LECTURE NOTE

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Question of unit-5 to be asked in examination

(i) Define universal Gravitational constant.

(ii) state Newton's law of Gravitation.

(iii) Dimension formula for G.

(iv) Relation between g and G.

(v) ~~Variation~~ Derive the variation of small g with altitude and depth.

Questions to be asked in examination of unit-1

(i) Define SHM. Derive the expression for displacement, velocity and acceleration

(ii) ~~Re~~ ~~Est~~ Establish the Relation betwe v, λ and f.

(iii) Comparission between Transverse and Longitudinal wave.

(iv) What is ultrasonic. Write down t properties and Application of ultrason

UNIT - 7 Heat & Thermodynamics

7.1 **Heat & temperature** Heat is a physical quantity that causes an increase in the temp of a body to which it is added and a decrease in the temp. of a body from which it is removed provided that the body does not change state during the process.

Temperature is a property that determines the direction in which heat will flow if two bodies are kept in thermal contact.

Heat is a form of energy that flows betn a system and its surroundings by virtue of temp difference between them

7.2 **Unit of Heat** . calorie - It is the quantity of heat required to raise the temp of one gram of water through one ~~celsius~~ centigrade degree. 1 cal.

S.I Joule.

CGS erg

$1J = 10^7 erg$

7.3 **Specific Heat** It is defined as the amount of heat per unit mass absorbed or rejected by the substance to change its temperature by 1 unit. It is denoted by c.

$$c = \frac{1}{m} \cdot \frac{dQ}{dT}$$

SI - $\frac{J}{Kg\,K}$

$[c] = L^2 T^{-2} K^{-1}$

CGS $\frac{cal}{g\,°C}$

Specific heat at constant pressure. $C_p = \frac{1}{m}\frac{dQ_p}{dT}$

Specific heat at const volume $C_v = \frac{1}{m}\frac{dQ_v}{dT}$

7.4 **change of state, Latent heat**

A transition from one of these phases to another is called a phase change or change of state.

The amount of heat transfered during a change of phase of the substance is called latent heat of transformation for the process.

$Q = mL$

$L = \frac{Q}{m}$

$[L] = L^2 T^{-2}$

Scalar quantity

SI unit - Joule / Kg

7.5 Thermal expansion.

In general when an object is heated whether it be a solid, liquid, gas, it expands.

7.7 Coefficients of linear, superficial & cubical expansions of Solids

(a) Linear expansion - A long and thin rod can be considered to be one dimensional of its length is very large compared to its diameter.

let l_0 = be length of rod at 0°C.

l_t = length of rod at t°C.

$$l_t - l_0 \propto l_0$$

$$l_t - l_0 \propto t$$

$$l_t - l_0 = \alpha l_0 t$$

$$\alpha = \frac{l_t - l_0}{l_0 t}$$

Thus co-efficient of linear expansion may, in general be defined as the increase in length per unit length per degree centigrade rise of temp.

Unit. $°C^{-1}$

(b) Superficial expansion A surface having some length and breadth but having negligible thickness can be considered to be two dimensional.

S_0 ≡ area of sheet at 0°C

S_t ≡ area of sheet at t°C

$$S_t - S_0 \propto S_0$$

$$S_t - S_0 \propto t$$

$$S_t - S_0 = \beta S_0 t$$

$$\beta = \frac{S_t - S_0}{S_0 t}$$

Co-efficient of superficial expansion is defined as the change in area of the surface of unit area at 0°C per degree centigrade rise of temp.

(c) Cubical expansion A body having length, breadth, and thickness is said to be three dimensional.

$V_0 \equiv$ Volume of a cube at 0°C

$V_t \equiv$ volume of a cube at t°C

$V_t - V_0 \propto V_0$

$V_t - V_0 \propto t$

$V_t - V_0 = \gamma \cdot V_0 t$

Therefore coefficient of cubical expansion is defined as the change in volume per unit volume at 0°C, per degree centigrade rise of temperature.

