Post Mids

Electrodynamics

CH

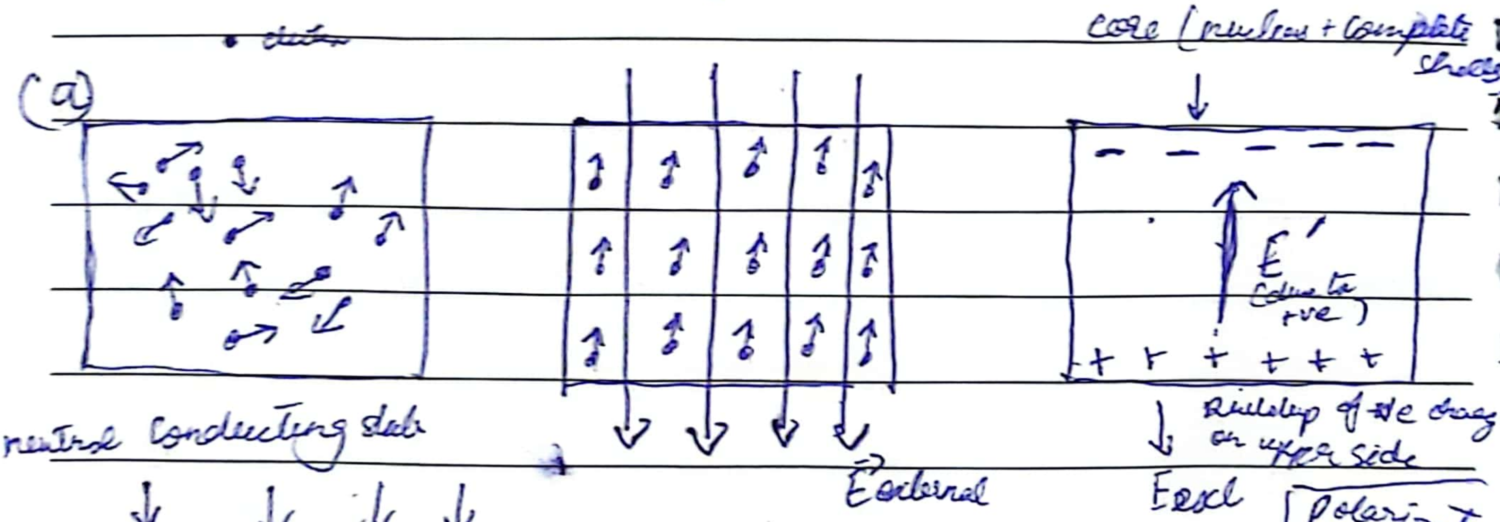
Electrical properties of materials

Types of Materials

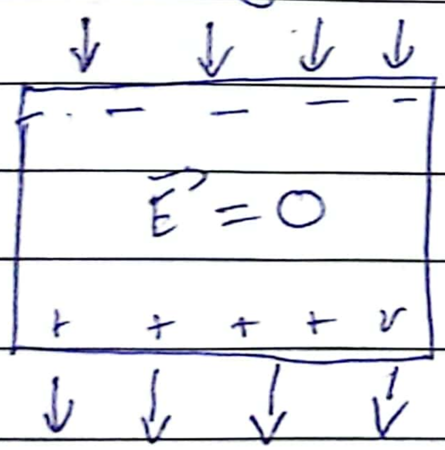
- Conductors
- Insulators
- Semiconductors
- Superconductors

A Conductor in an electric field (Static Conditions)

(a)



Polarization



if $2E_{ext}$ then E' is $2E'$
so $E = 0$

$$E = \vec{E}_{ext} + \vec{E}'$$

$$E = E_{ext} - E'$$

For inside conductors

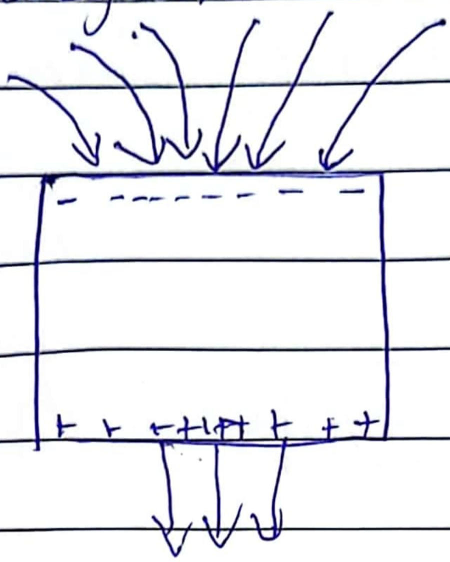
$$E' = E_{ext}$$

$$E = 0$$

There is buildup of -ve charge on upper side and +ve charge on lower side

Pg 663 29.2 Fig

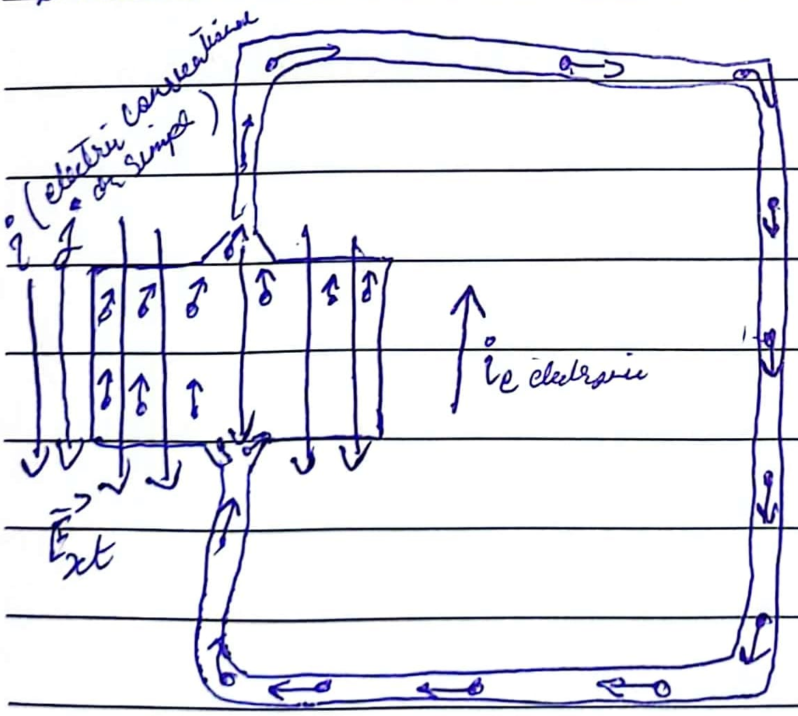
For non uniform



$E' \propto E_{ext}$

A conductor in an electric field (Dynamic condition):-

Electric current



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

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

$Ampere = \frac{C}{S}$

magnitude direction

educative

current has direction but doesn't obeys laws of vector that's why it isn't a vector

