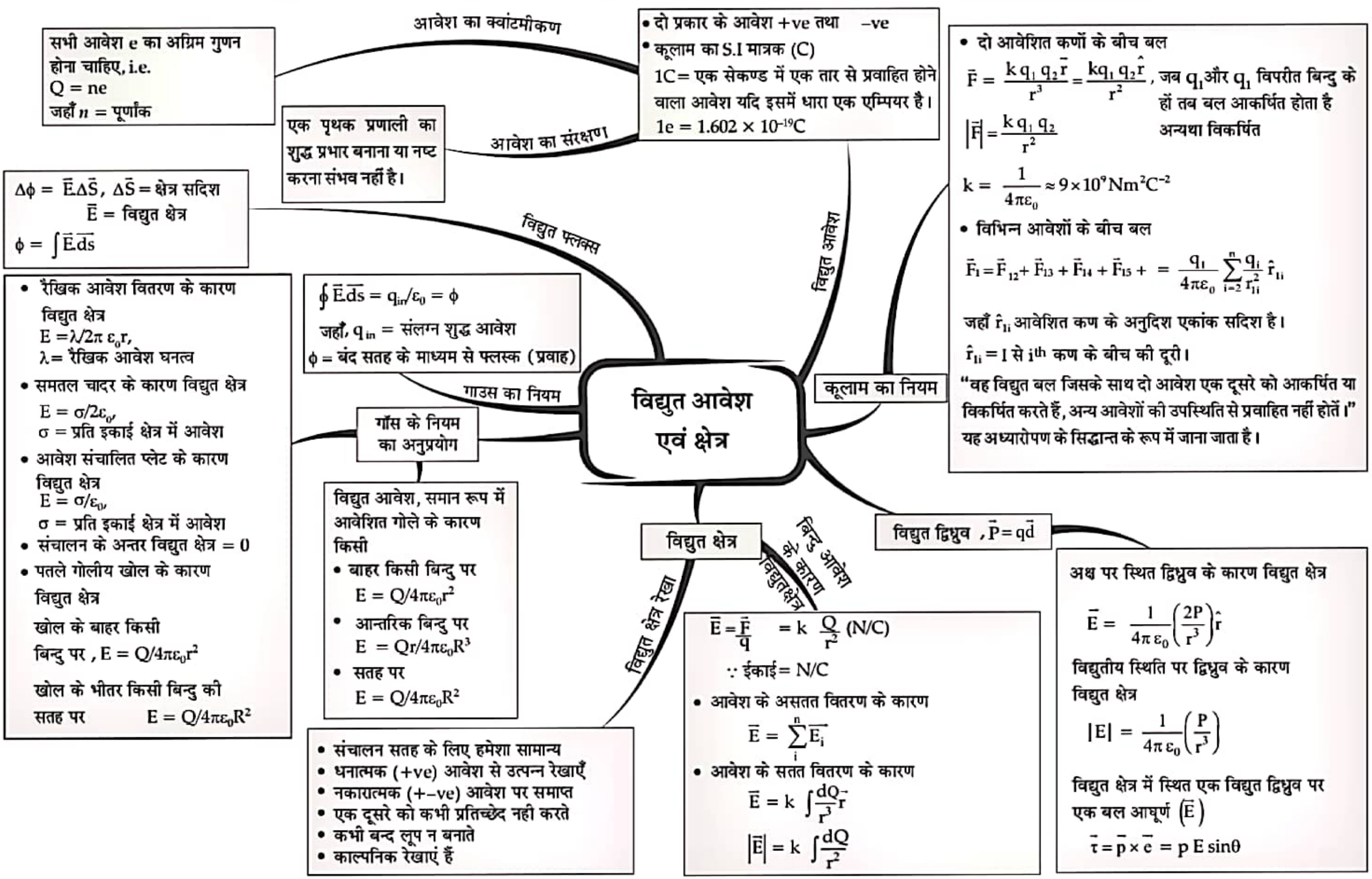
अध्याय — 1 विद्युत आवेश एवं क्षेत्र



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Electric Charges & Fields

Electric charges

- Two kinds of charges + ve and – ve
- S.I unit is coulomb (C)
  1 C = charge flowing through a wire in 1 sec if current in it is 1A
  $1e = 1.602 \times 10^{-19}$ C

Quantization of charge

All charges must be a multiple of charge (e)
$Q = ne$
Where n is an integer

Conservation of charge

It is not possible to create or destroy net charge of an isolated system.

Coulomb's Law

In 1985, Charles Augustin de Coulomb gave Coulomb's law

- Force between two charged particles

$\vec{F} = \dfrac{k\, q_1\, q_2\, \vec{r}}{r^3} = \dfrac{k q_1\, q_2 \hat{r}}{r^2}$, force is attractive when q_1 and q_2 are of opposite sign, otherwise repulsive

$|\vec{F}| = \dfrac{k\, q_1\, q_2}{r^2}$

$k = \dfrac{1}{4\pi\varepsilon_0} \approx 9\times10^9\ \mathrm{Nm^2C^{-2}}$

- Force between multiple charges

$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \vec{F}_{15} + \ldots\ldots = \dfrac{q_1}{4\pi\varepsilon_0}\sum_{i=2}^{n}\dfrac{q_i}{r_{1i}^2}\hat{r}_{1i}$

where is the unit vector along charge particle under consideration
$\hat{r}_{1i}$ = distance between Ist and i^{th} particle

"The electric force with which two charges attract or repel one another are not affected by the presence of other charges". It is known as Superposition Principle.

Electric flux

$\Delta\phi = \vec{E}.\Delta\vec{S}$, $\Delta\vec{S}$ = area vector
$\vec{E}$ = electric field
$\phi = \int \vec{E}.\vec{ds}$

Gauss's Theorem

$\oint \vec{E}\vec{ds} = q_{in}/\varepsilon_0 = \phi$

where, q_{in} = net charge enclosed
ϕ = flux through a closed surface

Applications of Gauss's Law

- Electric Field due to linear charge distribution
  $E = \lambda/2\pi\,\varepsilon_0 r$,
  λ = linear charge density
- Electric Field due to a plane sheet of charge
  $E = \sigma/2\varepsilon_0$,
  σ = charge per unit area
- Electric Field due to a charged conducting plate
  $E = \sigma/\varepsilon_0$,
  σ = charge per unit area
- Electric Field inside a conductor = 0
- Electric field due to a thin spherical shell at a point
  Outside the shell, $E = Q/4\pi\varepsilon_0 r^2$
  Inside the shell, $E = 0$
  On the surface, $E = Q/4\pi\varepsilon_0 R^2$

Electric field due to uniformly charged spherical shell at :

- Outside point,
  $E = Q/4\pi\varepsilon_0 r^2$
- Internal point,
  $E = Q/4\pi\varepsilon_0 R^3$
- The surface,
  $E = Q/4\pi\varepsilon_0 R^2$

Electric Field

Electric field due to point charge

$\vec{E} = \dfrac{\vec{F}}{q} = k\dfrac{Q}{r^2}$ (N/C)

$\because$ unit = N/C

- Due to discrete distribution of charges
  $\vec{E} = \sum_{i}^{n} \vec{E}_i$
- Due to continuous distribution of charges
  $\vec{E} = k\int \dfrac{dQ}{r^3}\vec{r}$
  $|\vec{E}| = k\int \dfrac{dQ}{r^2}$

Electric field lines

- Always normal to conducting surface
- Lines originating from +ve charge
- Terminating at –ve charge
- Never intersect each other
- Do not form closed loop
- Are imaginary lines.

Electric Dipole moment, $\vec{p} = q\vec{d}$

- Electric field due to dipole at axial position,
  $\vec{E} = \dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{2p}{r^3}\right)\hat{r}$
- Electric field due to dipole at an equatorial position,
  $|E| = \dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{p}{r^3}\right)$
- Torque on an electric dipole placed in an electric field $(\vec{E})$
  $\vec{\tau} = \vec{p}\times\vec{E} = pE\sin\theta$

Trace the Mind Map

- First Level
- Second Level
- Third Level

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Electrostatic Potential and Capacitance

Electric potential

- Work done per unit test charge by an external agent in moving the test charge from reference point to the desired point. Its SI unit is J/C
  $V_0 = W/q_0$.

Electric potential due to a point charge

$V_P = Q/4\pi\varepsilon_0 r$

Potential due to a system of charges

$V = \frac{1}{4\pi\varepsilon_0}\sum \frac{Q_i}{r_i}$

Potential due to a dipole

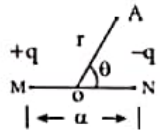
$V = \frac{1}{4\pi\varepsilon_0}\frac{p\cos\theta}{r^2}$

Where, $p = qd$

$\theta = \angle AON$

At $\theta = 0°$, $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$ [axial position]

At $\theta = 90°$, $V = 0$ [equitorial position]



In 1774, Alessandro Volta wrote treatise"on the forces of attraction of electric fire".

Conductors & Insulators

Conductors	Insulators
A material which when placed in an electric field, the free electrons move in a direction opposite to the field.	material in which electrons are tightly bound, and when exposed in an electric field, electrons do not move *i.e.* having no free electrons.

- Electric field inside a conductor is always zero.
- Electric field is always perpendicular to the charged surface.
- In static state, there will be no additional charge in a conductor.

Dielectric

- Force $F = \frac{q_1 q_2}{4\pi K\varepsilon_0 r^2}$, K = dielectric constant of medium
- A dielectric is an electrical insulator that can be polarized by "application of" electric field.

Equipotential surface

- Potential is same at all the points of the surface.
- Component of electric field parallel to an equipotential surface is zero.

Electric potential energy

- It is negative count of work done by the electric force as the configuration of the system changes.
- $U_{r_2} - U_{r_1} = -W = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$
- If the separation between charges is 'r', then $U_{(r)} = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0 r}$
- Potential Difference,

  $V_B - V_A = \frac{U_B - U_A}{q}$

  $U_B - U_A$ = Change in Potential energy

  q = Test charge

Potential energy of a dipole

$dU = pE\sin\theta d\theta$

If we choose P.E. of dipole to be zero when $\theta = 90°$, then

$U_\theta - U_{90°} = \int_{90°}^{\theta} pE\sin\theta\, d\theta$

If it is rotated through angle θ against the torque,

$U_\theta = -pE\cos\theta = -\vec{p}\cdot\vec{E}$

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

Capacitance of a parallel plate capacitor,
$C = K\varepsilon_0 A/d$, K = dielectric constant

Capacitance when material slab is inserted between the plates
$C = K\varepsilon_0 A/[Kd - x(K-1)]$
where, x = thickness of the slab inserted

Energy stored in a capacitor,
$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = 1/2\,QV$

Series grouping of capacitors,
$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{- - - -} + \frac{1}{C_n}$

For two, $C = \frac{C_1C_2}{C_1 + C_2}$

Parallel grouping of capacitors,
$C = C_1 + C_2 + C_3 + \text{- - - -} + C_n$
for two capacitors, $C = C_1 + C_2$

Capacitance of a spherical capacitor,
$C = 4\pi\varepsilon_0 / \left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

For isolated sphere,
$C = 4\pi\varepsilon_0 R$

Trace the Mind Map
- First Level
- Second Level
- Third Level

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अध्याय — 2 स्थिर वैद्युत विभव तथा धारिता

स्थिर वैद्युत विभव तथा धारिता

वैद्युत विभव

- बाह्य बल द्वारा किसी एकांक धनावेश को संदर्भ बिन्दु से वोधित बिन्दु तक लाने में किया गया कार्य। SI मात्रक J/C.