7.8 Relation.

(i) α & β.

$$S_0 = l_0^2 \quad \text{at } 0°C$$

$$S_t = l_t^2 = l_0^2 (1+\alpha t)^2$$

$$\beta = \frac{S_t - S_0}{S_0 t} = \frac{l_0^2 (1+\alpha t)^2 - l_0^2}{l_0^2 t} = \frac{1 + 2\alpha t + \alpha^2 t^2 - 1}{t}$$

$$= \frac{2\alpha t + \alpha^2 t^2}{t} = 2\alpha + \alpha^2 t$$

$$\beta = 2\alpha$$

(ii) α & γ.

$$V_0 = l_0^3$$

$$V_t = l_t^3 = l_0^3 (1+\alpha t)^3$$

$$\gamma = \frac{V_t - V_0}{V_0 t} = \frac{l_0^3 (1+\alpha t)^3 - l_0^3}{l_0^3 t} = \frac{1 + \alpha^3 t^3 + 3\alpha t (1+\alpha t) - 1}{t}$$

$$= \frac{\alpha^3 t^3 + 3\alpha t + 3\alpha^2 t^2}{t}$$

$$= 3\alpha + 3\alpha^2 t + \alpha^3 t^2$$

$$\gamma = 3\alpha$$

7.9. Work & Heat.

Whenever heat is converted into work or work into heat, the quantity of energy disappearing in one form is equivalent to the quantity of energy appearing in the other

7.10 Joule mechanical equivalent of Heat

If an amount of work W results in the production of an amount H of heat

$W \propto H$

$W = JH$

where J = Joule's mechanical equivalent of heat.

$1 J = 4.2 cal$

$J = \frac{W}{H}$

Joule's mechanical equivalent of heat is defined as the amount of work required to produce a unit quantity of heat.

7.11 First law of Thermodynamics

If the quantity of heat supplied to a system is capable of doing work, then the quantity of heat absorbed by the system is equal to the sum of increase in the internal energy of the system & the external work done by it.

$$dQ = dU + dW$$

8.1 Reflection & Refraction — 1. Phenomenon by virtue of which ray of light send back to the same medium. 2- Phenomenon by virtue of which the rays of light travelling from one medium to another medium suffers a change in velocity.

8.2 Laws of Reflection & refraction

Reflection

It states that 1. incident ray, reflected ray and normal to the incidence all lie on the same plane.

II. angle of incidence is equal to angle of reflection $\angle i = \angle r$.

It states that 1. Incident ray, refracted ray and normal at the point of incidence all lie in same plane.

2. $\mu_2^1 = \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$

8.3 Refractive index — Refractive index of a medium is defined as the ratio of the velocity of light in air to the velocity of light in medium.

$$\mu = \frac{c}{v}$$

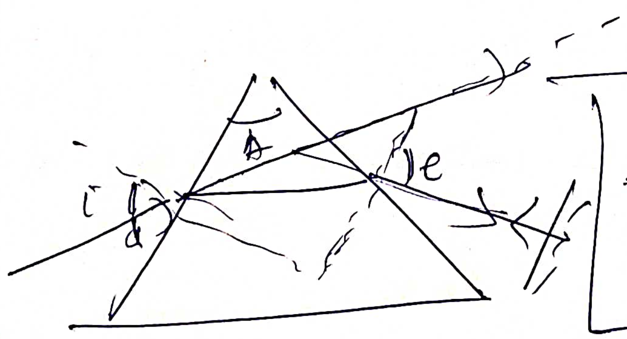
Where c = velocity of light in vaccum
v = velocity of light in medium

4. Critical Angle & TIR (Total internal reflection).

When a ray of light travelling from denser medium to rarer medium for a particular angle of incidence in denser medium for which the angle of refraction is 90°, that angle of incidence in the denser medium known as critical angle. $\mu = \frac{1}{\sin C}$

When a ray of light travelling from denser to rarer medium if the angle of incidence in denser medium is greater than critical angle the ray of light send back to the same medium - This phenomenon is called TIR.

8.5 Refraction through prism



$$\mu = \frac{\sin\left(\frac{A + d_m}{2}\right)}{\sin\frac{A}{2}}$$

μ = R.I of the prism.

Where A = Angle of prism, d_m = Angle of minimum deviation

ELECTROSTATICS & MAGNETOSTATICS

Electrostatic - Defination & concept

study of nature, behaviour, interaction, properties of a charged of a body at rest is called electrostatic.