Vector has 4 prop
direction unit magnitude
Laws of vectors

same goes for θ theta

magnitude ~~magnitude unit~~

$\vec{C}$urrent density & Drift velocity

$$j = \frac{i}{A} = Am^{-2}$$

(crosssectional Area of wire)

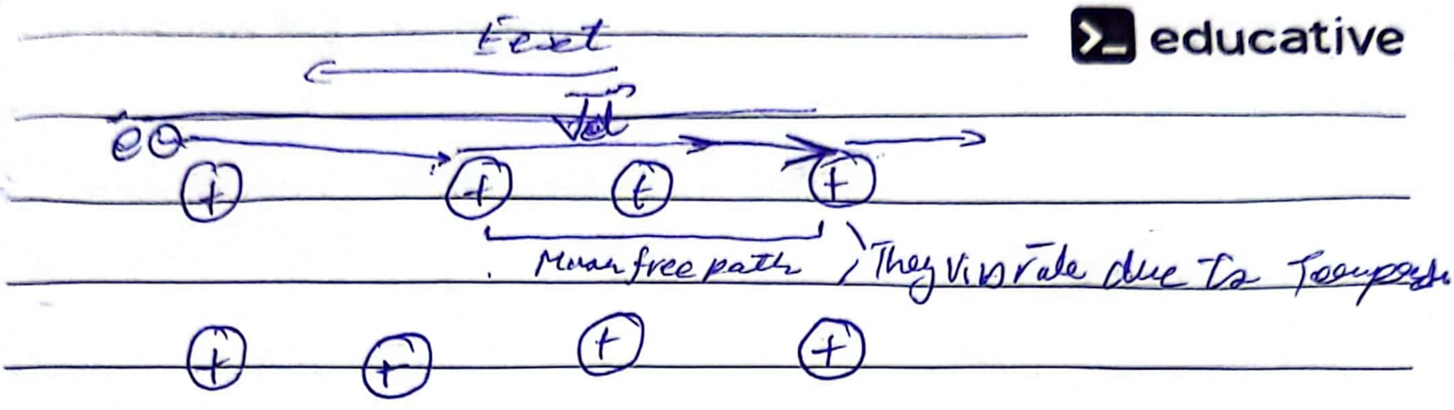
current density
Ampere per meter sq

j is a vector quantity
and its direction is in direction of conventional current

scalar i = vector j vector A

$$i = jA$$

$$i = \vec{j} \cdot \vec{A}$$



Resistance :-

opposition offered To flow of current is called Resistance R

Drift velocity

The velocity of an electron under the influence of applied electric field is called Drift velocity (Average Velocity) of electron. This is average velocity

$V_d \propto E$ and also depends upon material

as atomic size is change ~~and~~ collision happens

Avg

Mean free Path :-

The distance covered b/w successive collisions is called Mean free path

Distance A > Distance B

Avg

Mean free time (τ)

Tau (scalar)

Time taken b/w successive collisions.

B is better conductor

$\tau_B > \tau_A$

$\Phi = EA$

$E = \rho J$

$\Phi = \rho J A$

$\Phi = \rho \frac{I}{\cancel{A}} \cancel{A}$

MCQs Pg 672

diff

1, 2, (3), 4, 5, 7, 8, 11, 12, 13

B, D, B, a) E, b) E, c) C, C, C, C, a) A, b) C

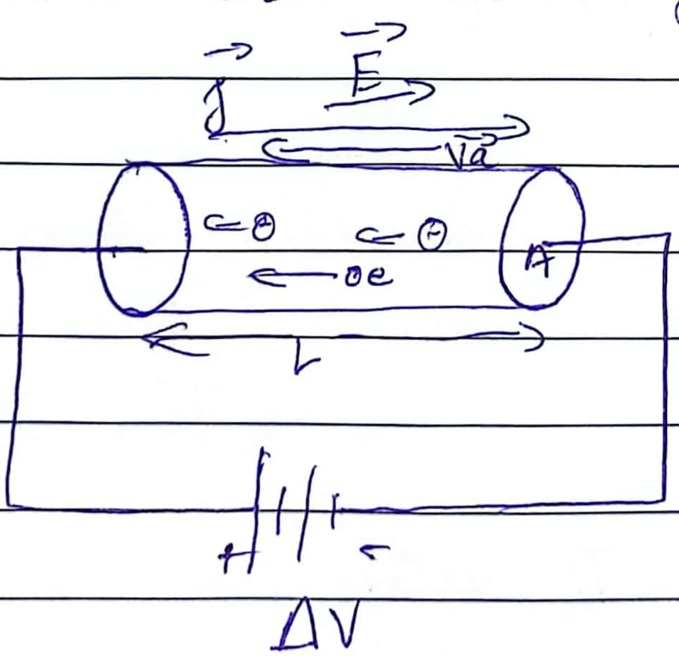
In conductor $E = 0$

insulator E is reduced

Resistor → Material

V_d will remain same because V_d is avg

Relation B/w Current Density (j) & Drift Velocity (V_d)



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$$j = \frac{i}{A} = \frac{q}{At}$$