T_0 = किया गया कार्य/आवेश

एक बिन्दु आवेश के कारण वैद्युत विभव

$V_P = Q/4\pi\varepsilon_0 r$

आवेशों की प्रणाली के कारण विभव

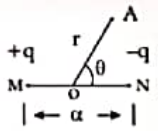
$$V = \frac{1}{4\pi\varepsilon_0}\sum\frac{Q_i}{r_i}$$

द्विध्रुव के कारण विभव

$$V = \frac{1}{4\pi\varepsilon_0}\frac{p\,\mathrm{Cos}\theta}{r^2}$$

जहाँ = qd

θ = ∠AON



At θ = 0, $V = \frac{1}{4\pi\varepsilon_0}\frac{p}{r^2}$ [अक्षीय स्थिति]

At, θ = 90°, V = 0 [विषुवतीय स्थिति]

समविभव पृष्ठ

- सतह के बिन्दुओं पर विभव समान होता है।
- एक समविभव पृष्ठ के समानान्तर विद्युत क्षेत्र के संघटक शून्य होते हैं।

विद्युत विभव ऊर्जा

- यह विद्युत क्षेत्र द्वारा किए गए का कार्य का ऋणात्मक मान है। क्योंकि प्रणाली का विन्यास बदल जाता है।
- $Ur_2 - Ur_1 = -W = \frac{q_1 \cdot q_2}{4\pi\varepsilon_0}\left(\frac{1}{r_2} - \frac{1}{r_1}\right)$
- यदि आवेशों के बीच का पृथक्करण 'r' हो, तब

  $U_{(r)} = \frac{q_1\ q_2}{4\pi\varepsilon r}$
- विभवान्तर

  $V_B - V_A = \frac{U_B - U_A}{q}$

  $U_B - U_A$ = विभव ऊर्जा में परिवर्तन

  q = परीक्षण आवेश

द्विध्रुव का विभव ऊर्जा

$dU = pE\sin\theta d\theta$

यदि हम द्विध्रुव के विभव ऊर्जा को शून्य लेते हैं, जब θ = 90°तब

$$U_\theta - U_{90°} = \int_{90°}^{\theta} pE\sin\theta d\theta$$

$U_\theta = -pE\cos\theta = -\vec{p}\times\vec{E}$

यदि यह आघूर्ण के विपरीत कोण के माध्यम से घुमाया जाता है।

चालक एवं कुचालक

चालक	कुचालक
वह पदार्थ जिसे जब विद्युत क्षेत्र में रखा जाता है, तब मुक्त इलेक्ट्रॉन विद्युत क्षेत्र के विपरीत दिशा में गति करता है।	वह पदार्थ जिसमें इलेक्ट्रॉन कसकर बधें होते हैं, और जब उन्हें विद्युत क्षेत्र में रखा जाता है, इलेक्ट्रॉन में गति नहीं होता अर्थात् मुक्त इलेक्ट्रॉन नहीं होता।

- चालक के अन्दर विद्युत क्षेत्र शून्य होता है।
- विद्युत क्षेत्र आवेशित सतह पर हमेशा लम्बवत् होती है।
- स्थित अवस्था में, चालक पर कोई अतिरिक्त आवेश नहीं होता।

परावैद्युत

- $F = \frac{q_1 q_2}{4\pi K\varepsilon_0 r^2}$, K = माध्यम का परावैद्युतांक
- परावैद्युत एक विद्युत कुचालक होता है जो विद्युत क्षेत्र के प्रयोग के ध्रुवीकृत किया जाता है।

धारिता , $C = \frac{Q}{V}$

समानान्तर प्लेट धारित्र की धारिता

$C = K\varepsilon_0 A/d$, K = परावैद्युतांक

धारिता, जब प्लेटों के बीच सामग्री स्लैब डाला जाता है।

$C = K\varepsilon_0 A/[Kd - x(K-1)]$

जहाँ x = डाली गई स्लैब की मोटाई

गोलीय चालकों की धारिता

$$C = 4\pi\varepsilon_0/\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

वियुक्त गोले के लिए

$C = 4\pi\varepsilon_0 R$

धारित्रों का समानान्तर क्रम में संयोजन

$C = C_1 + C_2 + C_3 + ---- + C_n$

दो के लिए $C = C_1 + C_2$

धारित्रों का श्रेणी क्रम में संयोजन

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

दो क लिए , $C = \frac{C_1 C_2}{C_1 + C_2}$

धारित्र में संचित ऊर्जा

$$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$$

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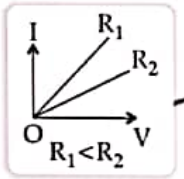
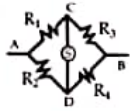
Current Electricity

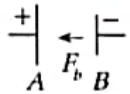


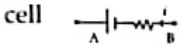
- **Electric Current**
  - Rate of flow of charge through an area,
  - $i = \frac{Q}{t}$
  - $i = \int \vec{J}.\vec{ds}$
- **Current density**
  - $\vec{J} = \frac{\Delta i}{\Delta s \cos\theta} = \sigma E$
  - Δs = Area of cross-section
  - θ = Angle between Area vector and current flow
  - σ = Conductivity
- **Drift velocity**
  - $V_d = \frac{i}{neA} = \frac{J}{ne}$
- **Mobility**
  - $\mu = \frac{V_d}{E} = \frac{e\tau}{m}$
  - τ = Average collision time
- **Ohm's Law**
  - $J = \sigma E$ or $V = IR$
  - Characteristics

- **Resistance**
  - $R = \rho \frac{l}{A}$
- **Resistivity**
  - $\rho = \frac{1}{\sigma} \Omega m$
- **Conductivity**
  - $\sigma = J/E$
- **Grouping of Resistors**
  - $R = R_1 + R_2 + R_3 + \cdots + R_n$
  - For two resistors, $R = R_1 + R_2$
  - $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$
  - For two resistors $R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$
- **Temperature Dependence of Resistance**
  - $R = R_0[1 + \alpha(T - T_0)]$
  - $\rho = \rho_0 \; [1 + \alpha(T - T_0)]$
  - R = Resistance at temperature T
  - R_0 = Resistance at temperature T_0
  - α = Coefficient of resistivity
- **Wheatstone Bridge**
  - Condition for balanced wheatstone bridge
  - If $\frac{R_1}{R_2} = \frac{R_3}{R_4}$

  - $V_c = V_D$
  - No current through G
- **Meter Bridge**
  - Unknown resistance
  - $S = \frac{R(100-l)}{l}$
  - l = Balancing length
  - R = Known resistance
- **Potentiometer**
  - $P = \frac{V_A - V_B}{l} = \frac{\text{Potential difference}}{\text{Length of wire}}$
  - Comparison of emf, $\frac{E_1}{E_2} = \frac{l_1}{l_2}$
  - Internal Resistance (r) $= R\left(\frac{l_1}{l_2} - 1\right)$
  - l_1 and l_2 are lengths of null point
- **Electric cell**
  - It is a device which maintains a potential difference between its two terminals.
  - EMF
    - $\text{emf} = E = \frac{W}{q} = \frac{F_b}{d}$
    - It is equal to the potential difference between the terminals when the they are not connected externally.





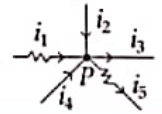


  - Internal Resistance
    - $V_A - V_B = E - ir$
    - r = Internal resistance of the cell

- **Grouping of Cell**
  - Parallel grouping
    - $E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$, $i = \frac{E_{eq}}{R + \frac{r_1 r_2}{r_1 + r_2}}$
  - Series grouping
    - $i = \frac{E_1 + E_2}{R + (r_1 + r_2)} = \frac{E_0}{R_1 + R_2}$
    - $E_0 = E_1 + E_2$, $R_2 = r_1 + r_2$
- **Kirchhoff's Law**
  - Junction Law
    - $i_1 + i_2 + i_4 = i_3 + i_5$
    - The algebraic sum of all currents directed towards a point (junction) is zero.
    - $\Sigma I_p = 0$

  - Loop Law
    - The algebraic sum of all the potential difference along a closed loop is zero.
    - $\Sigma E = 0$

Trace the Mind Map
- First Level
- Second Level
- Third Level



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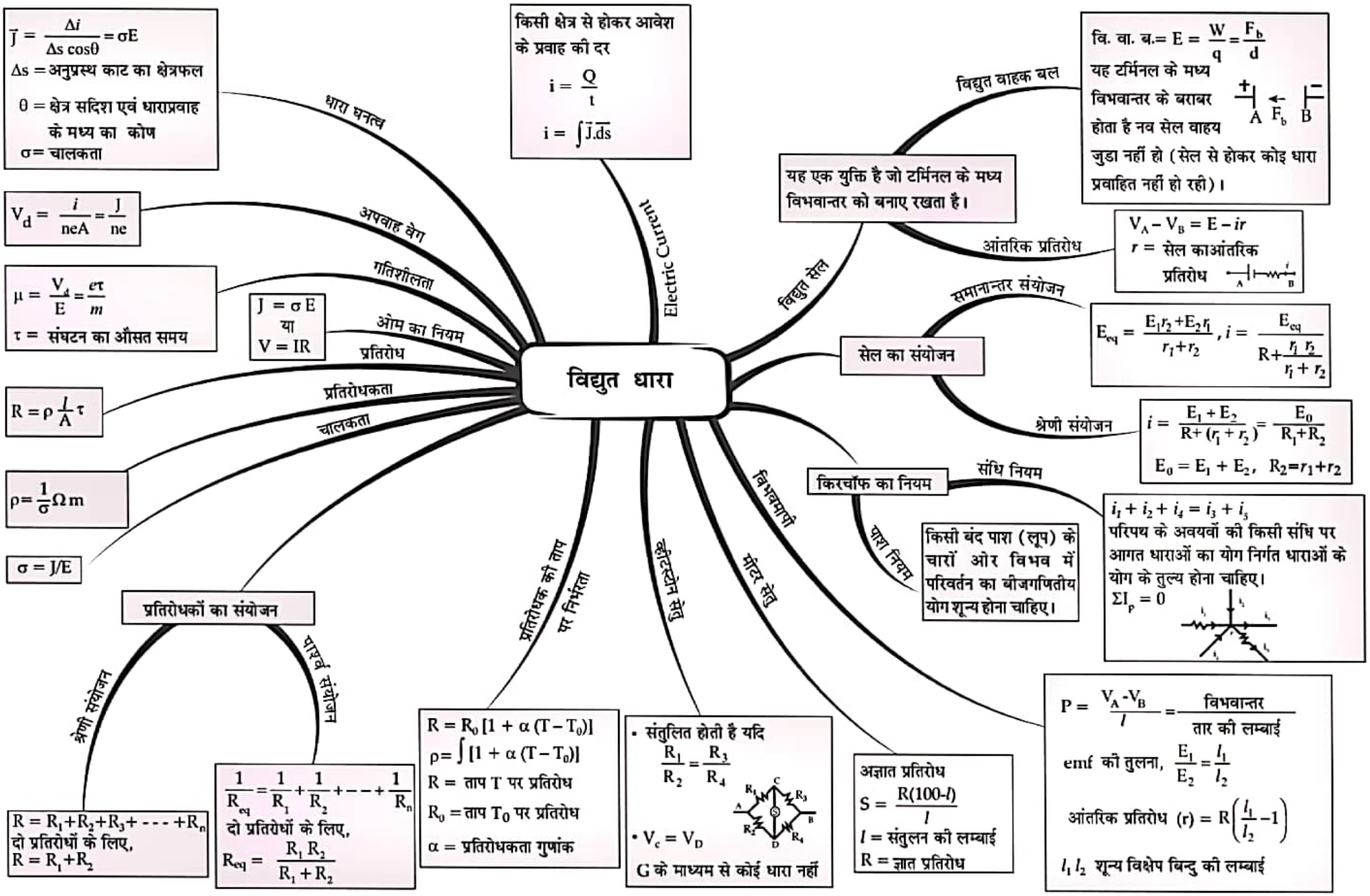
अध्याय — 3 विद्युत धारा



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Moving Charges & Magnetism

Magnetic Field ($\vec{B}$)

- It is a region around a magnet or current carrying conductor or a moving charge in which its magnetic effect can be felt
- SI unit is Tesla(T) = weber/m^2
- 1 Gauss = 10^{-4} Tesla where gauss is the CGS unit

Magnetic Force on a moving charge

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

$= qvB \sin\theta$

- For $\theta = 0, \vec{F} = 0$ along the magnetic field
- For $\theta = 90°$, *i.e.* if charge's velocity is perpendicular to field direction, force is perpendicular to both field and velocity

$F = qvB = \frac{mv^2}{r}$

$r = \frac{mv}{qB}$ = Radius of the circle in which charge rotates

Time period $(T) = \frac{2\pi m}{qB}$

ν(frequency) $= \frac{1}{T} = \frac{qB}{2\pi m}$

If $\theta \neq 0, 180°, 90°$

Then, $F = qvB\sin\theta$

And the charge particle will follow helical path whose

$r = \frac{mv_\perp}{qB}$ and pitch $= V_\parallel \times T = V_\parallel \times \frac{2\pi m}{qB}$

Cyclotron

To accelerate a charged particle (except electron)

Max. energy gained $= \left(\frac{q^2B^2}{2m}\right)r^2$

Oersted's Law

In April 1820, Hans Christian Oersted discovered that flow of current in a wire can deflect a nearby magnetic compass needle.

Ampere's Law

$\oint \vec{B}.\vec{dl} = \mu_0 i$

where i = Total current crossing the area bounded by closed curve.

Solenoid

- Magnetic field at a point inside due to a long solenoid, $B = \mu_0 ni$
- At a point on one end $B = \frac{\mu_0 ni}{2}$

where n = number of turns per unit length along the length of solenoid.

Magnetic field due to Toroid

$B = \frac{\mu_0 Ni}{2\pi r}$, N = Total Number of turns, i = Current in toroid

Force on a current carrying conductor

$d\vec{F} = i(\vec{dl} \times \vec{B})\, F = ilB$

Force between parallel current carrying wires

$F = \frac{\mu_0 i_1 i_2}{2\pi d}$

Torque experienced by a loop in uniform magnetic field

$\vec{\tau} = \vec{M} \times \vec{B}$

$\vec{\tau} = NBiA$

Definition of Ampere

If two parallel wire kept 1 m apart, if and $F = 2\times10^{-7}$ N, then current = 1A in each wire.

