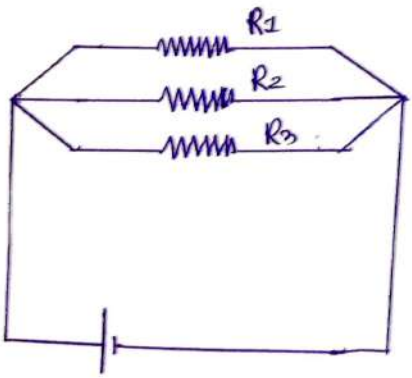
(i) Series grouping or series connection

(ii) Parallel grouping or parallel connection




Series connection

$R = R_1 + R_2 + R_3$




Parallel connection

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

## Problem 1

Find equivalent resistance of four resistors of resistance 2Ω, 4Ω, 1Ω and 3Ω when connected in series and parallel.

Ans – Resistance when connected in series

$$R = 2\Omega + 4\Omega + 1\Omega + 3\Omega$$
$$= 10\Omega$$

Resistance when connected in parallel

$$\frac{1}{R} = \frac{1}{2} + \frac{1}{4} + \frac{1}{1} + \frac{1}{3} = \frac{12+6+24+8}{24} = \frac{50}{24} = \frac{25}{12}$$

$$R = \frac{12}{25} = 0.48\Omega$$

## Problem 2

Three resistors of resistance 2Ω, 100 mΩ and 10Ω are connected in series. Find total resistance.

Ans – Given,

$R_1 = 2\Omega$

$R_2 = 100\,m\Omega = 100 \times \frac{1}{1000} = \frac{1}{10} = 0.1\Omega$

$R_3 = 10\Omega$

Resistance when connected in series

$R_{total} = 2\Omega + 0.1\Omega + 10\Omega$

$= 12.1\Omega$

Grouping of capacitors

series → $\frac{1}{c_1} + \frac{1}{c_2} + \frac{1}{c_3} = \frac{1}{C_{total}}$

parallel :- $C_1 + C_2 + C_3 = C_{total}$

Problem 3

Three capacitor of capacitance 2F, 1000 mF and 10F when connected in series and parallel.

Ans - Capacitance when connected in series

$$\frac{1}{C_t} = \frac{1}{2} + \frac{1}{1} + \frac{1}{10}$$

$$= \frac{10+20+2}{20}$$

$$= \frac{32}{20}$$

$$C_t = \frac{20}{32}$$

Capacitance when connected in parallel

$$C_t = C_1 + C_2 + C_3$$

$$= 2 + 1 + 10$$

$$= 13F$$

Q. State Krichoff's laws.

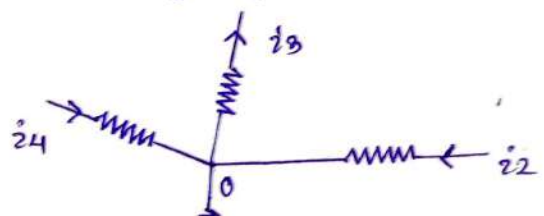
Ans - Krichhoff's laws

(i) KCL (Krichhoff's current law)

(ii) KVL (Krichhoff's voltage law)

KCL

The algebric sum of current meeting at a junction is zero.



Sign of convention

(i) The currents leaving the junction are taken as negative.

(ii) The currents entering the junction are taken as positive.

Applying KCL to the given figure, we get

$$(-i_1) + (i_2) + (-i_3) + (i_4)$$

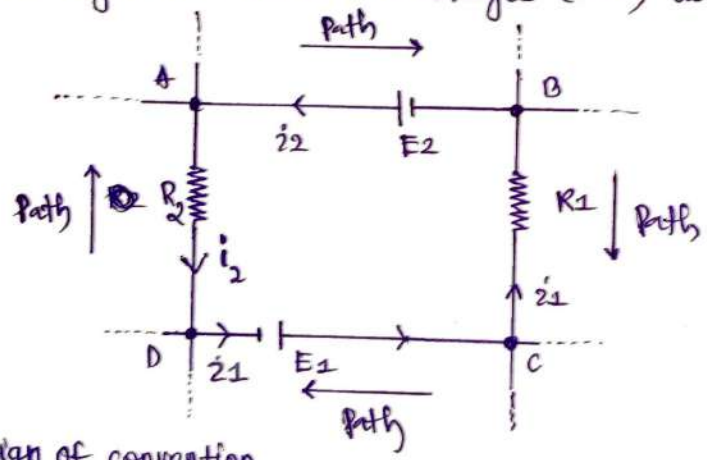
$$= -i_1 + i_2 - i_3 + i_4$$

$$= i_4 + i_2 = i_1 + i_3$$

KVL

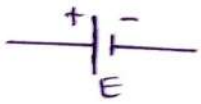
Statement

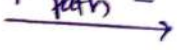
The algebraic sum of the voltages (emf) across a closed loop is zero.