$q = Ne$ quantization

$$j = \frac{Ne}{At}$$

Number density $n = \frac{N}{V} = \frac{N}{AL}$ number of charge per unit Volume

$$N = nAL$$

$$j = \frac{n\cancel{A}Le}{\cancel{A}t}$$

$$j = ne\left(\frac{L}{t}\right) \quad \frac{\text{distan}}{\text{time}}$$

$$j = ne\,V_d$$

In vector for

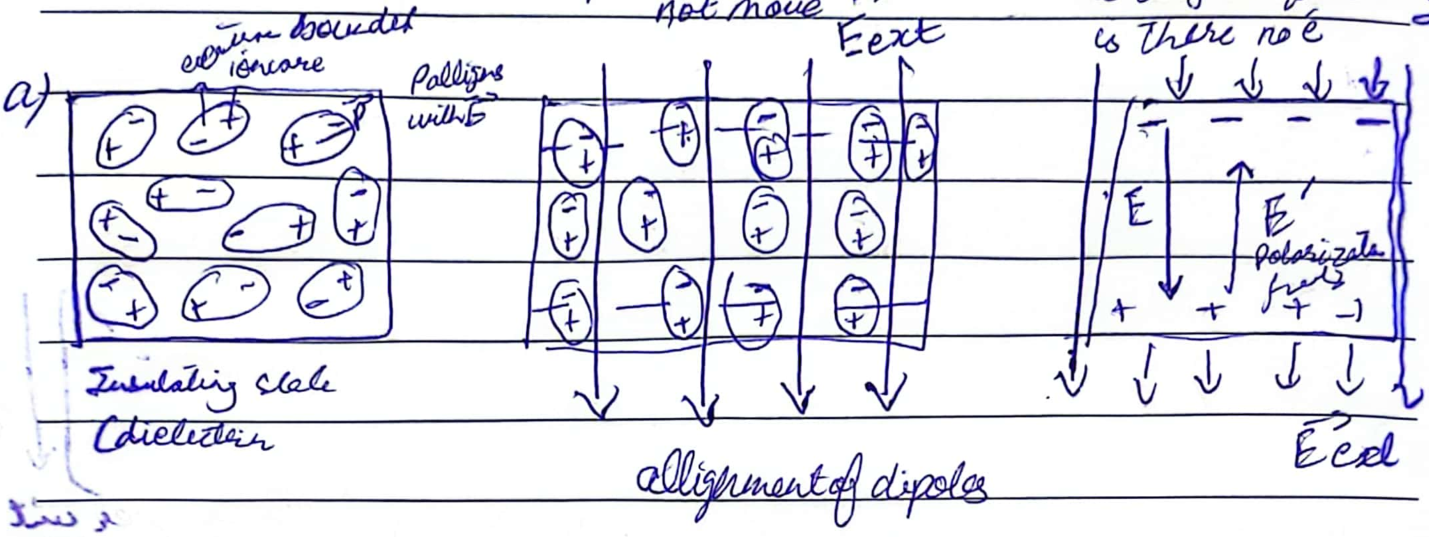
$$\vec{j} = -ne\,\vec{V_d}$$

j is opposite to V_d

randomly oriented dipoles

Insulator = dielectric

An Insulator in a electric field



$E = \vec{E}_{ext} + \vec{E}'$

$E = E_{ext} - E'$ Answer

E' is opposite to E_{ext} thats why (−)

$E' < E_{ext}$

G 71 table 29

Inside Insulator field is reduced :-

$E \propto E_{ext}$

$E = \frac{1}{K_e} E_{ext}$

Kepa E is dependent on material

(Kepa) dielectric constant

$K_e = 1$ in vacuum

$K_e = 1.00059$ in air

$K_e > 1$ other material

Ohmic Materials :-

we consider wires as ideal wires $R=0$

$V_d = \frac{L}{t}$

Macroscopic form of Ohms law

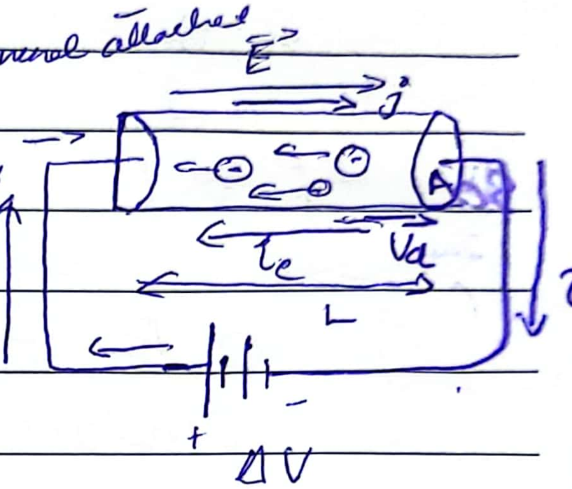
$i \propto \Delta V$

$i = \frac{1}{R} \Delta V$

$\Delta V = iR \quad -①$] Valid for non ohmic (diode)

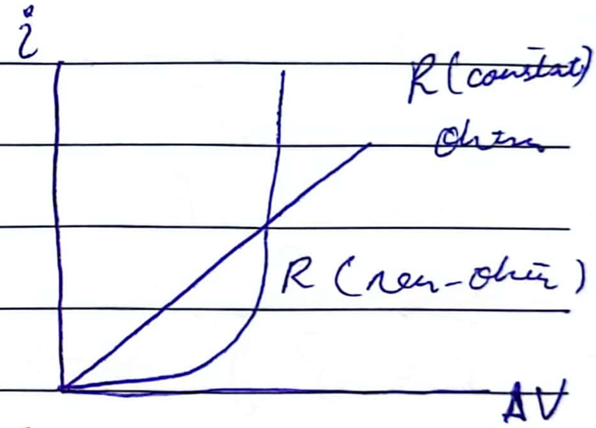
Area where terminal attached

L distance b/w 2 Terminals



$R = \frac{\cancel{\Delta V}}{i}$ not dependant

$\text{Ohm} = \frac{\text{Volt}}{\text{Amp}}$

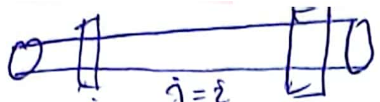


If proportionality is there but no linearity then non ohmic
pn junction

In ohmic conductors R is constt over changing ΔV

Resistance of a material is independant of applied Voltage

Equation 1 is a general expression to find Voltage, current and resistance of any kind of material whether that is ohmic material or not



M-CQ # 5

educative

Microscopic form of Ohm's law :-

$j = ne\,v_d$

$j \propto v_d$ — electron drift due to force of E

$v_d \propto E$

So $j \propto E$

$$\vec{j} = \sigma \vec{E} \longrightarrow (2a)$$

σ = conductivity

$\sigma = \frac{1}{\rho}$ — ρ = resistivity

$j = \frac{1}{\rho} E$

$$\vec{E} = \rho \vec{j} \longrightarrow (2b)$$

PreMed

$\Delta V = \int \vec{E} \cdot d\vec{s}$

$\Delta V = EL$

$\rho = \frac{E}{j}$

$\rho = \frac{\bar{E}}{j}$ — Prove $\rho = \Omega m$

$A = L \times L$

$\because j = i/A$

$$\rho = \frac{\Delta V}{Lj} = \frac{\Delta V \cancel{A} L}{\cancel{L}\, i} \;\; \frac{\Delta V\, L}{i} = \Omega m$$

$$\rho = \frac{E}{j} \quad \text{as} \quad E = \frac{\Delta V}{L} \quad \text{and} \quad j = \frac{i}{A}$$

$$\rho = \frac{\Delta V}{L\, i} \times A \qquad \because A = L \times L$$

$$\rho = \frac{\Delta V}{\cancel{L}\, i} \times \cancel{L} \times L$$

$$\rho = \frac{\Delta V}{i} \times L \qquad \frac{\Delta V}{i} = R$$

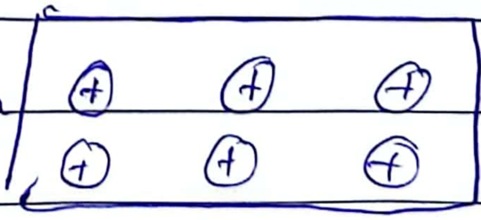
$$\rho = R \times L$$

$\rho \rightarrow \Omega\, m$ → show unit

$\sigma \rightarrow$ mho m^{-1}

Properties of ohmic Materials:-

- Homogenous / Same composition
- Isotropic



(Same electric properties in all direction) ρ, σ, R.