Galvanometer

Sensitivity

Voltage sensitivity = NBA/CG current sensitivity = NBA/C

Ammeter

$S = \frac{Ig}{I_T - Ig}G$

Voltmeter

$R = \frac{V}{Ig} - G$

biot-Savart Law

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{id\vec{l} \times \vec{r}}{r^3}$ [θ = angle between $d\vec{l}$ and $\vec{r}$]

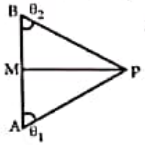
$dB = \frac{\mu_0}{4\pi}\frac{idl\sin\theta}{r^2}$ [Direction of field will be perpendicular to the plane containing current element and the point of observation]

where $\mu_0 = \frac{1}{\varepsilon_0 c^2}$

Magnetic field due to straight current carrying wire

$B = \frac{\mu_0 i}{4\pi d}(\sin\theta_1 + \sin\theta_2)$

where θ_1 and θ_2 are the angles corresponding to the lower and upper ends respectively



i.e $\theta_1 = 0$

$\theta_2 = \pi$

$B = \frac{\mu_0 i}{2\pi d}$

Field due to a current carrying circular ring

Field at the centre

$B = \frac{\mu_0 i}{2a}$

Field at an axial point

$B = \frac{\mu_0 i a^2}{2(a^2 + d^2)^{3/2}}$

i.e. for $d >>> a$

$B = \frac{\mu_0 i a^2}{2d^3}$

Field at a point far away from the centre

Trace the Mind Map

- First Level
- Second Level
- Third Level

Scanned with CamScanner

अध्याय — 4 गतिमान आवेश और चुम्बकत्व

यह एक चुम्बक या धारा प्रवाह वाले चालक या गतिमान आवेश के आसपास का क्षेत्र है जिसमें इसके चुम्बकीय प्रभाव को महसूस किया जा सकता है।

अप्रैल 1820 में हैंस क्रिश्चियन ऑर्स्टेड ने खोज की कि तार में प्रवाहित धारा नजदीकी चुम्बकीय सूई में विक्षेप उत्पन्न करता है।

गतिमान आवेश और चुम्बकत्व

चुम्बकीय क्षेत्र

$\vec{F} = q\vec{v} \times \vec{B}$

$= qvB \sin\theta$

- $\theta = 0$ के लिए $\vec{F} = 0$ चुम्बकीय क्षेत्र के साथ
- $\theta = 90°$ के लिए, अर्थात् यदि आवेश का वेग क्षेत्र की दिशा के लम्बवत् है तो बल क्षेत्र एवं वेग दोनों के लम्बवत् होती है।

$F = qvB = \frac{mv^2}{r}$

$r = \frac{mv}{qB}$ = वृत्त की त्रिज्या जिसमें आवेश घूर्णन करता है।

समय अवधि $(T) = \frac{2\pi m}{qB}$

V (आवृति) $= \frac{1}{T} = \frac{qB}{2\pi m}$

यदि $\theta \neq 0, 180°, 90°$

तब $F = qvB \sin\theta$

एवं आवेशित कण कुंडलिनी पथ का अनुसरण करेगा जिसका

$r = \frac{m v_\perp}{q B}$ एवं पिच या चूड़ी अंतराल $= V_\parallel \times T = V_\parallel \times \frac{2\pi m}{qB}$

गतिमान आवेश पर चुम्बकीय बल

ऑर्स्टेड नियम

एम्पीयर का नियम

$\oint \vec{B}.d\vec{l} = \mu_0 i$

जहाँ i = बंद वक्र द्वारा परिबद्ध क्षेत्र से पार करने वाली कुल धारा।

परिनालिका

- लम्बी परिनालिका के कारण एक आन्तरिक बिन्दु पर चुम्बकीय क्षेत्र $B = \mu_0 ni$
- एवं एक छोर पर बिन्दु $B = \frac{\mu_0 ni}{2}$

जहाँ n = परिनालिका के लम्बाई के साथ प्रति ईकाई लम्बाई फेरों की संख्या।

टोरॉइड के कारण चुम्बकीय क्षेत्र

$B = \frac{\mu_0 Ni}{2\pi r}$, N = फेरों की कुल संख्या

i = टोरॉइड में धारा

चालक में प्रवाहित धारा पर बल

$d\vec{F} = i\, d\vec{l} \times \vec{B}$, $F = ilB$

समानान्तर धारा के बीच बल

$F = \frac{\mu_0 i_1 i_2}{2\pi d}$

एकसमान चुम्बकीय क्षेत्र में एक पाश (लूप) द्वारा अनुभव किया गया बल आघूर्ण।

$\vec{\tau} = MB \sin\theta\, \hat{n} = \vec{M} \times \vec{B}$

एम्पीयर की परिभाषा

यदि दो समानान्तर तार 1m की दूरी पर रखा जाए, यदि $F = 2\times10^{-7}$, तब प्रत्येक में धारा = 1A

सुग्राहिता

गतिमान कुंडली गैल्वेनोमीटर की सुग्राहिता है nBA/K

गैल्वेनोमीटर से अमीटर

$S = \frac{Ig}{I_T - Ig} G$

गैल्वेनोमीटर से वोल्टमीटर

$R = \frac{V}{Ig} - G$

वायो-सावर्ट नियम

$d\vec{B} = \frac{1}{4\pi\varepsilon_0 c^2} \frac{i d\vec{l} \times \vec{r}}{r^3}$

$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i d\vec{l} \times \vec{r}}{r^3}$ [$\theta = d\vec{l}$ के बीच का कोण $\vec{r}$]

$dB = \frac{\mu_0}{4\pi} \frac{i dl \sin\theta}{r^2}$ [क्षेत्र की दिशा, धारा तत्व युक्त पृष्ठ एवं अवलोकन बिन्दु के लम्बवत् होगा]

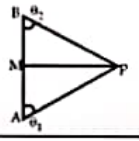
जहाँ $\mu_0 = \frac{1}{\varepsilon_0 c^2}$

$= 4\pi \times 10^{-7}\ TmA^{-1}$

सीधी तार में प्रवाहित धारा के कारण चुम्बकीय क्षेत्र

$B = \frac{\mu_0 i}{4\pi d} (\cos\theta_1 - \cos\theta_2)$

जहां θ_1 एवं θ_2 क्रमशः निचली एवं ऊपरी छोर के कोण हैं।



लम्बी सीधी रेखा में प्रवाहित धारा के कारण क्षेत्र

$i.e\ \theta_1 = 0$

$\theta_2 = \pi$

$B = \frac{\mu_0 i}{2\pi d}$

वृत्ताकार छल्ला ⊙ में प्रवाहित धारा के कारण क्षेत्र

केन्द्र पर क्षेत्र

$B = \frac{\mu_0 i}{2a}$ ⊗ ⊙

केन्द्र से दूर एक बिन्दु पर क्षेत्र

अक्षीय बिन्दु पर क्षेत्र

$B = \frac{\mu_0 i a^2}{2(a^2 + d^2)^{3/2}}$

(i.e.)के लिये $d >>> a$

$B = \frac{\mu_0 i a^2}{2d^3}$

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Magnetism & Matter

Trace the Mind Map
- First Level
- Second Level
- Third Level

Dipole moment

Circular Loop
Current loop of area A = πr^2 carrying current i may be replaced by a magnetic dipole of dipole moment, $\mu = md = iA$

Revolving electron
$|\vec{\mu}| = iA = \frac{ev}{2\pi r} \times \pi r^2$

$= evr/2$

$\vec{\mu} = \frac{-e}{2m_e}\vec{L}$

$\mu = md$

m = Magnetic charge or pole strength

d = Separation between poles

r = Radius of circular orbit

e = Charge on electron

v = Speed of electron;

L = Angular momentum

m_e = Mass of electron

Solenoid
$\mu = NIA$,

N = Number of turns

I = Current

A = Area

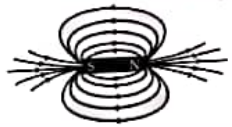
Earth's magnetic field

Earth is a natural source of magnetic field having geometric north and geometric south pole

- **Declination**: Angle between magnetic meridian and geographical meridian.
- **Inclination or dip (δ)**: Angle made by Earth's magnetic field with horizontal in the magnetic direction, $\delta_{equator} = 0$, $\delta_{pole} = 90°$
- **Horizontal component**: $B_H = B\cos\theta$; B_H (at pole) = 0; B_H (at equator) is maximum

Magnetic field lines

Continuous imaginary lines which represent the direction of magnetic field.



Magnetic substance

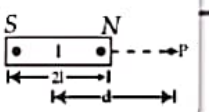
- **Para-magnetism**: Tendency to increase the magnetic field due to magnetization, *e.g. Al, Mn* (c_m low and $-ve$, $\mu_r > 1$)
- **Diamagnetism**: Tendency of strong magnetization in the direction of magnetic field. *e.g. Fe, Co, Ni*, ($\mu_r, \chi_m >> 1$)
- **Ferromagnetism**: Tendency to magnetise in a direction opposite to direction of magnetic field *e.g. Bi, Cu, Hg, Ni.* ($\mu_r, \chi_m < 1$)

Electromagnets

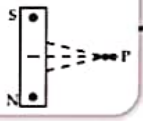
Magnet in which the magnetic field is produced by an electric current. Magnetic field disappears when current is turned off.

Bar magnet

Magnetic field intensity
- End–on–position: $= \frac{\mu_0}{4\pi}\frac{2M}{d^3}$; $M = 2ml$; $d >>> l$



- Broadside Position, $B = \frac{\mu_0}{4\pi}\frac{M}{(d^2+l^2)^{3/2}}$; For $d >>> l$, $B = \mu_0 M/4\pi d^3$



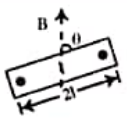
Potential energy of a Field-Magnet System
$U_\theta = U_\theta - U_{90°} = -MB\cos\theta = -\vec{M}.\vec{B}$

we take P.E. at $\theta = 90°$ to be zero

Torque
$\vec{\tau} = \vec{M} \times \vec{B} = MB\sin\theta$

$M = 2ml$

B = Magnetic field



Magnetic terms

- **Magnetic intensity**: $H = \frac{B_0}{\mu}$
- **Magnetic permeability**: $\mu = \mu_0(1 + c_m)$
- **Magnetic Susceptibility**: $\chi = \frac{I}{H}$
- **Intensity of magnetization**: $I = \frac{M}{V}$
- **Time period oscillating bar magnet**: $T = 2\pi\sqrt{\frac{I}{MB}}$

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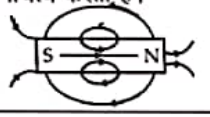
अध्याय – 5 चुम्बकत्व एवं द्रव

चुम्बकत्व एवं द्रव

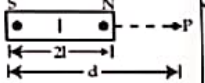
द्विध्रुव आघूर्ण
- **वृत्तीय धारा (लूप)**: क्षेत्र A के धारा लूप = πr^2, प्रवाहित धारा i द्विध्रुव आघूर्ण के चुम्बकीय द्विध्रुव द्वारा प्रतिस्थापित हो सकता है।
- **परिक्रमण करता इलेक्ट्रॉन**:
  - $|\vec{\mu}| = iA = \frac{ev}{2\pi r} \times \pi r^2$
  - $= evr/2$
  - $\vec{\mu} = \frac{-e}{2m_e}\vec{L}$
  - $\mu = md$
  - m = चुम्बकीय आवेश या ध्रुव शक्ति
  - d = ध्रुवों के बीच आलगाव
  - r = वृतीय कक्ष की त्रिज्या
  - e = इलेक्ट्रॉन पर आवेश
  - v = इलेक्ट्रॉन की गति
  - L = कोणीय संवेग
  - m_e = इलेक्ट्रॉन का द्रव्यमान
- **परिनालिका**:
  - $\mu = NIA$,
  - N = फेरों की संख्या
  - I = धारा
  - A = क्षेत्र

छड़ चुम्बक
- **चुम्बकीय क्षेत्र तीव्रता**
  - अग्र आस्थिति
    - $= \frac{\mu_0}{4\pi}\frac{2M}{d^3}$
    - $M = 2ml$
    - $d >>> l$
    - (चित्र: S, N, P, 2l, d)
  - पार्श्व आस्थिति
    - $B = \frac{\mu_0}{4\pi}\frac{M}{(d^2+l^2)^{3/2}}$
    - $d >>> l$ के लिए
    - $B = \mu_0 M/4\pi d^3$
    - (चित्र: S, N, P)
- **क्षेत्र चुम्बक प्रणाली की स्थितिज ऊर्जा**: $U = U_0 - U_{90°} = -MB\cos\theta = -\vec{M}.\vec{B}$ हम स्थितिज ऊर्जा को θ = 90° पर शून्य लेते हैं।
- **बल आघूर्ण**:
  - $\vec{\tau} = \vec{M} \times \vec{B} = MB\sin\theta$
  - $M = 2ml$
  - B = चुम्बकीय क्षेत्र
  - (चित्र: B, θ, 2l)

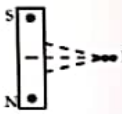


पृथ्वी का चुम्बकीय क्षेत्र
पृथ्वी चुम्बकीय क्षेत्र का प्राकृतिक स्रोत है जिसमें भौगोलिक उत्तर तथा भौगोलिक दक्षिणी ध्रुव है।
- **दिक्पात कोण**: चुम्बकीय याम्योत्तर एवं भौगोलिक याम्योत्तर के बीच का कोण
- **नमन कोण या आनति (δ)**: चुम्बकीय दिशा में क्षैतिज के साथ पृथ्वी के चुम्बकीय क्षेत्र द्वारा बनाया गया कोण। δ विषुवत = 0, δ विषुवत ध्रुव = 90°
- **क्षैतिज अवयव**:
  - $B_H = B\cos\theta$
  - B_H (ध्रुव पर) = 0
  - B_H (विषुवत पर) अधिकतम होता है।

चुम्बीय क्षेत्र रेखाएं
निरन्तर काल्पनिक रेखाएं जो चुम्बकीय क्षेत्र की दिशा का प्रतिनिधित्व करती हैं।



चुम्बकीय पदार्थ
- **अनुचुम्कत्व**: चुम्बकत्व के कारण चुम्बकीय क्षेत्र को बढ़ाने की प्रवृत्ति e.g. Al, Mn (χ_m, $\mu_r > 1$)
- **लौह चुम्बकत्व**: चुम्बकीय क्षेत्र की दिशा में मजबूत चुम्बकत्व की प्रवृत्ति। e.g. Fe, Co, Ni, (μ_r, $\chi_m >> 1$)
- **प्रतिचुम्बकत्व**: चुम्बकीय क्षेत्र की दिशा के विपरीत दिशा में चुम्बकत्व की प्रवृत्ति e.g. Bi, Cu, Hg, Ni. (μ_r, $\chi_m < 1$)



विद्युत चुम्बक
चुम्बक जिसमें चुम्बकीय क्षेत्र एक विद्युत प्रवाह द्वारा निर्मित होता है, धारा बंद होने पर चुम्बकीय क्षेत्र गायब हो जाता है।

चुम्बकीय पद
- **चुम्बकीय तीव्रता**: $H = \frac{B_0}{\mu}$
- **चुम्बकीय पारगम्यता**: $\mu = \mu_0(1+\chi_m)$
- **चुम्बकीय प्रवृत्ति**: $\chi = \frac{I}{H}$
- **चुम्बकन की तीव्रता**: $I = \frac{M}{V}$
- **दोलन करते छड़ चुम्बक की समय अवधि**: $(T) = 2\pi\sqrt{\frac{I}{MB}}$

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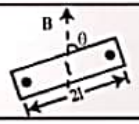


Electromagnetic Induction

Trace the Mind Map
- First Level
- Second Level
- Third Level

In 1831, Michael Faraday discovered electromagnetic induction and James Clerk Maxwell mathematically described it.