Coulomb's law, Unit charge

It states that the electrostatic force of attraction or repulsion between two charged bodies is directly proportional to the product of their charges and varies inversly as the square of the distance between them

$$F \propto q_1 q_2$$

$$F \propto \frac{1}{r^2}$$

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

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

Absolute & Relative permitivity

ϵ = Absolute permitivity of medium

ϵ_0 = Absolute permitivity of vaccum or air

ϵ_r = relative permitivity of the medium.

Relation

$\epsilon = \epsilon_0 \epsilon_r$

$\epsilon_r = \frac{\epsilon}{\epsilon_0}$

$\epsilon_0 = 8.85 \times 10^{-12} N^{-1} C^2 m^{-2}$

$\epsilon_r = 1$ for air

$[\epsilon_0] = [M^{-1} L^{-3} T^4 A^2]$

$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \ N m^2 C^{-2}$

$K = 1$

9.4 Electric potential and potential difference

There is a quantity which determines the direction of flow of charge from one body to other irrespective of the amounts of charge contained in the two bodies, the quantity called as Electric Potential.

Electric Potential may be defines as the quantity which determines the direction of flow of charge between them.

$$V(\vec{r}) = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$$

SI - volt $\quad 1\,\text{Volt} = \frac{1J}{1C}$

Potential at any point in an electric field is said to be 1 Volt if one Joule of work is done in moving a charge of 1 C between infinity to that point against the electric field along any path.

CGS statvolt $\quad 1\,\text{stat volt} = \frac{1\,\text{erg}}{1\,\text{stat Coulomb}}$

Potential at any point is said to be 1 esu or statvolt if one erg of work is done in moving a charge of one esu between infinity to that point against the electric field along any path.

Reln $\quad 1\,\text{Volt} = 10^8\,\text{stat volt}$.

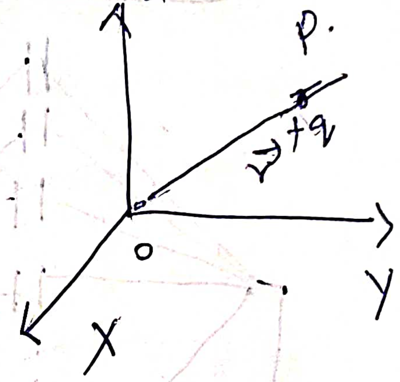
$1\,\text{stat volt} = 3\times10^{10}$ ab volt.

Electric field, Electric field Intensity

When an electric charge is placed at a point the properties of space around the charge get modified, the modified space around an electric charge is called electric field. The charge is known as the source of electric field.

The strength of an electric field is measured by noting force experienced by an unit positive charge placed at that point. The direction of field is given by direction of motion of an unit positive charge if it were free to do so.

$$\vec{E}(\vec{r}) = \lim_{q_0 \to 0} \frac{\vec{F}(\vec{r})}{q_0}$$



$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$

9.6 Capacitance

The capacity of a conductor is defined as the ratio between the charge on the conductor to its potential.

$$C = \frac{Q}{V}$$

When $V = 1$, $C = Q$.

The capacity of a conductor is ~~said to be 1 f.~~ is also defined as the charge required to raise it through unit potential.

Unit

S.I. farad. The capacity of a conductor is said to be 1 farad if a charge of 1 coulomb is sufficient to raise its potential through 1 volt.

$$1f = \frac{1C}{1V} \qquad 1\mu f = 10^{-6} f.$$

CGS

esu stat farad.

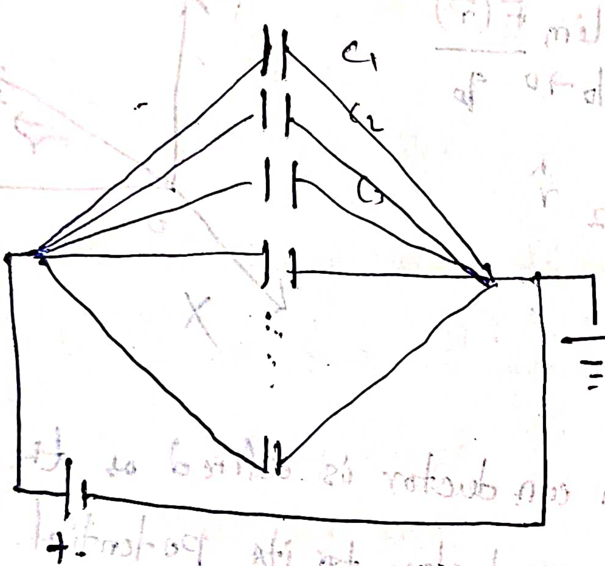
1 stat farad = $\frac{1 \text{ stat coulomb}}{1 \text{ stat volt}}$. 1 farad = 9×10^{4} stat farad