Resistivity same of same Material

Dependance of Resistance on Geometry.

$$\rho = \frac{E}{J}$$

$$\rho = \frac{\Delta V}{i} \quad \frac{A}{L}$$

$$\rho = R \frac{A}{L}$$

$$R = \rho \frac{L}{A}$$

$R \propto L$ no of collisions increase

$R \propto \frac{1}{A}$ free space increases b/w charges

pg 675 Q 1 - 5] H.W

Magnetism :-

Study of Magnetic field $\vec{B}$ & Magnetic Force $\vec{F_B}$ due to bar magnet

↳ sideway deflecting force

curve 90° force

the rotates

CH # 32 Magnetic Field.

Magnetic Interaction & Magnetic force

Electric charge ⇌ electric field $\vec{E}$ ⇌ Electric charge

can we write a similar Expression for magnetism

✗ Magnetic Charge ⇌ $\vec{B}$ magnetic field ⇌ Magnetic charge

✗ Magnetic Pole ⇌ $\vec{B}$ ⇌ Magnetic Pole

2 poles exist

no monopole

Quadropole

Moving Electric charge ⇌ $\vec{B}$ ⇌ Moving Electric charge

velocity

$\vec{v}$, q

$\vec{F_B}$ → q . $\vec{v}$

No Magnetic force at static charge

no force on neutron

no force on static

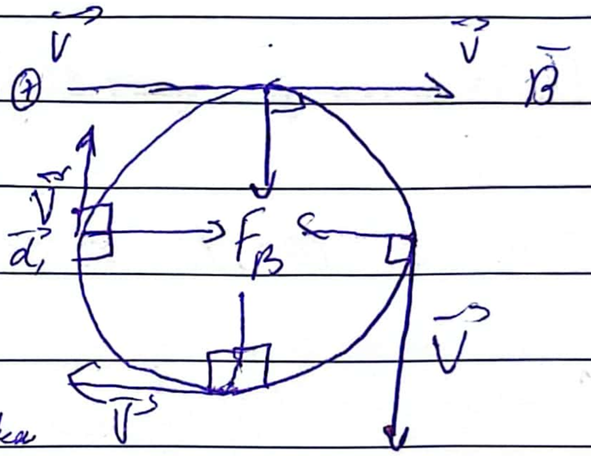
Answers of questions

1. Magnetic test charge does not exist
2. Moving electric charge can be used to probe (detect) the magnetic field only if it's moving

3. Moving charge established Magnetic field

Q Is there magnetic potential energy like electric potential energy

The magnetic potential is not associated with a moving electric test charge



$\vec{F}_B \perp \vec{V}$ sideway deflection

ΔU = Work & conservative

$\Delta U = -W = \vec{F}_e \cdot \vec{S}$

force is conservative

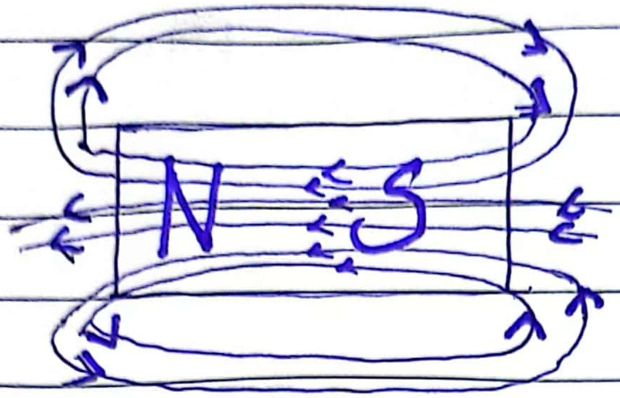
Magnetic force is velocity dependent force so it is non conservative force

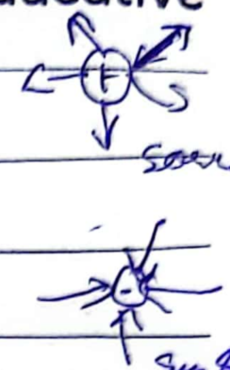
Magnetic Potential is conservative and independent of path so does not exist

Search Auroras — excitation, deexcitation — magnetic field is protective; if anything strike they deflect and revolve on Earth

no auroras at equator as field lines are far

Pg 729 Magnetic pic





Source and sink in electrostatic

Why magnetic monopole does not exist?

~~when no source~~ Because magnetic field lines are closed and vice versa

• when no source/Sink have to coexist

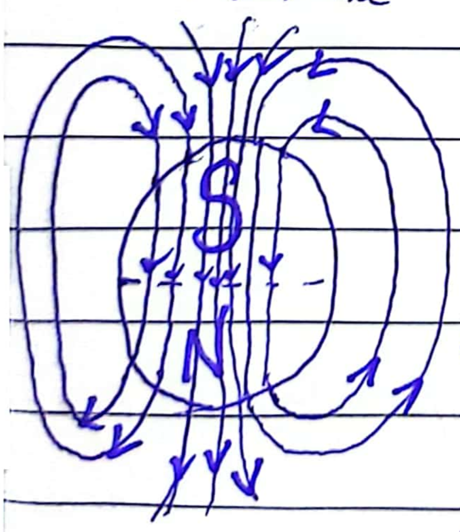
Like Poles repel eachother and unlike poles attract each other

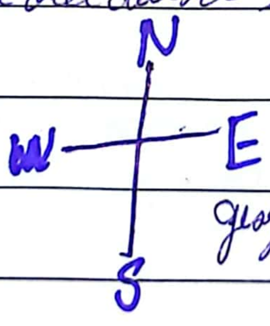
Earth's geographical North is its magnetic South