Faraday's law of electromagnetic induction

1. Whenever magnetic flux through an area bounded by a closed conducting loop changes, an emf is produced in the loop.
2. The emf is given by $E = -d\phi/dt$ where $\phi = \int \vec{B}.\vec{ds}$ is the magnetic flux through the area.

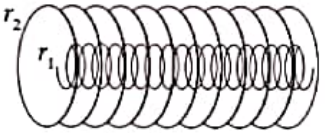
Mutual induction

$\phi = Mi$

$\frac{d\phi}{dt} = -M\frac{di}{dt}$

$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$

$M_{21} = \mu_0 n_1 n_2 \pi r_2^2 l$



Emf induced in an AC generator, $E = NBA\omega \sin \omega t$

Lenz's law

The direction of the induced current is such that it opposes the change that has induced it.

Induced current

$I = \frac{E}{R} = -\frac{1}{R}\frac{d\phi}{dt}$

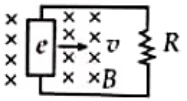
Induced EMF

Motional EMF

$E = \left|\frac{d\phi}{dt}\right| = \left|Bl\frac{dx}{dt}\right|$

$= Blv$

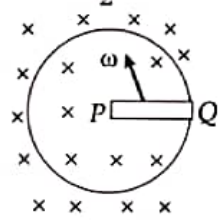
$i = Blv/(R+r)$



r = Resistance of rod moving with velocity v in uniform magnetic field $\vec{B}$

EMF induced in a rotating conductor

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



$E = \frac{1}{2}B\omega l^2$

Where l = Length of rod

Self induction

If we consider a solenoid of N turns, the flux through each turn, $\phi = \int \vec{B}.\vec{ds}$.

EMF induced between the ends of coil, $E = -N\frac{d}{dt}\int \vec{B}.\vec{ds}$

Self inductance of long solenoid

$L = \mu_0 n^2 \pi r^2 l$

n = Number of turns per unit length

ϕ = Flux = $(\mu_0 ni)\,\pi r^2$

r = Radius of each loop of solenoid

- **Growth of current in LR Circuit**

  $i = \frac{E}{R}(1 - e^{tR/L}) = i_0(1 - e^{-t/\tau})$

- **Decay of current**

  $i = i_0 e^{-t/\tau}$

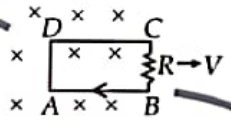
- **Energy stored in an Inductor**

  $U = \frac{1}{2}Li^2$

Eddy current

It is induced when magnetic flux linked with the conductor changes.

Rectangular loop



EMF induced

$E = vBl$

$i = \frac{vBl}{R}$

Magnetic force on the loop

$F = B^2l^2v/R$

= Force required to move the loop with constant velocity (v)

Thermal power developed in the loop is

$P = \frac{v^2B^2l^2}{R}$

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अध्याय — 6 वैद्युतचुम्बकीय प्रेरणा

वैद्युतचुम्बकीय प्रेरण

1831 में माइकल फैराडे ने वैद्युतचुम्बकीय प्रेरण की व्याख्या की तथा जैम्स मैक्सवेल ने इसकी गणितीय रूप से व्याख्या की।

फैराडे का वैद्युतचुम्बकीय प्रेरण का नियम

1. जब भी बंद चालक लूप (पाश) के माध्यम से चुम्बकीय फ्लक्स का प्रवाह होता है तो पाश (लूप) में विद्युत वाहक बल (emf) उत्पन्न होता है।
2. विद्युत वाहक बल प्राप्त होता है $E = -d\phi/dt$ जहाँ $\phi = \int \vec{B}.\vec{ds}$ क्षेत्र से होकर चुम्बकीय फ्लक्स है।

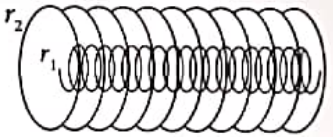
अन्योन्य प्रेरकत्व

$\phi = Mi$

$\frac{d\phi}{dt} = -M\frac{di}{dt}$

$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$

$M_{21} = \mu_0 n_1 n_2 \pi r_2^2 l$



प्रत्यावर्ती धारा जनित्र में प्रेरित वि. वा. बल, $E = NBA\omega \sin \omega t$

लेंज का नियम

प्रेरित विद्युत धारा की दिशा इस प्रकार होती है कि वह उसे उत्पन्न करने वाले चुम्बकीय क्षेत्र परिवर्तन का विरोध करे।

स्वप्रेरण

N फेरों की एक परिनालिका में, प्रत्येक फेरे से होकर फ्लक्स $= \phi = \int \vec{B}.\vec{ds}$

कुंडली के छोरों के मध्य प्रेरित वि. वा. तल $= E = -N\frac{d}{dt}\int \vec{B}.\vec{ds}$

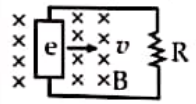
लम्बी परिनालिका का स्व-प्रेरकत्व

$L = \mu_0 n^2 \pi r^2 l$

n = प्रति इकाई लम्बाई फेरों की संख्या

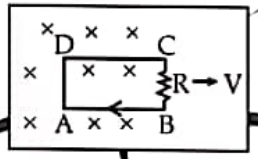
ϕ = फ्लक्स $= (\mu_0 n i)\,\pi r^2$

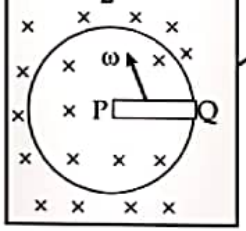
r = परिनालिका के प्रत्येक पाश (लूप) की त्रिज्या



- परिपथ में विद्युत धारा में वृद्धि
  $i = \frac{E}{R}(1 - e^{-tR/L}) = i_0(1 - e^{-t/\tau})$
- विद्युत धारा की क्षय
  $i = i_0 e^{-t/\tau}$
- प्रेरित्र में संग्रहित विद्यत धारा
  $U = \frac{1}{2}Li^2$

भँवर धाराएं





जब चालकों के स्थूल टुकड़ों को परिवर्तनशील चुम्बकीय फ्लक्स के प्रभाव में रखते हैं तो उनमें प्रेरित धाराएं उत्पन्न होती हैं।

प्रेरित विद्युत धारा

$I = \frac{E}{R} = -\frac{1}{R}\frac{d\phi}{dt}$

प्रेरित विद्युत वाहक बल

$E = \frac{d\phi}{dt}$

गतिक विद्युत वाहक बल

$E = \left|\frac{d\phi}{dt}\right| = \left|Bl\frac{dx}{dt}\right|$

$= Blv$

$i = vbl/(R+r)$

r = एक समान चुम्बकीय क्षेत्र $\vec{B}$ में वेग v से गतिमान छड़ का प्रतिरोध

घूर्णन करते चालक में प्रेरित वि. वा. बल

$E = \frac{1}{2}B\omega l^2$

आयताकार लूप

प्रेरित विद्युत वाहक बल
$E = vBl$
$i = \frac{vBl}{R}$

पाश (लूप) पर चुम्बकीय बल
$F = B^2 l^2 v/R$
= स्थिति वेग से पाश (लूप) की गति करने के लिए आवश्यक बल

पाश (लूप) में विकसित तापीय ऊर्जा
$P = \frac{v^2 B^2 l^2}{R}$

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अध्याय — 7 प्रत्यावर्ती धारा

प्रत्यावर्ती धारा

विद्युत धारा की दिशा एकान्तर रूप से परिवर्तित होती है।
$i = i_0 \sin\omega t$
$v = v_0 \sin\omega t$

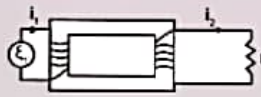
- वर्ग माध्य मूल (RMS) मान: $i_{rms} = i_0/\sqrt{2}$, $v_{rms} = v_0/\sqrt{2}$
- मध्यमान या ओसत मान: $i_{mean} = 2i_0/\pi$, $v_{rms} = 2v_0/\pi$
- शिखर मान या अधिकतम मान: $i_0 = \sqrt{2}\, i_{rms}$, $v_0 = \sqrt{2} v_{rms}$

प्रत्यावर्ती धारा जनित्र

एक उपकरण जो प्रत्यावर्ती धारा उत्पन्न करता है चम्बकीय तत्व, आर्मेचर एवं ग्रेफाइट ब्रश रहता है। विद्युत वाहक बल कुंडली के माध्यम से प्रेरित होता है।

$E = NBA\,\omega \sin\omega t$

$i = E/R = NBA\,\omega \sin\omega t/R$



$E_2 = -N_2E_1/N_1$

$i_2 = -N_1E_1/N_2$

यदि $N_2 > N_1$ यह उच्चायी ट्रांसफार्मर कहलाता है।

यदि $N_1 > N_2$, यह अपचयी ट्रांसफार्मर कहलाता है।

ट्रांसफार्मर

इसका उपयोग कम बोल्टता प्रत्यवर्ती धारा स्रोत से उच्च प्रत्यावर्ती धारा प्राप्त करने के लिए किया जाता है तथा इसका विपरीत।

ट्रांसफार्मर की दक्षता

- η = निर्गत शक्ति/निवेशी शक्ति
- 99% दक्षता आसानी से हासिल की जा सकती है।

प्रत्यावर्ती धारा परिपथ में शक्ति

$$P = E_{rms}\, i_{rms} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{i_0}{\sqrt{2}} \cos\phi = \frac{1}{2} E_0 i_0 \cos\phi$$

प्रतिबाधा

अनुप्रयुक्त वि. वा. बल एवं प्रत्यावर्ती धारा परिपथ में उत्पन्न धारा का अनुपात
$Z = E_0/i_0$ ओम

प्रतिघात

प्रेरक अथवा संधारित्र अथवा दोनों द्वारा प्रत्यावर्ती धारा (χ) के प्रवाह के लिए दिया गया अवरोध।

A C Circuits

प्रेरित (L) परिपथ

$$i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

V & I के बीच कला अन्तर $\phi = \pi/2$
शक्ति गुणांक $\cos(\phi) = 0$
बोल्टता धारा से $\pi/2$ कोण अग्रगामी होती है।
$P = 0$

संधारित्रीय (C) परिपथ

$$i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

$\phi = \pi/2$ or $-\pi/2$
$\cos\phi = 0$
शक्ति (P) = 0
धारा, बोल्टता से $\pi/2$ कोण अग्रगामी होती है।

प्रतिरोधकीय (R) परिपथ

$i = i_0 \sin(\omega t)$
$\phi = 0°$
$\cos\phi = 1$
$P = V_0 I_0/2$
धारा एवं वोल्टता दोनों समान कला में होते हैं।

R-C परिपथ

$= i_0 \sin(\omega t + \phi)$

$Z = \sqrt{R^2 + X_c^2}$

$X_c = 1/\omega C$

$\tan\phi = 1/\omega CR$

$i_0 = E_0/Z$

- शक्ति गुणांक $\cos\phi = \dfrac{R^2}{\sqrt{R^2 + X_c^2}}$
- अग्रगामी विद्युत धारा

L-C परिपथ

$$i = i_0 \sin\left(\omega t \pm \frac{\pi}{2}\right)$$

$X = X_L - X_C$

$\phi = \pi/2$

- शक्ति गुणांक = 0, या तो वोल्टता या विद्युत धारा अग्रगामी

L-C-R परिपथ

$i = i_0 \sin(\omega t \pm \phi)$

$Z = \sqrt{R^2 + (X_c - X_L)^2}$

$X = X_c - X_L$

$= \left(\dfrac{1}{\omega c} - \omega L\right)$

$\tan\phi = \left(\dfrac{1}{\omega c} - \omega L\right)/R$, $i_0 = \dfrac{E_0}{Z}$

L-R परिपथ

$i = i_0 \sin(\omega t + \phi)$

$Z = \sqrt{R^2 + X_L^2}$

$X_L = \omega L$

$\tan\phi = \omega L/R$

$i_0 = E_0/Z$

- शक्ति गुणांक = R/Z
- बोल्टता अग्रामी है।

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Alternating Current

AC Current

Direction of current changes alternatively

$i = i_0 \sin\omega t$

$v = v_0 \sin\omega t$

RMS value or root mean square value

$i_{rms} = i_0/\sqrt{2}$

$v_{rms} = v_0/\sqrt{2}$

Mean value or Average value

$i_{mean} = 2i_0/\pi$

$v_{rms} = 2v_0/\pi$

Peak value or Maxm value

$i_0 = \sqrt{2}\, i_{rms}$

$v_0 = \sqrt{2}\, v_{rms}$

Contribution

In 1883, Nikola Tesla inverted fixer AC motor, AC generator and AC transmission technology.