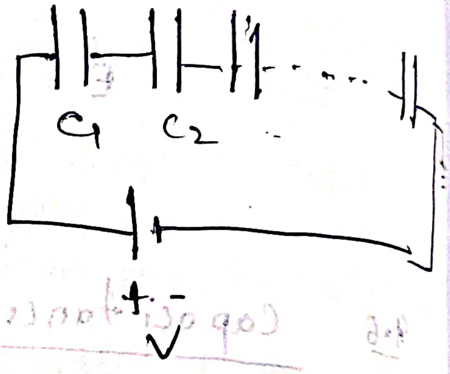
emu ab farad

1 ab farad = $\frac{1 \text{ ab coulomb}}{1 \text{ ab volt}}$ 1 farad = $\frac{1}{10^9}$ abf

$[C] = [M^{-1} L^{-2} T^{4} A^{2}]$

9.7 Series & paralel combination of capacitors





$C = C_1 + C_2 + C_3 + \dots$

$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}$

9.8 Magnet, Properties

A piece of substance which possesses the property of attracting small pieces of iron towards it is called magnet

1. Two poles of a magnet.

magnetic length (2l) = $\frac{7}{8}$ x geometric length.

2. Attracting property of a magnet.
3. Directional property of a magnetic

South - geographical South

Non existance of isolated magnetic poles.
Nature of force between two poles.
Coulomb law in magnetism.

The magnitude of force between two magnetic poles varies directly as the product of the strengths of their poles and inversly proportional to square of the distance between them.

$$F \propto m_1 m_2$$

$$F \propto \frac{1}{r^2}$$

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

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

SI. $K = \frac{\mu_0}{4\pi} = 10^{-7}\ wb\ A^{-1} m^{-1}$

CGS $K = 1$

$\mu_0 = 4\pi \times 10^{-7}\ wb A^{-1} m^{-1}$

Unit pole. SI - A unit pole is that pole which when placed in air at a distance of 1m from a similar pole repels it with a force of 10^{-7}N.

CGS: A unit pole is that pole which when placed in air at a distance of 1cm from a similar pole repels it with a force of 1dyne.

9.10 Magnetic field, magnetic field Intensity. $T = 10^{4}$ Gauss

Magnetic field of any magnetic pole is the region (space) around it in which its magnetic influence can be realised.

Strength of magnetic field at any point is defined as the force experienced by an unit north pole at that point. The direction of field is the direction in which the unit north pole would ...

9.11 Magnetic lines of force.

Lines of force is the path along which a unit north pole would move if it were free to do so.

Properties

1. Lines of force are directed away from a north pole and are directed towards a south pole.
2. Tangent at any point to the magnetic line of force gives the direction of magnetic intensity at that point.
3. Two lines of force never cross each other.
4. The number of lines of force per unit area is proportional to magnitude of strength of field at that point.
5. The lines of force tend to contract longitudinally or length wise, Unlike poles attract.
6. The lines of force tend to exert lateral pressure. Like pole repulsion.
7. 4π lines of force start from a unit magnetic pole.

Representation of magnetic field

- Uniform MB: Same strength at every point
- Non uniform MB: Different strength at different point.

Flux Density

$\phi_B = \vec{B} \cdot \vec{A} = BA \cos\theta = A(B\cos\theta)$

$B\cos\theta$ = component of B ⊥r to the area A.

Magnetic flux linked with a surface, is defined as the product of area and component of B ⊥r to the area.

Case-1

$\theta = 90°$

$\phi_B = 0$

No magnetic flux is linked with the surface

Case-2

$\theta = 0$

$\phi_B = BA$.