(as (north seeking pole will attract south pole (magnetic)))

geographical

Pg 723 Earth pic





geographical

Van Allen Belts

magnetic Earth

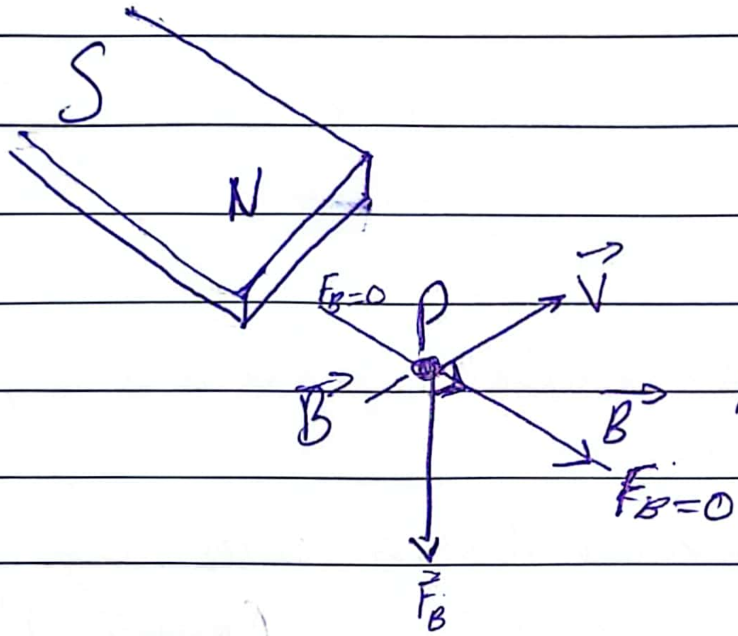
Magnetic Force on a moving charge.

$F_B \propto q$

$F_B \propto v$

$\vec{F} \perp \vec{v}$ angle $\theta = 90°$ deflected

Force is angle dependent



parallel and antiparallel to magnet field

$\theta = 0$ $\vec{F}_B = 0$

θ is angle b/w $\vec{V}$ and $\vec{B} = 0°$

Where θ is angle b/w velocity and that orientation of velocity for which $\vec{F}_B = 0$

$F_B \propto \sin\theta$

$F_B \propto qv\sin\theta$ B is proportionality constant

$F_B = q\underbrace{vB\sin\theta}$ $\vec{B}$ of Bar is not constant

as q is not vector But is constant at point

In vector form :-

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

$\sin\theta$ is dimension less

$$B = \frac{F}{qv\sin\theta}$$

$$F_{B\,max} = qvB\sin 90$$

$$\frac{F_{B\,max}}{qv} = B$$

$$B = \frac{N}{C\,m\,s^{-1}} = N\,s\,C^{-1}m^{-1} = \text{Tesla} = 10^4\ \text{Gauss}$$

4 times Right Hand Rule

$A \times B = AB\sin\theta\,\hat{n}$

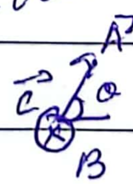
Right Hand Rule no 1 : (when x product) $A \times B$ have $\hat{n}$

⊗ inside
⊙ outside

Fingers cross product 1st

palm shows 2nd also hand orientation by Zna

thumb shows resultant



$$C = \vec{A} \times \vec{B}$$

3 1 2

if whole question .

educative

If whole question by electron.

for electron

$$\vec{F_B} = -e(\vec{v} \times \vec{B})$$

Sample Problem 32.1

$V = 1.2\ mT$ $\qquad \vec{F} = ?$ $\qquad 1eV = 1.6 \times 10^{-19}$ C·J

$KE_p = 5.3\ MeV = \Gamma\ 5.3 \times 1.6 \times 10^{-19} \times 10^6\ V$

+ve charge

After right hand rule Direction is in East

$m = 1.6 \times 10^{-27}\ Kg$

$$KE = \frac{1}{2} mv^2 =$$

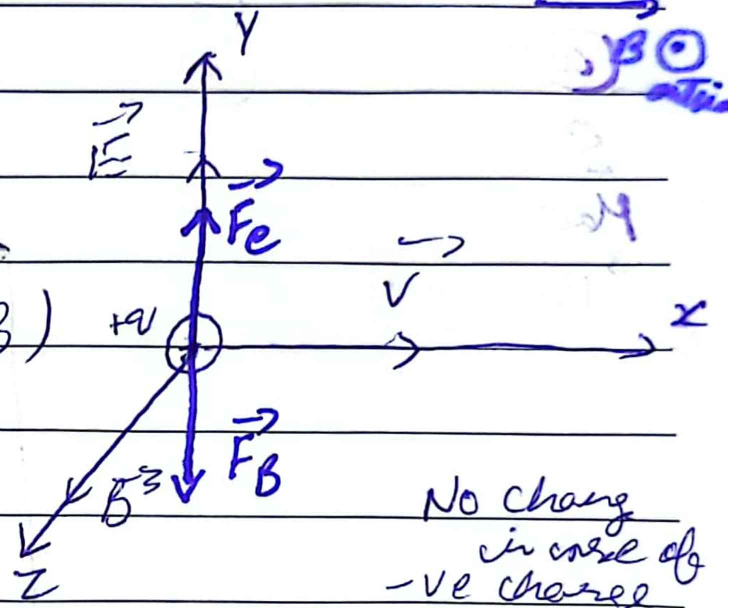
$$v = \sqrt{\frac{2K.E}{m}} = 2$$

$\vec{F}_B = q(\vec{v} \times \vec{B})$ Magnetic force on moving charge

educative

Combined Electric & Magnetic Field

Consider a positive charge $+q$ we apply electric & Magnetic fields perpendicular to the direction of motion of charge



$\vec{F} = \vec{F}_e + \vec{F}_B$

Lorentz force $= q\vec{E} + q(\vec{v} \times B)$

No change in case of $-ve$ charge

particle moves straight if both equal

$0 = qE - qvB \sin 90$

if $\vec{F}_e \uparrow$ particle moves straight

if $\vec{F}_B \uparrow$ particle rotates downwards

$qE = qvB$

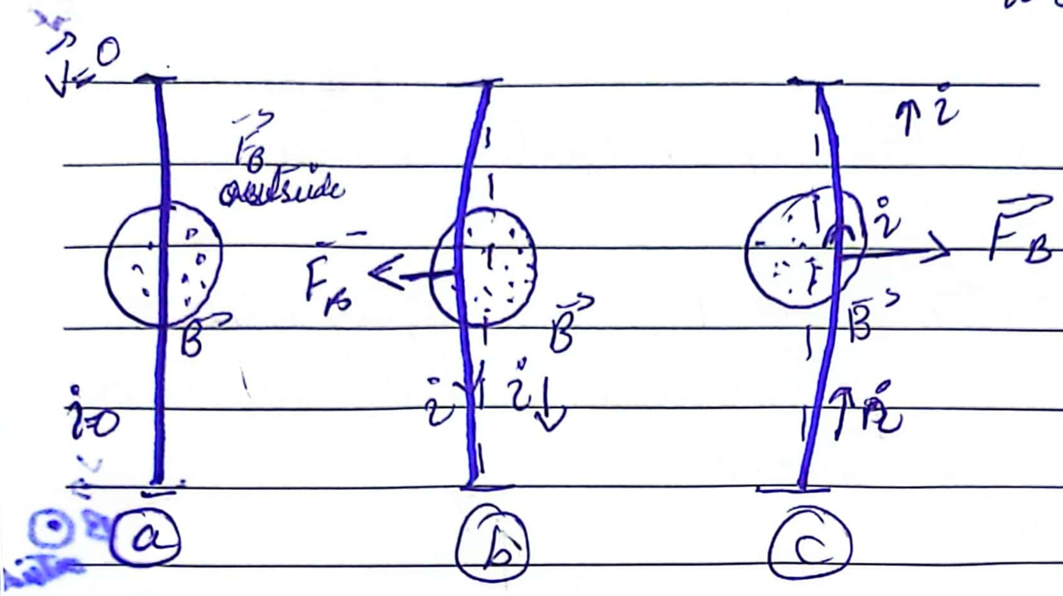
$V = \dfrac{E}{B}$] Velocity Selector.