Sign of convention

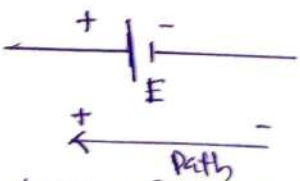
(i)



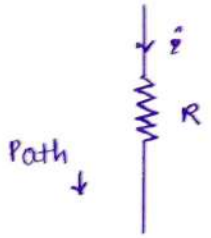

Voltage will taken as negative.

(ii)

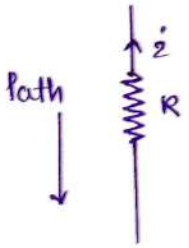



Voltage will taken as positive.

(iii) The direction of current are opposite, then IR is positive.




(iv) The direction of path and direction of current are the same, then IR is negative.




By applying KVL to the given loop ABCDA, we get

$$-E_1 + \dot{i}_1 R_1 + (-E_2) + \dot{i}_2 R_2 = 0$$

$$-E_1 + \dot{i}_1 R_1 - E_2 + \dot{i}_2 R_2 = 0$$

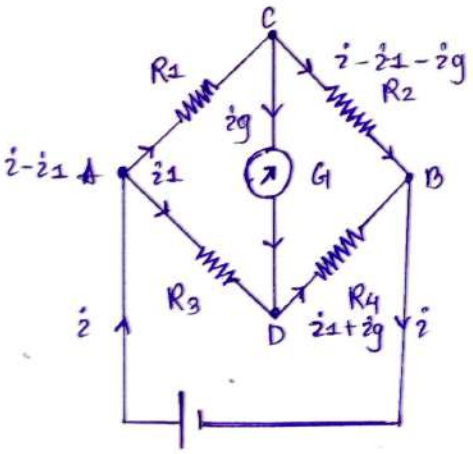
Q. State Krichoff's laws. Find balance condition for wheatstone bridge by applying krichhoff's laws.

Ans - Krichhoff's laws

KCL : The algebraic sum of currents meeting at a junction is zero.

KVL : The algebraic sum of voltages across a closed loop is zero.

Balance condition for wheatstone bridge



Applying KVL to the loop ACDA

$$-(i-i_1)R_1 + [-i_g G] + i_1 R_3 = 0$$

$$= -(i-i_1)R_1 - i_g G + i_1 R_3 = 0 \quad \text{— (1)}$$

Applying KVL to the closed loop CBDC

$$-(i-i_1-i_g)R_2 + (i_1+i_g)R_4 + i_g G = 0 \quad \text{— (2)}$$

For balanced wheatstone bridge, $i_g = 0$ — (3)

Putting $i_g = 0$ in eqn (1)

$$-(i-i_1)R_1 + i_1 R_3 = 0$$

$$\Rightarrow i_1 R_3 = (i-i_1)R_1 \quad \text{— (4)}$$

Putting $i_g = 0$ in eqn (2)

$$-(i-i_1-0)R_2 + (i_1+0)R_4 + 0.G$$

$$= -(i-i_1)R_2 + (i_1)R_4 = 0$$

$$= i_1 R_4 = (i-i_1)R_2 \quad \text{— (5)}$$

Divide eqn (4) by eqn (5)

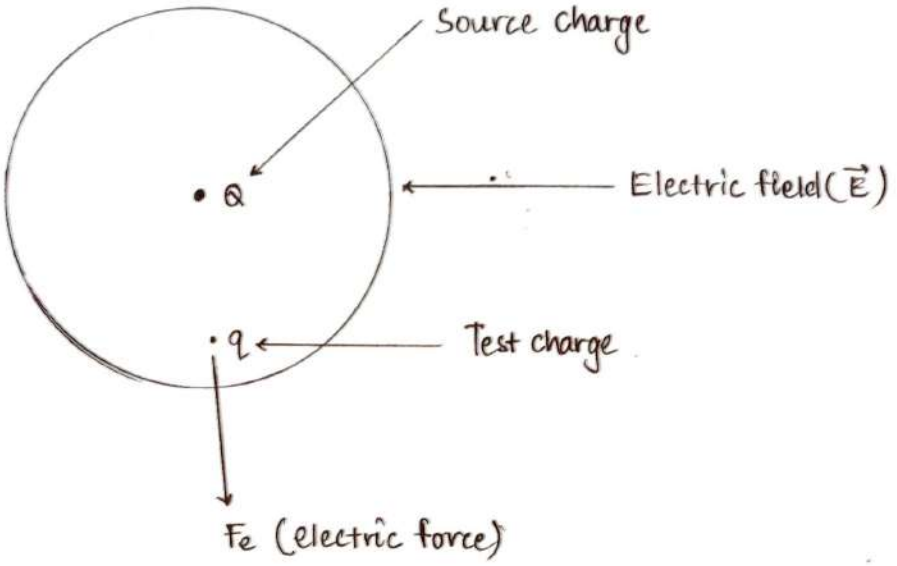
$$\frac{\cancel{i_1} R_3}{\cancel{i_1} R_4} = \frac{\cancel{(i-i_1)} R_1}{\cancel{(i-i_1)} R_2}$$

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

This is the ~~balan~~ required solution.