Maximum magnetic flux is linked.

Unit

SI — weber.

CGS — maxwell

1 weber $= 10^8$ maxwell

$[\phi_B] = [M^1 L^2 T^{-2} A^{-1}]$

Magnetic flux density at any point is defined as number of magnetic lines of force passing through an unit area placed at that ~~placed~~ point of the area is held ⊥r to the direction of lines.

Magnetic flux density inside the material is $B = B_0 + B_M$

(B_0 due to vacuum, B_M due to two poles)

Unit

SI. — weber per meter^2

CGS

Electric current

The current through a given cross sectional area in a conductor is defined as the time rate of flow of charge through that area.

mathematically $I = \frac{dq}{dt}$.

Here dq is the net flow of charge through the cross sectional area in the time interval dt.

Electric current is a scalar quantity.

$[I] = A$.

SI unit - Ampere.

$1A = \frac{1C}{1S}$.

The current is one ampere, if charge is being transferred at a rate of 1C per second.

Ohm's Law It states that the electric current flowing through a conductor is directly proportional to potential difference across the conductor.

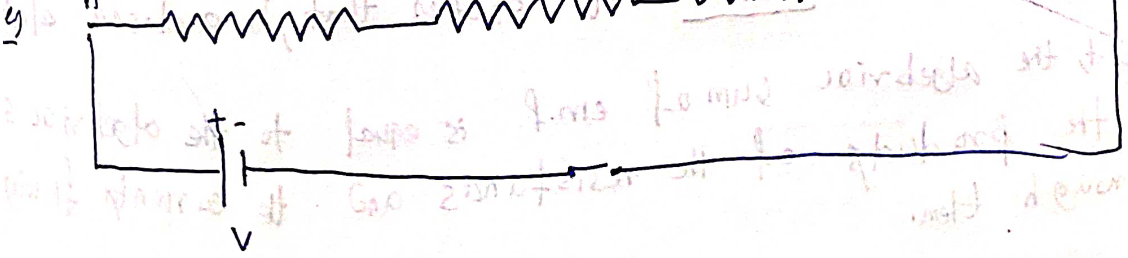
mathematically $I \propto V$

$I = \frac{1}{R}V$

$V = IR$

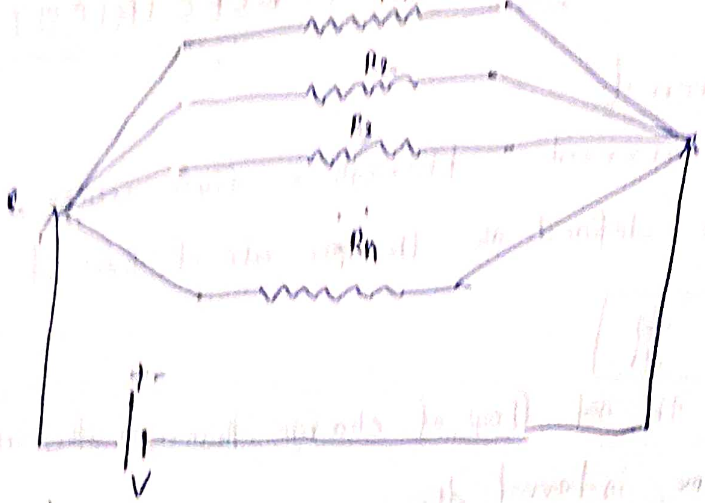
where $\frac{1}{R}$ = proportionality constant & R is resistance of the conductor.

Series & parallel combination of resistors



$R_{net} = R_1 + R_2 + R_3 + \cdots + R_n$.

Parallel



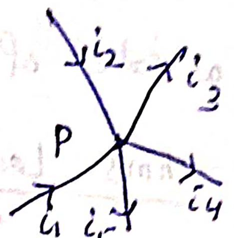
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}.$$

10.4 Kirchhoff's law

First law (KCL)

Statement: It states that the algebriac sum of currents meeting at a point

Explanation: To explain this law consider a number of wires connected at a point P. Currents i_1, i_2, i_3, i_4 & i_5 flow through these wires in the directions as show in fig.