Magnetic Force on a Current carrying Wire

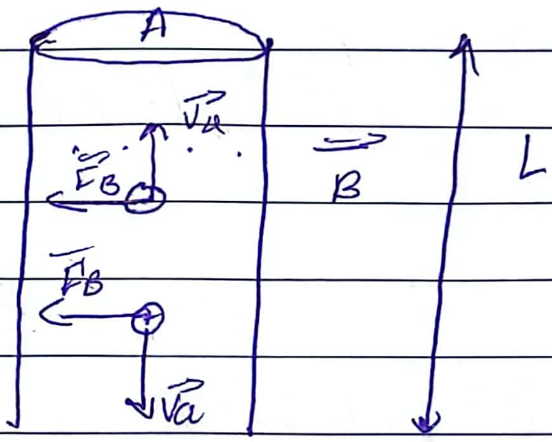
$\vec{F}_B = Nq(\vec{v} \times \vec{B})$

- wire

wire will deflect



Macroscopic View of B



$\vec{F_B} = Nq(\vec{v} \times \vec{B})$

Let electron to be the charge carrier

$\vec{F_B} = -Ne(\vec{v_d} \times \vec{B})$ - ①

Cross product does n't change forsets

$n = \frac{N}{V} = \frac{N}{AL}$

$N = nAL$ - ②

$\vec{j} = -ne\vec{v_d}$

$j = \frac{i}{A}$

$\vec{F_B} = -nALe\,\vec{v_d} \times \vec{B}$

$\vec{F_B} = i\,\vec{L} \times \vec{B}$

Not a vector

i gives direction to Length

$\times$ will be between 2 vectors

length not drawn scale

Short

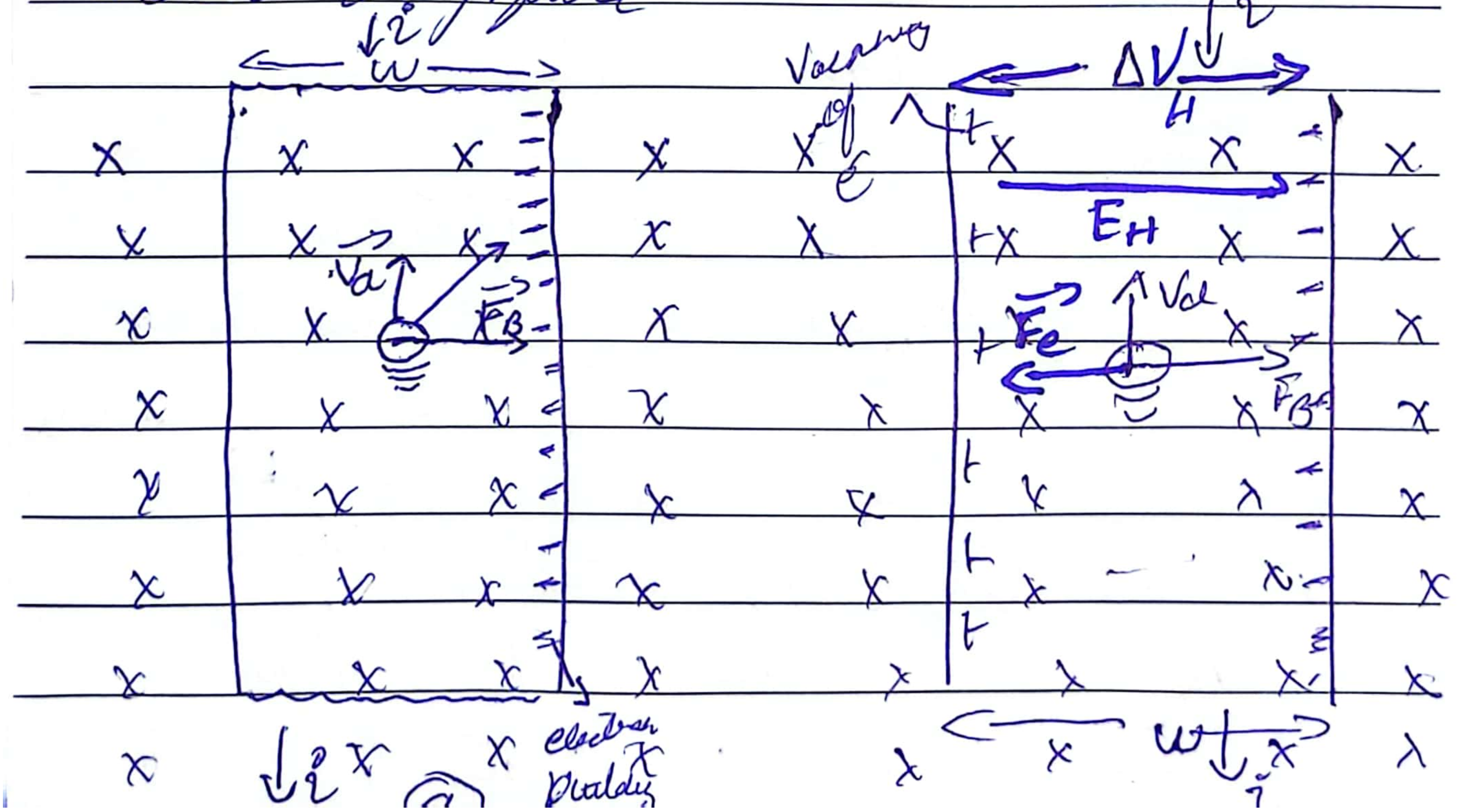
$$\vec{F}_B = q(\vec{V} \times \vec{B})$$

$$= i\,t\left(\frac{\vec{L}}{t} \times \vec{B}\right)$$

$$\vec{F}_B = i(\vec{L} \times \vec{B})$$

The Hall effect

The Hall effect provides a way to determine the density of the charge carrier, we consider a current carrying strip with width w and length l and we place it in a uniform magnetic field pointing inside page as shown in figure