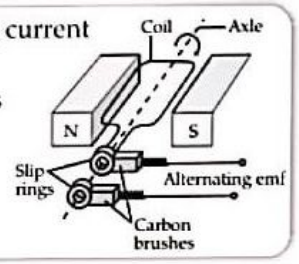
A C Generator

A device generating alternating current having elements magnet, Armature and graphite Brushes

emf induced through coil

$E = NBA\,\omega \sin\omega t$

$i = E/R = NBA\,\omega \sin\omega t/R$



Transformer

It is used to obtain a high AC voltage from a Low–voltage AC source or vice–versa

Efficiency of a transformer

η = output power/Input power

99% efficiency can easily achieved

Turnsratio

$$\frac{E_s}{E_p} = \frac{I_p}{I_s} = \frac{N_s}{N_p} = K$$

Impedance

The ratio of emf applied and the current produced in an AC circuit

$Z = E_0/i_0$ Ohm

Reactance

The hindrance offered by inductor or capacitor or both to the flow of AC (c_1 or c_2)

Power in AC Circuit

$$P = E_{rms} i_{rms} \cos\phi = \frac{E_0}{\sqrt{2}} \times \frac{i_0}{\sqrt{2}} \cos\phi = \frac{1}{2} E_0 i_0 \cos\phi$$

A C Circuits

Inductive (L) circuit

$$i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

Phase difference b/w V&I, $\phi = \pi/2$

Power factor $\cos(\phi) = 0$

Voltage leads current by $\pi/2$

$P = 0$

Capacitive (C) circuit

$$i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

$\phi = \pi/2$ or $-\pi/2$

Power factor $\cos\phi = 0$

Power $(P) = 0$

Current leads the voltage by $\pi/2$

Resistive (R) circuit

$i = i_0 \sin(\omega t)$

$\phi = 0°$

$\cos\phi = 1$

$P = V_0 I_0/2$

Current & voltage both are in same phase

R–C circuit

$i = i_0 \sin(\omega t + \phi)$

$Z = \sqrt{R^2 + X_c^2}$

$X_c = 1/\omega C$

$\tan\phi = 1/\omega CR$

$i_0 = E_0/Z$

- Power factor $\cos\phi = \dfrac{R^2}{\sqrt{R^2 + X_c^2}}$
- current leading.

L–C circuit

$$i = i_0 \sin\left(\omega t \pm \frac{\pi}{2}\right)$$

$X = X_L - X_C$

$\phi = \pi/2$

- Power factor = 0, Either voltage or current leading

L–R circuit

$i = i_0 \sin(\omega t + \phi)$

$Z = \sqrt{R^2 + X_L^2}$

$X_L = \omega L$

$\tan\phi = \omega L/R$

$i_0 = E_0/Z$

- power factor = R/Z
- voltage is leading

L–C–R circuit

$i = i_0 \sin(\omega t \pm \phi)$

$Z = \sqrt{R^2 + (X_c - X_L)^2}$

$X = X_c - X_L$

$= \left(\dfrac{1}{\omega c} - \omega L\right)$

$\tan\phi = \left(\dfrac{1}{\omega c} - \omega L\right)/R$, $i_0 = \dfrac{E_0}{Z}$

Trace the Mind Map

- First Level
- Second Level
- Third Level

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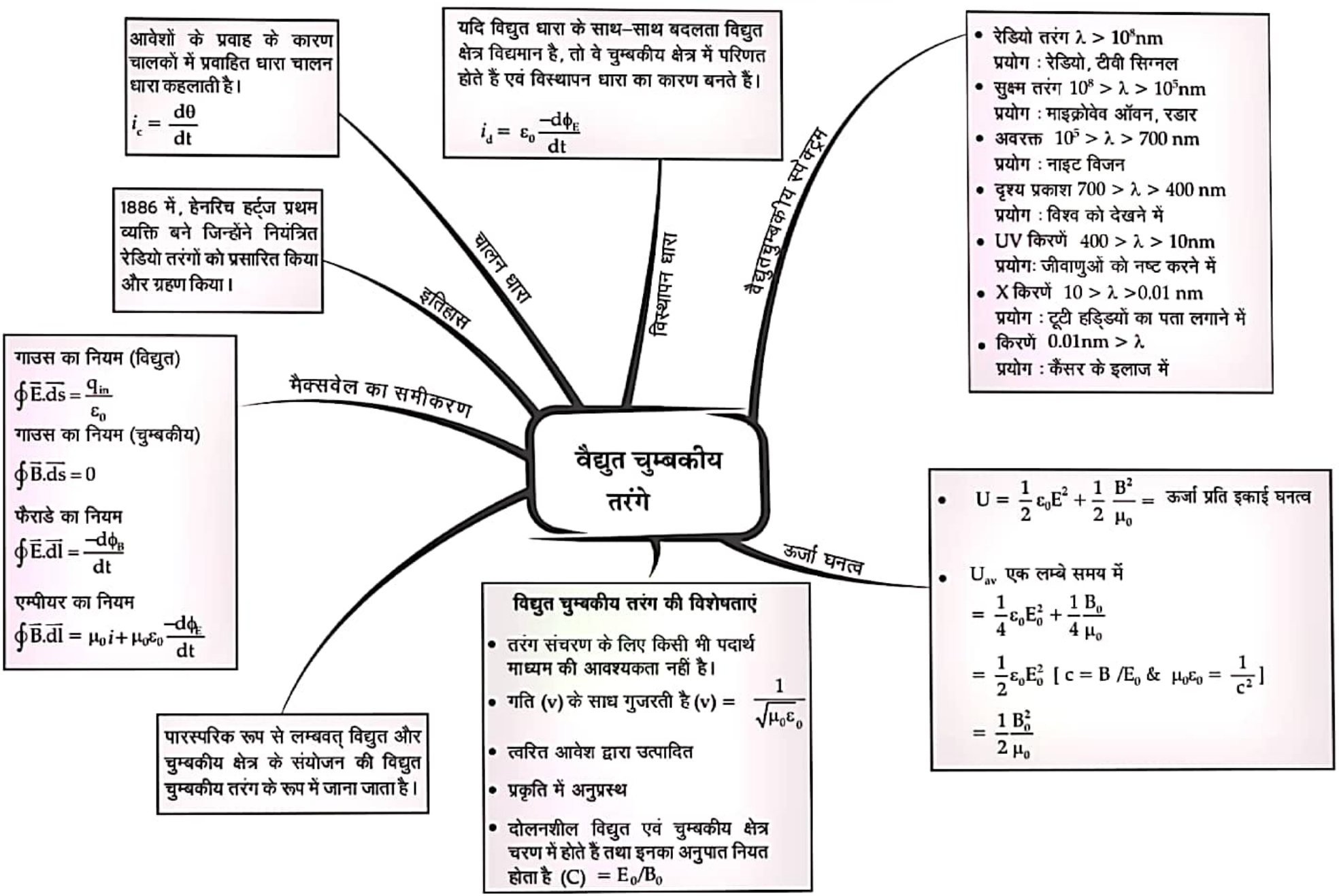
अध्याय — 8 वैद्युत चुम्बकीय तरंगे



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Electromagnetic Waves

History

In 1886 Heinrich Hertz became the first person to transmit and receive controlled radio.

Conduction current

The current due to flow of charge is often called conduction current,

$i_c = \frac{dq}{dt}$

Displacement current

If there exists an electric current as well as a changing electric field, if results magnetic field and causes displacement current,

$i_d = \varepsilon_0 \frac{-d\phi_E}{dt}$

Electromagnetic spectrum

- Radio waves : $\lambda > 10^8$nm
  Use : radio, TV signal
- Micro waves : $10^8 > \lambda > 10^5$nm
  Use : micro wave oven, radar
- Infrared : $10^5 > \lambda > 700$ nm
  Use : night vision
- Visible light : $700 > \lambda > 400$ nm
  Use : to observe world
- UV rays : $400 > \lambda > 10$nm
  Use : destroying bacteria
- X-rays : $10 > \lambda > 0.01$ nm
  Use : detect bone break
- γ rays : $0.01\text{nm} > \lambda$
  Use : to treat cancer

Maxwell's equations

Gauss's law (electricity)

$\oint \vec{E}.\vec{ds} = \frac{q_{in}}{\varepsilon_0}$

Gauss's law (magnetism)

$\oint \vec{B}.\vec{ds} = 0$

Faraday's law

$\oint \vec{E}.\vec{dl} = \frac{-d\phi_B}{dt}$

Ampere's law

$\oint \vec{B}.\vec{dl} = \mu_0 i + \mu_0 \varepsilon_0 \frac{-d\phi_E}{dt}$

Energy density

- $U = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$ = Total energy per unit volume
- U_{av} over a long time
  $= \frac{1}{4}\varepsilon_0 E_0^2 + \frac{1}{4}\frac{B_0}{\mu_0}$
  $= \frac{1}{2}\varepsilon_0 E_0^2$ [as $c = \frac{E_0}{B_0}$ and $\mu_0\varepsilon_0 = \frac{1}{c^2}$]
  $= \frac{1}{2}\frac{B_0^2}{\mu_0}$

Characteristics of Electromagnetic waves

- Do not need any material medium for propagation
- Travel with speed of light (c) $= \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$
- Produced be accelerated charged particle
- Transverse in nature
- Oscillating electric & magnetic fields are in phase and their ratio is constant (c)=E_0/B_0

Combination of mutually perpendicular electric and magnetic fields is referred to as an electromagnetic wave

Trace the Mind Map

- First Level
- Second Level
- Third Level

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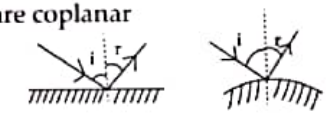
Ray Optics & Optical Instruments

Sign Conventions

- Pole is taken as origin
- Principle axis as the X-axis
- All distances are measured from origin (or pole)
- All distances measured in the direction of incident ray are taken + ve.
- All distances measured in the direction opposite to the incident ray are taken - ve.

Reflection of Light

- $\angle i = \angle r$
- Incident ray reflected ray and normal to the reflecting surface are coplanar



Prism

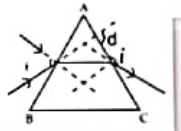
So hitting of polychromatic light into constituent colours.

Dispersion

Angle of deviation $\delta = i - i' - A$

$\delta_{minimum} = 2i - A \quad [i = i']$

$\delta_{minimum} = (\mu - 1)A$, if A is small



Scattering of Light

Light scattered i.e. redirected in different paths when interacts with particle. e.g., sunset & sunrise, colours blue colour of sky.

Optica Instruments

Microscope

$M = 1 + \frac{D}{f}$ [image at near point]

$M = D / f$ [image at infinity]

Compound Microscope

$M = \frac{v}{u}\left[\frac{D}{f_e}\right]$ [normal adjustment]

$M = \frac{v}{u}\left(1 + \frac{D}{f_e}\right) = -\frac{1}{f_o}\left(1 + \frac{D}{f_e}\right)$

For final image at least distance

Telescope

$M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$ [image at near point]

$M = -\frac{fo}{fe}$ [image at infinite]

Spherical Mirror

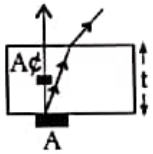
$\frac{1}{u} + \frac{1}{v} = \frac{2}{R} = \frac{1}{f}$

Lateral Magnification $= \frac{h_2}{h_1} = -\frac{v}{u}$

Refraction of light

$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$

$\mu = \frac{real\ depth}{apparent\ depth}$



$\Delta t = \left(1 - \frac{1}{\mu}\right)t$ = image shift

Total Internal reflection

When ray passes from optically denser to rarer medium, if incident angle (i) greater than critical angle, entire light is then reflected back to the denser medium again, this process is called T.I.R. It is used in optical fibre.

Critical Angle

- Incident angle (θ_c) for which angle of refraction is 90°

$i.e.\ \sin\theta_c = 1/\mu$

$\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$

When ray passes from optically denser to rarer medium.