# UNIT - 11 ELECTROMAGINETISM & ELECTRO MAGINETIC INDUCTION

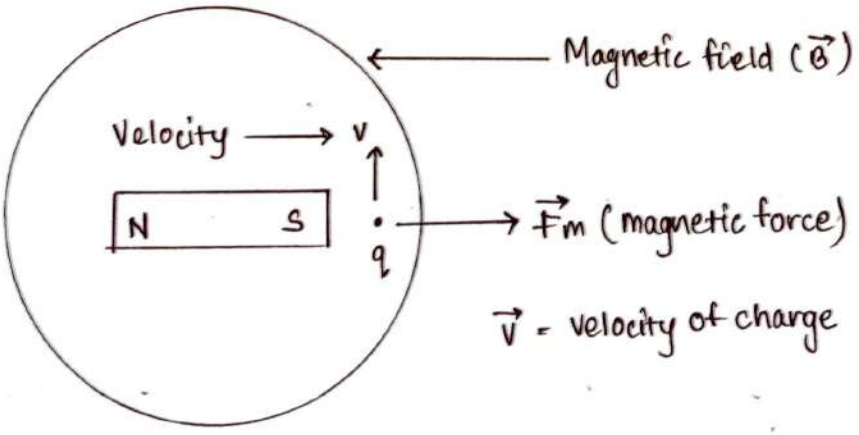
## Electric field




$$\vec{E} = \frac{\vec{Fe}}{q}$$

$$\vec{Fe} = q\vec{E}$$

## Magnetic field

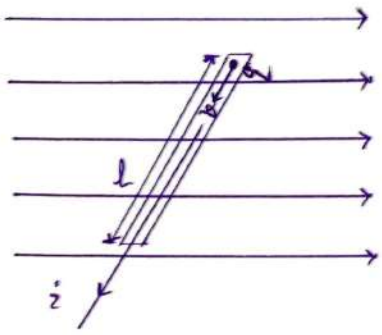



$$\vec{Fm} = q(\vec{v} \times \vec{B})$$

$$\Rightarrow \vec{Fm} = q v B \sin\theta \hat{n}$$

Q. Derive an expression for the force acting on a current carrying conductor placed in a uniform magnetic field.

Ans - Expression for force acting on a current carrying conductor placed in a uniform magnetic field.




Uniform magnetic field ($\vec{B}$)

Let, $l$ → length of the conductor

We have, $\vec{F}_m = q(\vec{v} \times \vec{B})$

$\Rightarrow \vec{F}_m = qvB \sin\theta \hat{n}$

$\Rightarrow \vec{F}_m = q\frac{l}{t} B \sin\theta \hat{n}$

$\Rightarrow \vec{F}_m = I l B \sin\theta \hat{n}$

$\Rightarrow \vec{F}_m = I(\vec{l} \times \vec{B})$

This is the required expression.

Q. State faraday's law of electromagnetic induction.

Ans - Faraday's laws of electromagnetic induction

1st law

Whenever a magnetic flux linked with a circuit changes, an emf is induced in the circuit.

2nd law

The induced emf exist in the circuit so long as the change in magnetic flux linked with the circuit continues.

3rd law

Induced emf $\propto$ negative rate of change of magnetic flux.

$$E \propto -\frac{d\Phi_B}{dt}$$

Q. What is Lenz's law.

Ans - Lenz's law : The law states that the direction of induced emf is such that it oppose the cause which produce it. (Induced emf oppose it's cause)

Q. Distinguish between Fleming's left hand rule (FLHR) and fleming's right hand rule (FRHR).

Ans -

| FLHR | FRHR |
|---|---|
| (i) It gives direction force on current carrying conductor placed in a uniform magnetic field. | (i) It gives the direction of induced (induced current) due to change in magnetic flux linked with circuit. |
| (ii) It is applicable to DC motors. | (ii) It is applicable to DC generators. |
| (iii) Mid finger → direction of magnetic field ($\vec{B}$).<br>fore finger → direction of current.<br>Thumb → direction of force | (iii) Thumb - direction of motion.<br>Middle finger - direction of magnetic field.<br>fore finger - direction of induced emf. |