$q\vec{E}_H + q(\vec{v_d} \times \vec{B}) = 0$

$qE_H - q\, v_d B \sin 90^\circ = 0$

$qE_H = q\, v_d B$

$v_d = \frac{i}{ne}$

$E_H = v_d B$

$\Delta V = \int \vec{E} \cdot \vec{ds}$

$EL = \Delta V$

$E_H = \frac{j}{ne} B$

$\Delta V_H = E_H w$

$\frac{\Delta V_H}{w} = \frac{j}{ne} B$

$A = L \times w$

$\frac{\Delta V_H}{\cancel{w}} = \frac{i / L \times \cancel{w}}{ne} B$

$\Delta V_H = \frac{i}{Lne} B$

$n = \frac{iB}{\Delta V_H L e}$

if known, we can find number density

Assignment 1 E 2(a)

M-CQs 1, 2, 12,

a,c e

a,c

$F \perp B$ $F \perp V$

F_E V V F_B

Assignment Pg 743 Exercises 1 — 8

1 a,c 2a(e) b) $V = \frac{E}{B}(d)$ 12, c $F = I(\vec{L} \times \vec{B})$

CH The Magnetic field of a current

Electromagnetism

Study of magnetic field

The Magnetic field of current :-

if Biot-Savart till end drawbacks

The Magnetic field of a moving charge :-

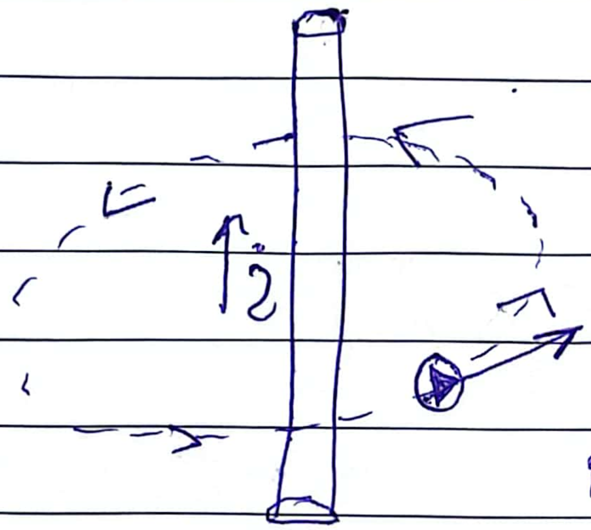
Right hand rule 2

$i \Leftrightarrow \vec{B}$

closed closed

Thumb in direction of i

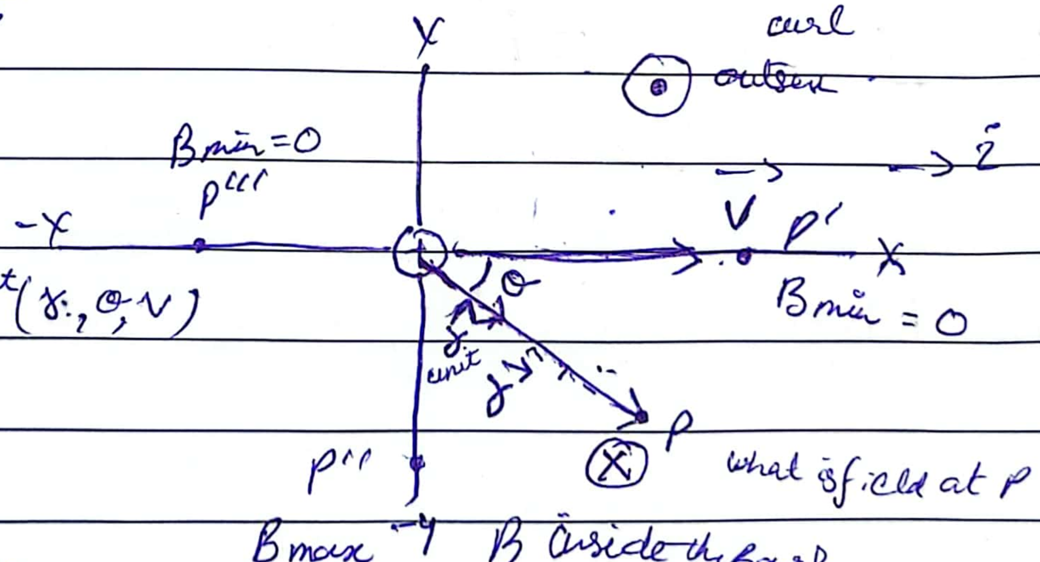
if electron ie ↓ opposite



if i towards you

$\vec{B}$ anticlockwise

$\vec{B} \to q, \vec{v}$



$B \propto q$ when others are constant (r, θ, v)

$B \propto v$

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

$B \propto \sin\theta$

θ b/w $\vec{r}$ and $\vec{v}$

$$B \propto \frac{qv\sin\theta}{r^2}$$

$1/4\pi\varepsilon_0$

$$B = \frac{Kqv\sin\theta}{r^2}$$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3\times10^8 \, ms^{-1}$$