Refraction on Spherical surface

$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

Lateral Magnification

$m = \frac{h_2}{h_1} = \frac{\mu_1 v}{\mu_2 u} = \frac{R - v}{R - u}$

Lens Marker's Formula

$\frac{1}{v} - \frac{1}{u} = \frac{\mu_2 - \mu_1}{\mu_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ [If $\mu_2 = \mu, \mu_1 = 1\ (air)$]

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ (lens formula)

Lateral Magnification $= \frac{h_2}{h_1} = \frac{v}{u}$

Power of a lens

$P = \frac{1}{f}$

[For combination of lens when they are in contact]

$P = \frac{1}{f_1} + \frac{1}{f_2}$

[For combination of lens when they are separated]

$P = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

Trace the Mind Map

- First Level
- Second Level
- Third Level

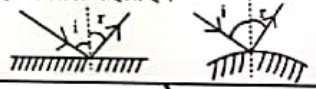
Scanned with CamScanner

अध्याय – 9 किरण प्रकाशिकी एवं प्रकाशिक यंत्र

किरण प्रकाशिकी एवं प्रकाशिक यंत्र

चिन्ह परिपाटी
- ध्रुव को उद्गम के रूप में लिया जाता है।
- मुख्य अक्ष को x-अक्ष के रूप में लिया जाता है।
- सभी दूरियाँ ध्रुव अथवा उद्गम से मापी जाती है।
- आपतित प्रकाश की दिशा में मापी गई दूरियाँ +ve ली जाती है।
- आपतित प्रकाश की विपरीत दिशा में मापी गई दूरियाँ –ve मानी जाती है।

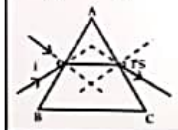
प्रकाश का परावर्तन
- $\angle i = \angle r$
- आपतित किरण, परावर्तित किरण तथा परावर्तक पृष्ठ के आपतन बिन्दु पर अभिलम्ब एक ही समतल में होते हैं।



प्रिज्म
विचलन कोण $\delta = i + i' + A$

δ न्यूनतम $= 2i - A \ [i = i']$

δ न्यूनतम $= (\mu - 1)A$, यदि A कम होता है।



प्रकाश का प्रकीर्णन
प्रकीर्णित प्रकाश अर्थात् जब कणों के साथ परस्पर क्रिया कर विभिन्न पथों पर पुनर्निर्देशित। उदाहरण–सूर्यास्त, सूर्योदय, आकाश का नीला रंग।

गोलीय दर्पण
$$\frac{1}{u} + \frac{1}{v} = \frac{2}{R} = \frac{1}{f}$$

पार्श्विक अवर्धन $= \frac{h_2}{h_1} = -\frac{v}{u}$

प्रकाश का अपवर्तन
$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$$

$$\mu = \frac{\text{वास्तविक गहराई}}{\text{आभासी गहराई}}$$

$\Delta t = \left(1 - \frac{1}{\mu}\right)t =$ प्रतिविम्ब विस्थापन

पूर्ण आन्तरिक परावर्तन
जब प्रकाश किसी प्रकाशत: सघन माध्यम से प्रकाशत: विरल माध्यम में गमन करता है, यदि आपतित कोण (i) को आगे क्रांतिक कोण (θ) तक बढ़ाया जाता है, आपतित किरण पूर्णत: सघन माचयम में परावतर्ति हो जाती है। यह प्रक्रिया पूर्ण आंतरिक परावर्तन कहलाती है। यह प्रकाशिक तंतु में प्रयुक्त होता है।

क्रांतिक कोण
- वह आयतन कोण (θ_C) जिसका तदनुरूपी अपवर्तन कोण 90° होता है।

i.e. $\sin\theta_c = 1/\mu$

$$\theta_c = \sin^{-1}\left(\frac{1}{\mu}\right)$$

जब किरण प्रकाशत: सघन माध्यम से विरल माध्यम में गमन करती है।

गोलीय सतह पर अपवर्तन
$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

पार्श्विक आवर्धन

$$m = \frac{h_2}{h_1} = \frac{\mu_1 v}{\mu_2 u} = \frac{R - v}{R - u}$$

लेंस मेकर का सूत्र
$$\frac{1}{v} - \frac{1}{u} = \frac{\mu_2 - \mu_1}{\mu_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad [If\ \mu_2 = \mu, \mu_1 = 1 \text{(हवा)}]$$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \quad \text{(लेंस सूत्र)}$$

पार्श्विक आवर्धन $= \frac{h_2}{h_1} = \frac{v}{u}$

लेंस की क्षमता
$$P = \frac{1}{f}$$

(लेंस के संयोजन के लिए)

$$P = \frac{1}{f_1} + \frac{1}{f_2}$$

प्रकाशित यंत्र

सूक्ष्मदर्शी
$M = 1 + \frac{D}{f}$ [नजदीकी बिन्दु पर प्रतिबिम्ब]

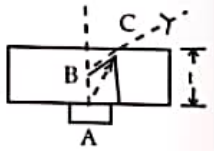
$M = D/f$ [प्रतिबिम्ब अनन्त पर]

संयुक्त सूक्ष्मदर्शी
$M = \frac{v}{u}\left[\frac{D}{f_e}\right]$ [सामान्य समायोजन]

$M = \frac{v}{u}\left(1 + \frac{D}{f_e}\right) = -\frac{1}{f_o}\left(1 + \frac{D}{f_e}\right)$

अंतिम प्रतिबिम्ब के लिए न्यूनतम दूरी

दूरदर्शी
$M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$ (नजदीकी बिन्दु पर प्रतिबिम्ब)



$M = -\frac{fo}{fe}$ (प्रतिबिम्ब अनन्त पर)

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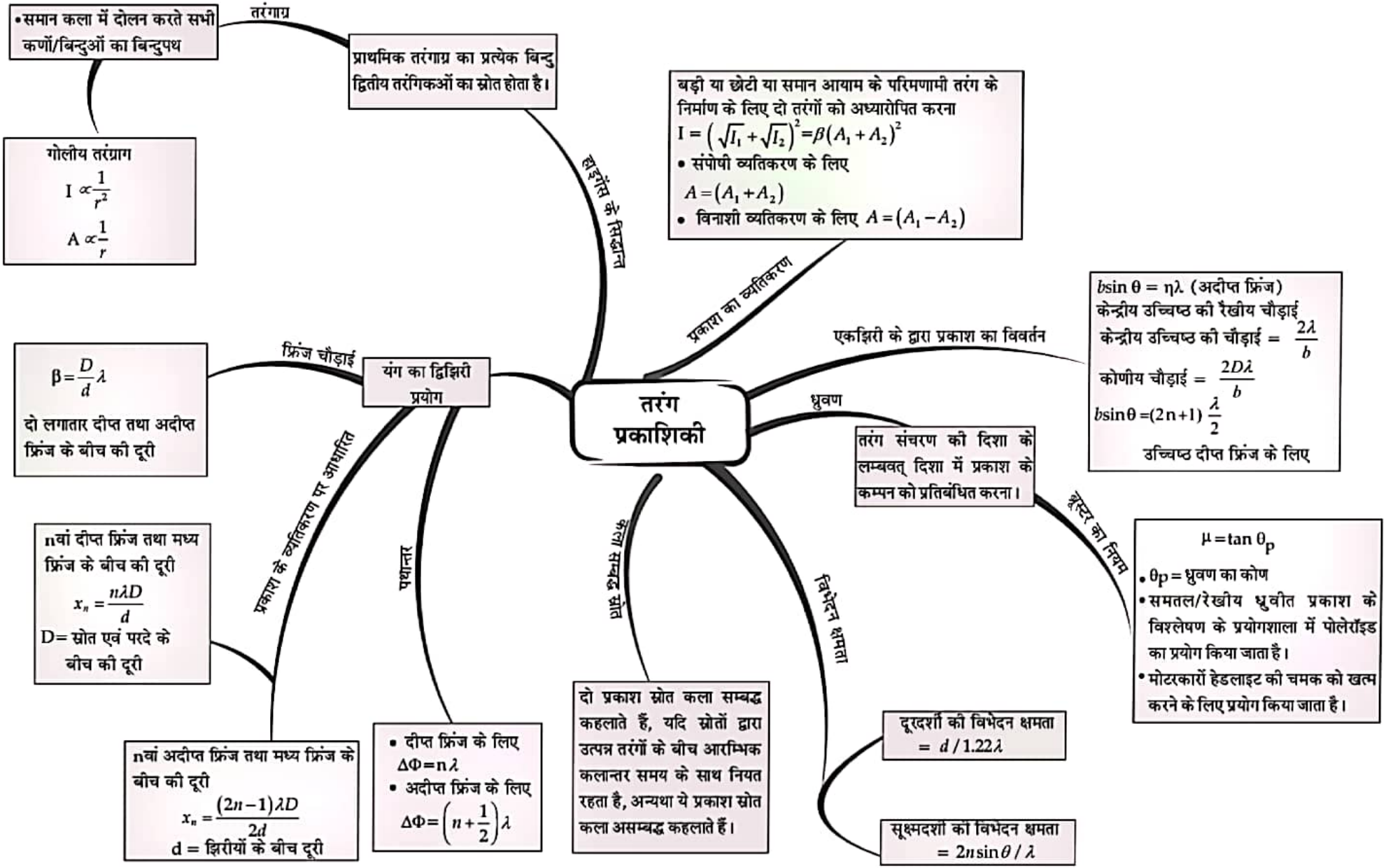
अध्याय — 10 तरंग प्रकाशिकी



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Wave Optics

Wave front

- Locus of all particles vibrating in some phase

For spherical wavefront

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

$$A \propto \frac{1}{r}$$

Each point on the primary wavefront is the source of a secondary wavelets

Huygens' Principle

Interference of Light

Two waves superimpose to form a resultant wave of greater or lower or same amplitude.

$$I = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = \beta\left(A_1 + A_2\right)^2$$

- For constructive Interference, $A = A_1 + A_2$
- For destructive interference, $A = (A_1 - A_2)$

Dropper's effect

When There is a relative motion between source and observers, the frequency appears to be different to the observers.

$$\frac{\Delta\upsilon}{\upsilon} = \frac{-v_{relative}}{e}$$

Diffraction of light by single slit

$b\sin\theta = \eta\lambda$ (dark fringe)

Linear width of central maxima

Width of central maxima $= \frac{2\lambda}{b}$

Angular width $= \frac{2D\lambda}{b}$

$b\sin\theta = (2n+1)\frac{\lambda}{2}$

(for maxima bright fringe)

Polarisation

Restricting the vibration of light in a particular direction perpendicular to the direction of propagation of wave

Brewster's Law

$\mu = \tan\theta_p$

θ_p = angle of polarisation

Value's Law

$I = I_0\cos^2\theta$

θ = Angle between polariser and analyser.

- Polariod used in lab to analyse plane polarised light
- used to eliminate the head light glare in motor cars.

Young's Double Slit Experiment

Fringe-width

$$\beta = \frac{D}{d}\lambda$$

It is the distance between two consecutive, bright or dark fringes.

Based on interference of light

Distance between n^{th} bright fringe and central fringe

$$x_n = \frac{n\lambda D}{d}$$

D = distance between source and screen

Distance between n^{th} dark fringe and central fringe

$$x_n = \frac{(2n-1)\lambda D}{2d}$$

d = distance between slits

Path difference

- For bright fringe $\Delta\phi = n\lambda$
- For dark fringe $\Delta\phi = \left(n + \frac{1}{2}\right)\lambda$

Coherent source

Two sources of light are said to be coherent if the initial phase difference between the waves emitted by the sources remains constant in time, otherwise they are called incoherent source of light.

Resolving power

Resolving power of telescope = $d / 1.22\lambda$

Resolving power of microscope = $2n\sin\theta / \lambda$

Trace the Mind Map

First Level · Second Level · Third Level

Scanned with CamScanner

अध्याय — 11 विकिरण तथा पदार्थ की द्वैत प्रकृति

विकिरण तथा पदार्थ की द्वैत प्रकृति

विकिरण का द्वैत प्रकृति

- प्रकाश कण होने के साथ तरंग प्रकृति दोनों रखता है।
- तरंग प्रकृति द्वारा व्यतिकरण की व्याख्या की जा सकती है।
- जब प्रकाश पर्याप्त रूप से कम तरंगदैर्ध्य का होता है तो यह कण के रूप में व्यवहार करता हैं।
- निश्चित ऊर्जा और निश्चित संवेग वाले प्रकाश कणों को 'फोटॉन' कहा जाता है।

प्रत्येक फोटॉन की ऊर्जा = $h\nu = hc/\lambda$

प्रत्येक फोटॉन का संवेग = $h/\lambda = E/c$

योगदान

आइंस्टीन, एक औसत शैक्षणिक कैरियर के पश्चात्, एक पेटेंट कार्यालय के ग्रेड III तकनीकी अधिकारी के रुप में कार्य करते हुए 1905 में प्रकाश के क्वांटम सिद्धान्त को आगे बढ़ाया।

द्रव्य तरंग

सभी द्रव्य तरंग जैसी आचरण प्रदर्शित करता है। जैसे इलेक्ट्रॉन का बीम जल तरंग के जैसे विवर्तित हो सकता है।

डी ब्रॉगली संबंध

$\lambda = h/p$

λ = कण से जुड़ी तरंगदैर्ध्य अथवा डी-ब्रोगली तरंगदैर्ध्य

p = संवेग

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2\,m\,K_{\text{उच्च}}}}$$

डेविसन तथा जर्मर प्रयोग

इलेक्ट्रॉन गन द्वारा उत्सर्जित इलेक्ट्रॉनों का बीम एक विशेष कोण पर क्यूबिकल एक्सिस के साथ निकेल क्रिस्टल कट पर गिरने से बना है। इलेक्ट्रॉन का प्रकीर्णित बीम संसूचक द्वारा प्राप्त की जाती है।

परिणाम : λ = ब्रागलीस तरंगदैर्ध्य

$= h/p$

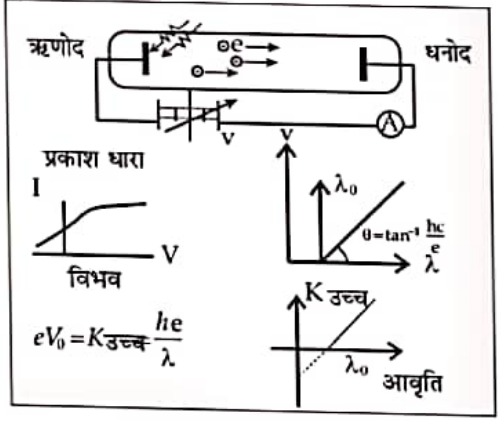
$= 1227/\sqrt{v}$ nm

$= 1227/\sqrt{54}$ nm

$= 0.167$ nm $= 1.67$ Å

यह प्रयोग इलेक्ट्रॉन के तरंग प्रकृति तथा डी ब्रोग्ली तरंगदैर्य के साथ संबंध को सत्यापित करता है।

हर्ट्ज तथा लीनार्ड के प्रेक्षण



आइंस्टीन का प्रकाश-विद्युत समीकरण

- $K_{\text{उच्च}} = E - \phi = eV_0$

$= \frac{hc}{\lambda} - \phi$, V_0 = रोधक विभव

$K_{\text{उच्च}}$ = उत्सर्जित इलेक्ट्रॉन की अधिकतम गतिज ऊर्जा

जहाँ, $\lambda_0 = hc/\phi$

λ_0 = देहली तरंगदैर्ध्य

$\lambda_0 = c/\lambda_0 = \phi/h$

λ_0 = देहली आवृति

$K_{\text{उच्च}} = \lambda(\nu - \nu_0)$

- यदि $\lambda = \lambda_0 = hc/\phi$

$K_{\text{उच्च}} = 0$, *i.e.*

इलेक्ट्रॉन बस बाहर आ सकता है।

- यदि $\lambda > \lambda_0$

अर्थात् $E < \phi$

कोई इलेक्ट्रॉन बाहर नहीं आएगी

- यदि $\lambda \le \lambda_0$.