To determine their algebriac sum of electric currents, we follow the following sign conventions.

(i) The currents approching a given point are taken as +ve.

(ii) The current leaving the given point are taken as -ve.

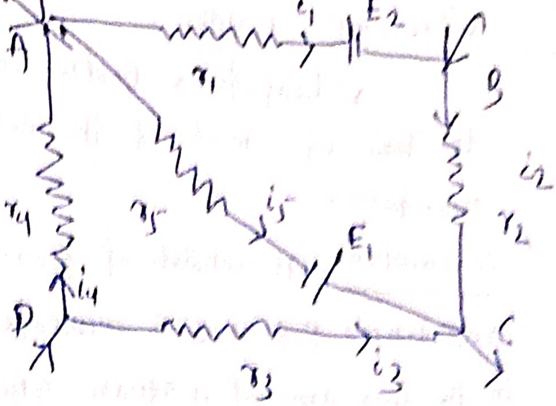
Following these sign convention, we find that i_1 & i_2 are +ve while i_3, i_4 and i_5 -ve.

So $i_1 + i_2 - i_3 - i_4 - i_5 = 0$

$$\sum_{i=1}^{5} i = 0$$

Second law (KVL) Statement - It states that, in a closed electric circuit, the algebriac sum of e.m.f is equal to the algebriac sum of the products of the resistances and the currents flowing through them.

Fig shows a closed electric circuit ABCD containing resistance r_1, r_2, r_3, r_4 & r_5 in the arms AB, BC, CD, DA & AC respectively. And let i_1, i_2, i_3, i_4, i_5 be the respective currents flowing in these parts in the directions shown by arrow heads. Two sources of emf's E_1 & E_2 are also connected in the mesh.



In order to use Kirchhoff's voltage ~~through the electrolyte of the cell from -ve~~ we shall follow the following sign conventions

(i) If the electric current flows through the electrolyte of the cell from -ve to +ve terminal the emf of the cell is taken as +ve. $(+E)$

(ii) If the electric current flows through the electrolyte of the cell from +ve to -ve terminal, the emf of the cell is take as -ve $(-E)$

(iii) If the path taken traverse the resistance is along the direction of current, the final point is at a lower potential than the initial point A. The product of current and resistance in this case is taken as -ve $(-ir)$.

(iv) If the path taken to traverse the resistance is against the direction of current, the final point (A) is at potential higher than that of initial point (B). The product of current and resistance in this case is taken as +ve $(+ir)$.

Applying KVL to mesh ABCA,

$$i_1 r_1 + i_2 r_2 - i_5 r_5 = E_1 - E_2.$$

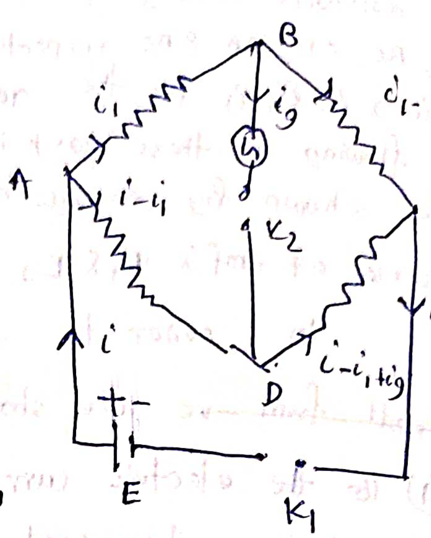
Applying KVL to mesh ACD,

$$i_5 r_5 - i_3 r_3 - i_4 r_4 = E_1$$

General form of KVL $\boxed{\Sigma i r = \Sigma E}$

10.5 Wheatstone Bridge.

Wheatstone bridge is an electrical arrangement which forms the basis of most of the instruments used to determine an unknown resistance.



Construction It consists of four resistances P, Q, R & S connected in the four arms of a square ABCD. A cell of emf E is connected between the points A & C through one way key K_1. A sensitive galvanometer of resistance G is connected between the terminals B & D through another one way K_2. After closing the keys K_1 & K_2, the resistance P Q R & S are so adjusted that the galvanometer shows no deflection. In this position the wheatstone bridge is said to be balanced.

Expln Using Kirchhoff's current law, the distribution of current and their directions through various resistances are as shown in fig.