प्रकाश विद्युत प्रभाव इस λ_0 का स्थान लेता है।

- λ_0 = प्रयुक्त धातु पर निर्भर करता है।

प्रकाश विद्युत प्रभाव

- जब पर्याप्त रूप से कम तरंग दैर्ध्य का प्रकाश धातु की सतह पर आपतित होता है तब इलेक्ट्रान उत्सर्जित होता है। यह घटना प्रकाश विद्युत प्रभाव कहलाता है।
- उत्सर्जित इलेक्ट्रॉन प्रकाशित इलेक्ट्रॉन कहलाते हैं।
- किसी इलेक्ट्रॉन को धातु से बाहर निकालने के लिए कार्य-फलन (ϕ) के बराबर उर्जा इलेक्ट्रॉन को अवश्य दी जानी चाहिए।

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Dual Nature of Radiation & Matter

Dual Nature of Radiation

- Light has both wave character as well as particle nature
- Interference can be explained by wave nature
- When light is of sufficiently small wavelength, it behaves as particle
- Light particles having definite energy and definite linear momentum are called "photons"
  Energy of each photon = $h\nu = hc/\lambda$
  Momentum of each photon = $h/\lambda = E/c$

Contribution

Einstein, after an average academic career put forward quantum theory of light in 1905 while working as a grade III technical officer in a patent office.

Matter waves

All matter can exhibit wave–like behaviour *e.g.*, beam of electrons can be diffracted like a water wave

de-Broglie relation

$\lambda = h/p$

λ = wavelength associated with particle or de-Broglie wavelength

p = momentum

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2\,m\,K_{max}}}$$

Photoelectric Effect

- When light of sufficient small wavelength is incident on metal surface, electrons are ejected from the metal, the phenomenon is called photoelectric effect.
- Ejected electrons are called photoelectrons
- Minimum energy equal to work function (ϕ) must be given to an electron so as to bring it out of the metal

Davisson-Germer Experiment

A beam of electrons emitted by an electron gun is made to fall on nickel crystal cut along cubical axis at a particular angle. Scattered beam of electrons is received by detector.

Results : λ = de Broglie's wavelength
$= h/p$
$= 1.227/\sqrt{V}$ nm
$= 1.227/\sqrt{54}$ nm
$= 0.167$ nm $= 1.67$ Å

This experiment verifies the wave nature of electrons & relation with de-Broglie wavelength.

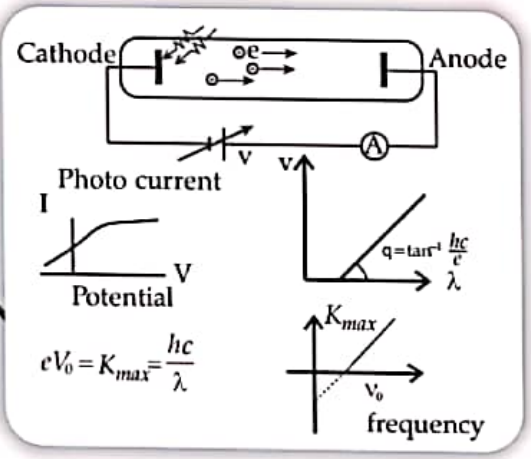
Einstein's Photoelectric equation

- $K_{max} = E - \phi = eV_0$
  $= \frac{hc}{\lambda} - \phi$, V_0 = stopping potential
  K_{max} = maximum kinetic energy of elected electrons

Here, $\lambda_0 = hc/\phi$
λ_0 = Threshold Wavelength
$\lambda_0 = c/\nu_0 = \phi/h$
ν_0 = Threshold frequency
$K_{max} = \lambda(\nu - \nu_0)$

- If $\lambda = \lambda_0 = hc/\phi$
  $K_{max} = 0$, *i.e.*
  Electron may just come out onto the surface
- If $\lambda > \lambda_0$
  i.e. $E < \phi$
  no electron will come out
- If $\lambda \le \lambda_0$.
  Photoelectric effect takes place
- λ_0 = depends on metal used

Hertz and Lenard's Observation



Trace the Mind Map
- First Level
- Second Level
- Third Level

Scanned with CamScanner

Atoms

Trace the Mind Map
- First Level
- Second Level
- Third Level

Contribution

In 1898, J.J Thomson proposed the first model of atom known as plum-pudding model.
In 1911, Ranther ford prepared planeting model of atom.
In 1913, Niels Bohv prepared a model of Hydrogen atom based on quantium theory.

α – particle scattering experiment

- α- particle bombarded on thin gold foil
- Most of a– particles passed undeviated or with a small angle
- 1 out of 8000 α– particles were deflected by scattering angle

Impact parameter

$$b = \frac{Ze^2 \cot \theta/2}{4\pi\varepsilon_0\left(\frac{1}{2}mv^2\right)}$$

Energy Level

Energy of electron in each stationary orbits is

Given by $E_n = -13.6\frac{Z^2}{n^2}$ eV

Where $n = 1,2,3....$

Z = atomic number of atom

- These stationary energy orbits are also called energy levels.
- When electron jumps from higher energy level to lower energy level, it releases energy.

$$\Delta E = E_f - E_i = 13.6\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]Z^2 \text{eV}$$

Hydrogen Spectrum

- Hydrogen gas heated in a sealed tube emits radiation when paused through prism components of different wavelength appear.
- Wavelength in each series given by

$$\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{n_i^2} - \frac{1}{n_f^2}\right]$$

$n_f > n_i$

- Lyman series [U.V. region]
  $n_i = 1$, $n_f = 2,3,4....$
  $\lambda_{min} = 912$ Å , $\lambda_{max} = 1216$ Å
- Balmer series [visible region]
  $n_i = 2$ $n_f = 3, 4, 5.....$
  $\lambda_{min} = 3648$ Å , $\lambda_{max} = 6563$ Å
- Paschan series [IR region]
  $n_i = 3$ $n_f = 4, 5, 6.....$
  $\lambda_{min} = 8208$ Å , $\lambda_{max} = 18761$ Å
- Brackett series [IR region]
  $n_i = 4$ $n_f = 5, 6, 7...$
  $\lambda_{min} = 14592$ Å $\lambda_{max} = 40533$ Å
- P fund [IR region]
  $n_i = 5$ $n_f = 6, 7, 8.....$
  $\lambda_{min} = 23850$ Å $\lambda_{max} = 74618$ Å

Rutherford's Model

Drawbacks

- Doesn't explain the stability of atom
- Doesn't explain the atomic spectra

Postulates

- Atoms have a central, massive, positively charged core called nucleus around which electrons revolve.
- Size of nucleus ≈ 1 fermi = 10^{-15}m

Bohr Model

Postulates

- Electron revolves around the nucleus in stationary orbits.
- Angular momentum of electron

$$mvr_n = n \times \frac{h}{2\pi}$$ where n is an integer

It is also known as principle Quantum Number.

- It explains spectrums of hydrogen or hydrogen like [He^+, Li^{++}] atoms.

Limitations

- Fails to explain spectrum of complex atoms/ions of multi electron system.
- Doesn't explain Zeeman's and Stark's effect.

Radius of 12th Bohr's orbit

$$R_n = \frac{\varepsilon_0 h^2}{\pi me^2}\left(\frac{n^2}{Z}\right) = 0.53\frac{n^2}{Z}\text{ Å}$$

Velocity of electron in nth Bohr's orbit

$$v_n = \frac{e^2}{2\varepsilon_0 h}\left(\frac{Z}{n}\right) = 2.2 \times 10^6 \frac{Z}{n}\text{ m/s}$$

Potential Energy

$$U_n = -\frac{KZe^2}{r_n} = \frac{-me^4}{4\varepsilon_0^2 h^2}\left(\frac{Z^2}{n^2}\right) = \frac{-27.2Z^2}{n^2}\text{ eV}$$

Kinetic Energy

$$E_k = \frac{KZe^2}{2r_n} = \frac{me^4}{8\varepsilon_0^2 h^2}\frac{Z^2}{n^2} = \frac{13.6^2}{n^2}Z^2\text{ eV}$$

Total Energy

$$E = U_n + E_k = -\frac{KZe^2}{2r_n} = \frac{-13.6Z^2}{n^2}\text{ eV} = \frac{U_n}{2} = -E_K$$

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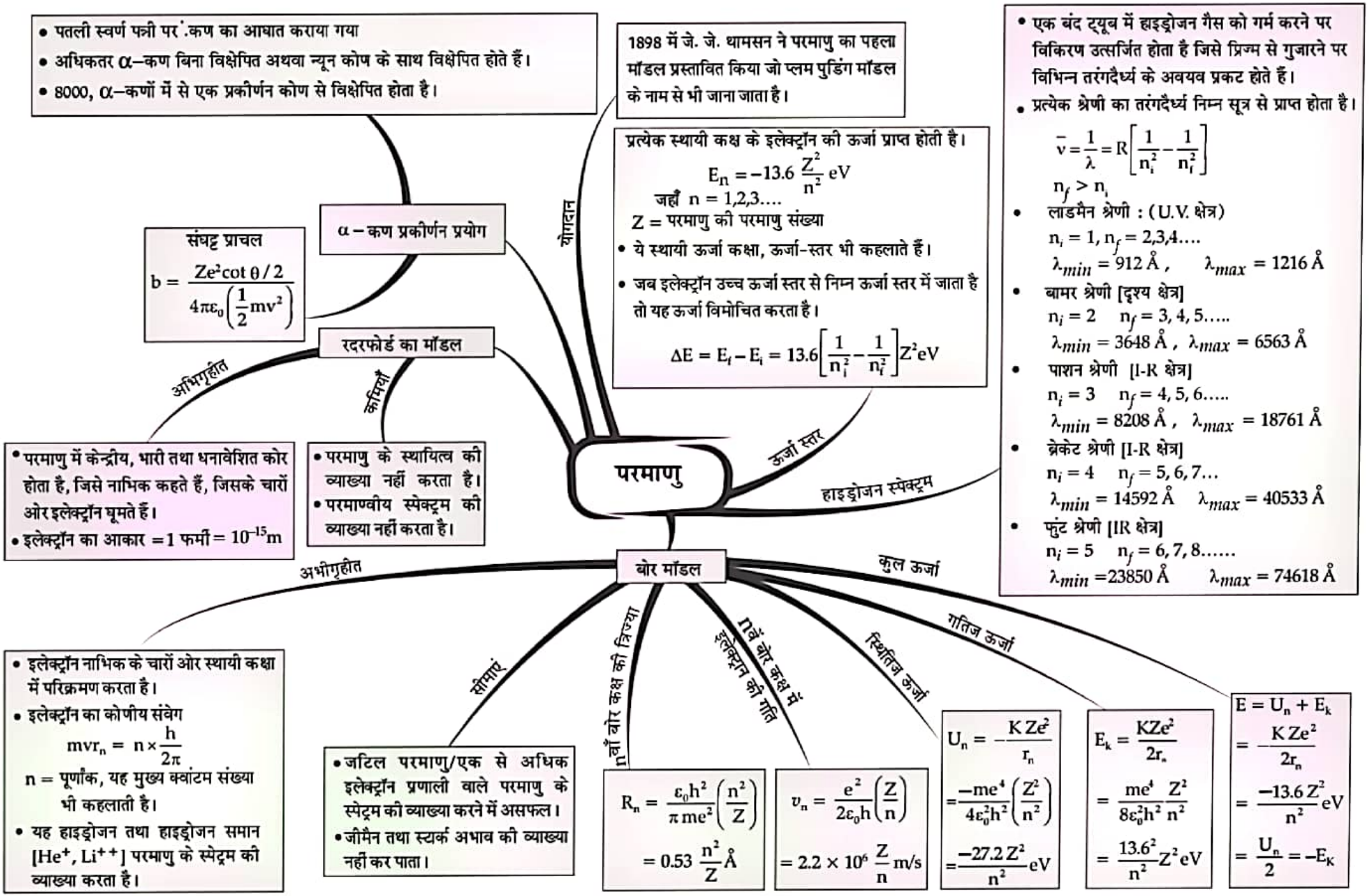
अध्याय — 12 परमाणु