Applying KVL to mesh ABD.

$$i_1 P + i_g G - (i - i_1) R = 0 \quad \text{—(I)}$$

Zero bcoz no emf in both the circuit.

mesh BCDB

$$(i_1 - i_g) Q - (i - i_1 + i_g) S - i_g G = 0 \quad \text{—(II)}$$

Balanced condition

$$i_g = 0$$

So eqn (I) & (II) becomes

$$i_1 P = (i - i_1) R \quad \text{—(III)}$$

$$i_1 Q = (i - i_1) S \quad \text{—(IV)}$$

Dividing

$$\frac{i_1 P}{i_1 Q} = \frac{(i - i_1) R}{(i - i_1) S}$$

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

This is the required condition for the bridge to be balanced & the principle of wheatstone bridge.

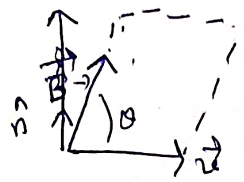
U-11

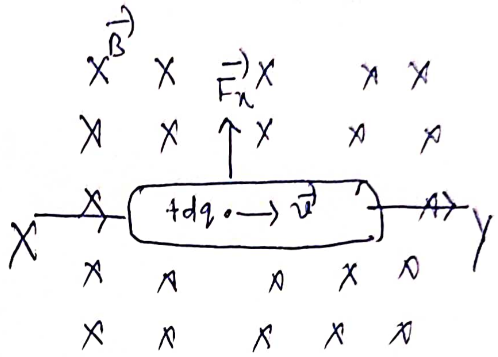
ELECTROMAGNETISM & EM INDUCTION

1) Electromagnetism: Electromagnetism is a brach of physics dealing with the em force and occurs between electrically charged particles.

Electromagnetism is produced when an electrical current flows through a simple conductor such as a length of wire or cable, and as current passes along the whole of the conductor.

Force acting on a current carrying conductor placed in a uniform magnetic field.





$$d\vec{F} = dq(\vec{v} \times \vec{B})$$
$$= dq\left(\frac{d\vec{l}}{dt} \times \vec{B}\right)$$
$$= \frac{dq}{dt}(d\vec{l} \times \vec{B})$$
$$= i\, d\vec{l} \times \vec{B}$$

$$\vec{F} = \int d\vec{F}$$
$$= i\int d\vec{l} \times \vec{B}$$
$$= i\, \vec{l} \times \vec{B}$$
$$= i\, lB\sin\theta\, \hat{n}$$

Fleming left hand rule: Direction of force $\vec{F}$ also be obtained by applying Fleming's left hand rule which can be stated as:

Stretch first finger, central finger and the thumb of your left hand in mutually ⊥r directions. If the first finger points towards magnetic field, central finger points towards electric current then the thumb gives the direction of force acting on the conductor.

Faraday law of EM induction

Whenever magnetic flux linked with a circuit changes an emf is induced in it. The induced emf exists in the circuit so long as the change in magnetic flux linked with it continues. The induced emf is directly proportional to the -ve rate of change of magnetic flux linked with the circuit.

$$E = -\frac{d\phi_B}{dt}$$

11.4 Lenz law   It states that direction of induced emf is s.t. it tends to oppose the very cause which ~~opposes~~ produces it.

11.5 Fleming's Right hand rule. Strech first finger and the thumb of your right hand in three mutually ⊥r directions. If the first finger points towards the magnetic fields, thumb points towards the direction of motion of conductor, the direction of central finger gives the direction of induced current set up in the conductor.

11.6 Comparison.

UNIT-12
MODERN PHYSICS

1. **Laser & Laser beam** Laser is light amplification by stimulated emission of radiation. A laser beam is extremely intense, coherent and highly parallel beam of light.

2. **Principle**

Population Inversion :- Population inversion is a method in which we there are more atoms in the meta stable state than the ground state.

Optical pumping :- This is done by supplying suitable energy to the atoms of the active medium with the help of pump. The process of bringing about population inversion is known as pumping.

3. **Properties**

→ Directionality
→ Intensity
→ Monochromaticity
→ coherence

Application

→ surgery
→ Industry
→ Science
→ warfare.