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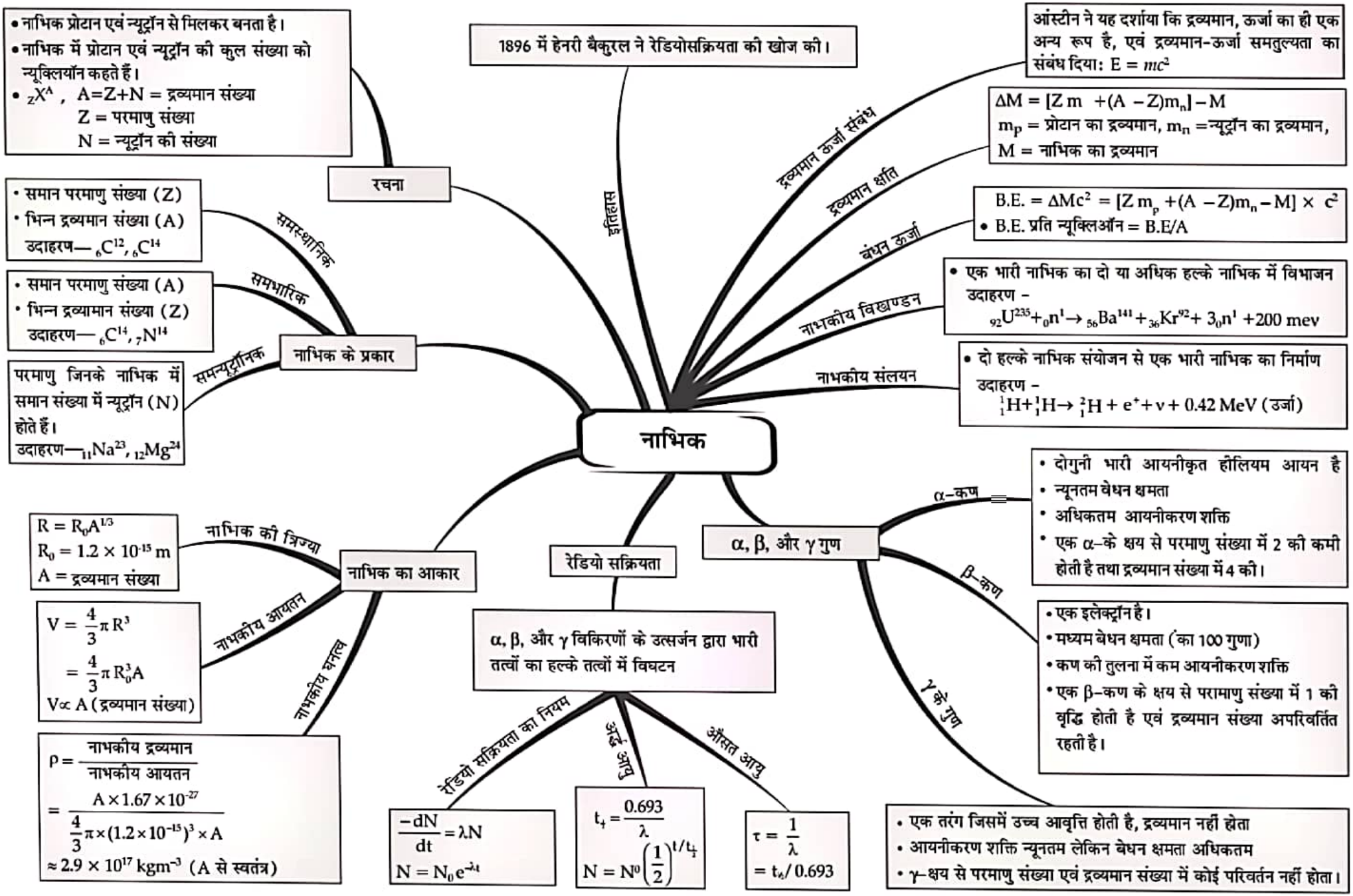
अध्याय — 13 नाभिक



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Nuclei

Composition
- Nuclei consist of protons and neutrons.
- Common name of protons & neutrons in the nucleus is nucleons
- $_ZX^A$, $A = Z + N$ = Mass Number
  - Z = Atomic Number
  - N = No. of neutrons

Contribution
In 1896, Henri Becquerel discoverd Radioactivity

Mass-Energy Relation
Einstein showed that mass is an another form of energy and gave a relation $E = mc^2$

Mass Defect
$\Delta M = [Z m_p + (A - Z) m_n] - M$

m_p = mass of proton,

m_n = mass of neut on

M = mass of nucleus

Binding Energy
- B.E. = $\Delta Mc^2 = [Z m_p + (A - Z) m_n - M] \times c^2$
- B.E. per nucleon = B.E/A

Nuclear Fission
- Splitting of a heavy nucleus into two or more lighter nuclei.

e.g., $_{92}U^{235} + _0n^1 \rightarrow _{56}Ba^{141} + _{36}Kr^{92} + 3_0n^1 + 200$ mev

Nuclear Fusion
- Combining two lighter nuclei to form a heavy nucleus

e.g., $^1_1H + ^1_1H \rightarrow ^2_1H + e^+ + \nu + 0.42$ MeV (energy)

Types of Nuclei

Isotopes
- Same atomic No. (Z)
- Different mass No. (A)

e.g., $_6C^{12}$, $_6C^{14}$

Isobars
- Same mass No. (A)
- Different atomic No. (Z)

e.g., $_6C^{14}$, $_7N^{14}$

Isotone
Atoms whose nuclei having same number of neutrons (N)

e.g. $_{11}Na^{23}$, $_{12}Mg^{24}$

Size of Nucleus

Nuclear Radius
$R = R_0 A^{1/3}$

$R_0 = 1.2 \times 10^{-15}$ m

A = Mass No.

Nuclear Volume
$V = \frac{4}{3}\pi R^3$

$= \frac{4}{3}\pi R_0^3 A$

$V \propto A$ (mass no.)

Nuclear Density
$\rho = \frac{\text{mass of nucleus}}{\text{volume of nucleus}}$

$= \frac{A \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi \times (1.2 \times 10^{-15})^3 \times A}$

$\approx 2.9 \times 10^{17}$ kgm^{-3} (independent of A)

Radioactivity
Disintegration of heavy elements into comparatively lighter elements by emission of α, β and γ radiations

Law of radioactivity
$-\frac{dN}{dt} = \lambda N$

$N = N_0 e^{-\lambda t}$

Half life
$t_{1/2} = \frac{0.693}{\lambda}$

$N = N_0 \left(\frac{1}{2}\right)^{t/t_{1/2}}$

Mean life
$\tau = \frac{1}{\lambda}$

$= t_{1/2} / 0.693$

Properties of α, β & γ

α-Particle
- heavy doubly ionized helium ion
- least penetrating power
- highest ionizing power
- decay of 1 α particle cause decrease in atomic no. by 2 and mass no. by 4.

β-Particle
- is an electron
- moderate penetrating power (100 times α)
- less ionizing power than α –particle
- one β – particle decay cause increase in atomic no. by 1 and mass no. remains unchanged.

γ Rays
- A wave having high frequency having no mass,
- least ionizing power but highest penetrating power
- No change in atomic No. and Mass No. on γ decay.

Trace the Mind Map
- First Level
- Second Level
- Third Level

7863/7 GSPLANET

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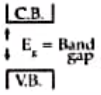
Semiconductor Electronics: Materials, Devices and Simple Circuits

Energy band

- **Valence Band**: The energy band which are completely filled with electron at Zero kelvin (0K)
- **Conduction Band**: The bands with higher energy above the valence band



A range of energies associated with the quantum states of electrons in a crystalline solid.

- **Band gap or forbidden gap**: The difference between the highest energy in a valence band and lowest energy in the next higher band.

Contribution

In 1927, Walter Heitler and Fritz London discovered energy bands.

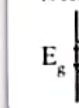
Semiconductor Diode

p.n. junction Diode
Device made by an atomic level contact of N–type and P–type semiconductors

- **Forward Biased**
  - +ve terminal to P-side
  - –ve to N–side
  - Diffusion current increases
  - Depletion layer reduced
- **Reverse Biased**
  - –ve terminal to P– side
  - +ve terminal to N–Side
  - Diffusion current decreases
  - Depletion layer increases
- **Light Emitting Diode / LED**: used in T.V. or electronic gadgets.
- **Photo Diode**: a p.n. junction whose function is controlled by the light allowed to fall on it.
- **Zener Diode**: used as a voltage regulator

Classification of metals, Semiconductors and Insulators on the basis of band theory

- **Condctors**
  - → $E_g = 0$ or less
  - → Density of charge carriers is very high (For electrons) $= 9 \times 10^{23}\ m^{-3}$ for For holes $= 0\ m^{-3}$ (in case of copper)
- **Semiconductors**
  - $E_g = 0.72$ eV for Ge ≈ 1.1ev for Si
  - $0 < E_g <$ Insulator
  - → very low (e)
    - For *n*–type $= 7 \times 10^{15} m^{-3}$ for *Si* doped with P



    - For *p*–type $= 1 \times 10^{9} m^{-3}$ for Si doped with Al
- **Insulators**: E_g = Very high ≈ 7eV, For diamond negligible ≈ 0

Intrinsic semiconductor

- Pure semiconductor
- Charge carrier concentration
  $n_i = n_e = n_h$
  $I = n_e + n_h$
  e.g. Si (Silicon)

Extrinsic semiconductor

Impure or doped semiconductor

- **N-type semiconductors**
  - Si or Ge doped with pentavalent. (P, As, Sb) elements
  - Electrons are majority carriers.
  - Holes are minority carriers.
- **P-type semiconductor**
  - Si or Ge doped with trivalent (B, Al) elements.
  - Electrons are minority carriers.
  - Holes are majority carriers.

Trace the Mind Map
First Level · Second Level · Third Level

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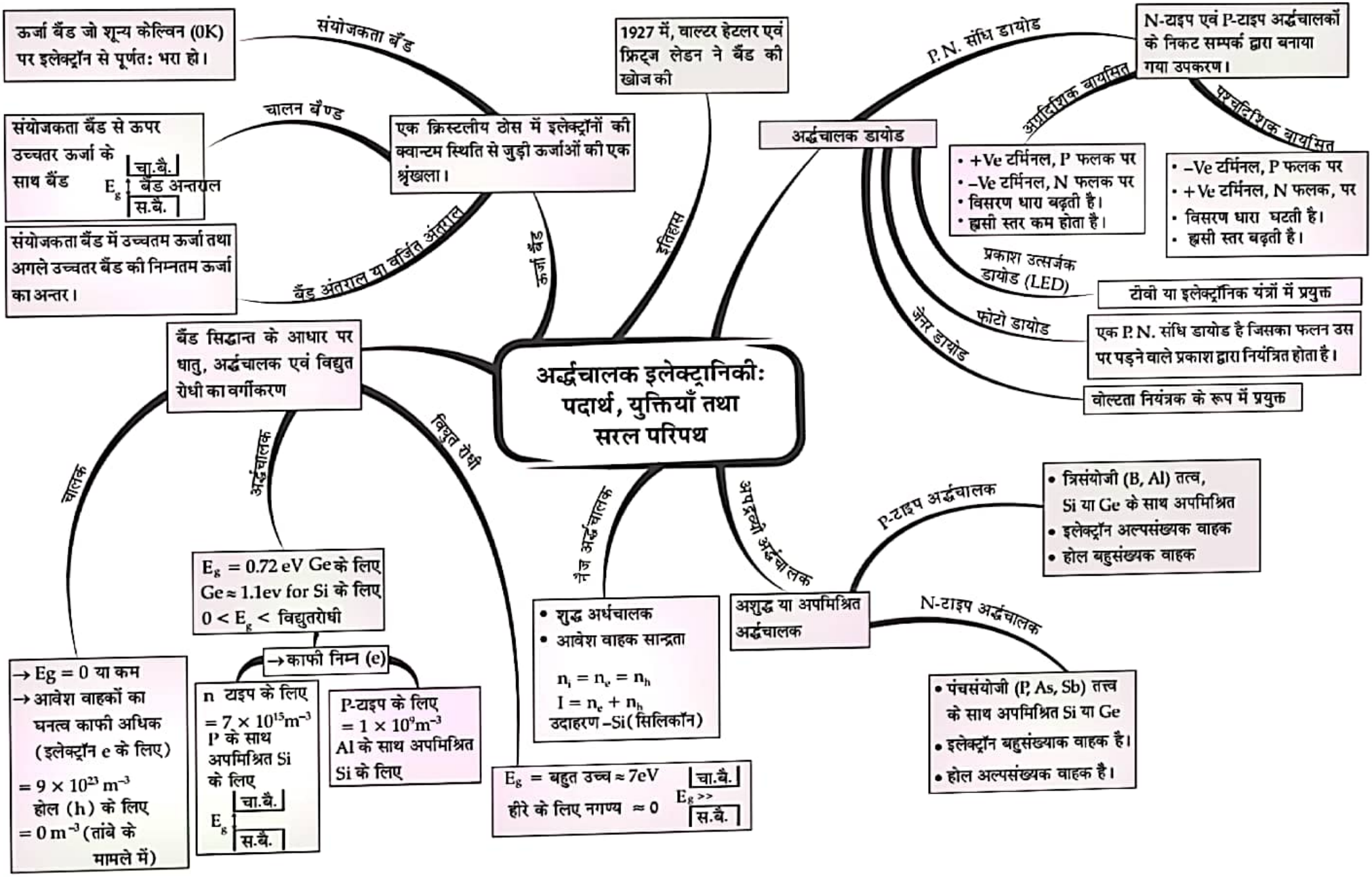
अध्याय — 14 अर्द्धचालक इलेक्ट्रानिकी: पदार्थ, युक्तियाँ तथा सरल परिपथ



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