K is magnetic constant $K = \frac{\mu_0}{4\pi}$ mew nol

$K = 10^{-7} \, TmA^{-1}$

In Vector Form

$\hat{r}$ = vector magnitud

$$\vec{B} = \frac{Kq(\vec{v} \times \hat{r})}{r^2}$$

cross product

$\therefore \vec{v} \times \hat{r} = v(1)\sin\theta = v\sin\theta$

$$\vec{B} = \frac{Kq(\vec{v} \times \vec{r})}{r^3}$$

The Magnetic field of a current :-

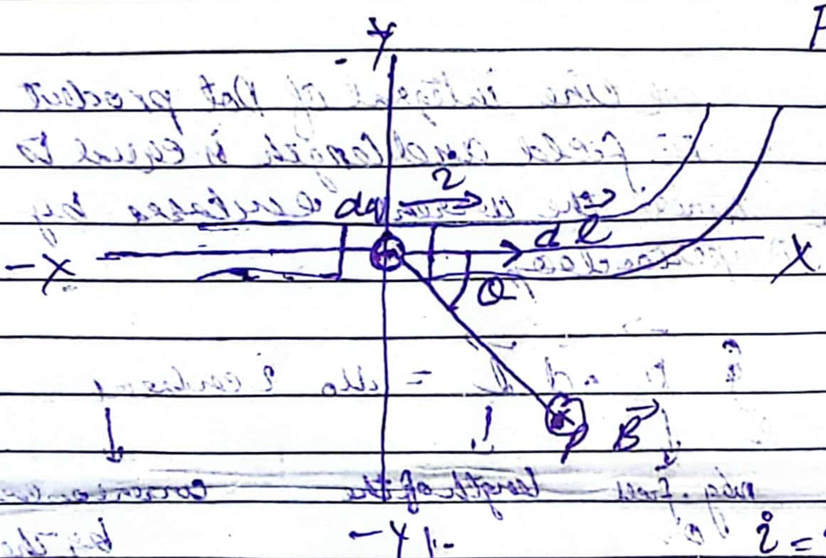
① Phy

DATE: ______ DAY: ______

$$\vec{B} = Kq \frac{\vec{v} \times \hat{r}}{r^2}$$ single charge

$$d\vec{B} = \frac{K\,dq\,\vec{v} \times \hat{r}}{r^2}$$ for a single particle

$$F = i(\vec{l} \times \vec{B})$$
dl



$$i = \frac{q}{t} = \frac{dq}{dt}$$

$$d\vec{B} = \frac{K\,i\,dt\,d\vec{l} \times \hat{r}}{dt\; r^2}$$

$dq = i\,dt$

$$\vec{v} = \frac{d\vec{l}}{dt}$$

$$\frac{d}{dt}$$

$$\int d\vec{B} = Ki \int \frac{d\vec{l} \times \hat{r}}{r^2}$$

$$\vec{B} = Ki \int \frac{d\vec{l} \times \hat{r}}{r^2}$$

Draw Back Biot Savart like Coulomb's law
It is only valid for moving charges Pg 253 Fig
33.7 Current
line of charge
33.13 ...

DATE: ____________ DAY: ____________

- Ampere's Law

This more fundamental and Basic than Biot Savart Law

Closed line integral 1D line

$$\oint_{l} \vec{B} \cdot d\vec{l} = \mu_0 \, i_{enclosed}$$

The closed line integral of Dot product of Magnetic field and length is equal to μ_0 times the current enclosed by the Amperian loop.

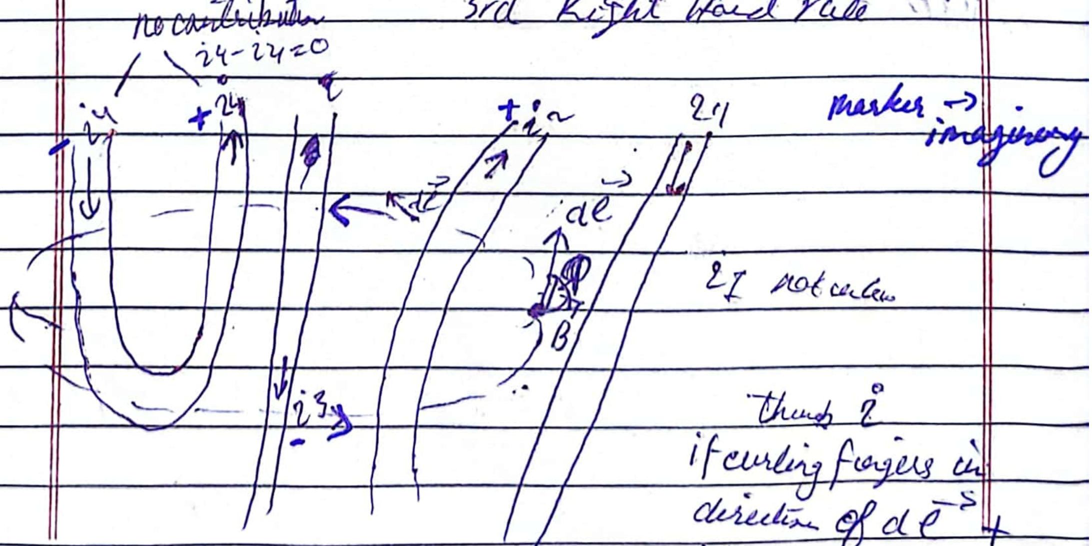
$$\oint_{l} \underbrace{\vec{B}}_{\text{mag. field on}} \cdot d\underbrace{\vec{l}}_{\text{length of the}} = \mu_0 \underbrace{i_{enclosed}}_{\text{current enclosed by the}}$$

→ Amperian field ←

- The direction of $d\vec{l}$ is arbitrary (clockwise or anticlockwise)

3rd Right Hand rule

fig 1

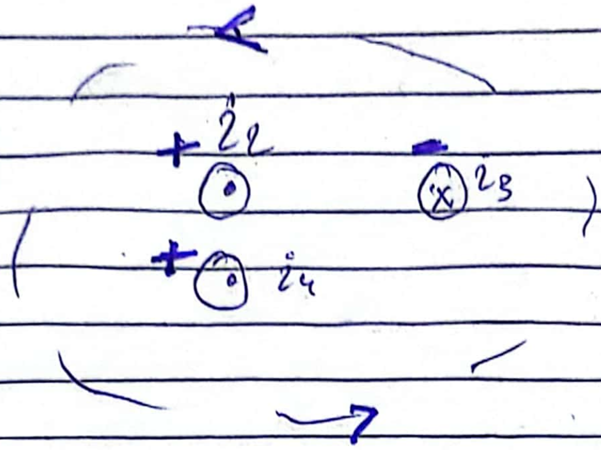


thumb i
if curling fingers in direction of $d\vec{l}$ +
if opposite −

From fig 1

$$\oint_l B\,dl\cos\theta = \mu_0(i_2 - i_3 + i_4 - i_4)$$

DATE: ____________ DAY: ____________



$$\oint_l B\,dl\cos\theta = \mu_0(i_2 - i_3 + i_4)$$

Place your thumb of right hand in direction of conventional current if your curling fingers are in direction of Amperian loop then current is taken to be as positive otherwise negative

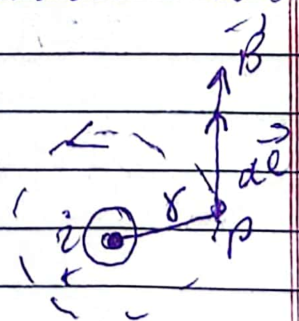
From

Application of Ampere's Law

$$\oint_l \vec{B}\cdot d\vec{l} = \mu_0\, i_{enclosed}$$

with the help of Ampere's Law we can find the B at different variation of current current distribution

First Application
Along straight wire



as length of circle $= 2\pi r$ $l = 2\pi r$

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$$\oint_l B\,dl\cos 0^\circ = \mu_0(+i)$$

$$B\oint_l dl = \mu_0 i$$

$$B(2\pi r) = \mu_0 i$$

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

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

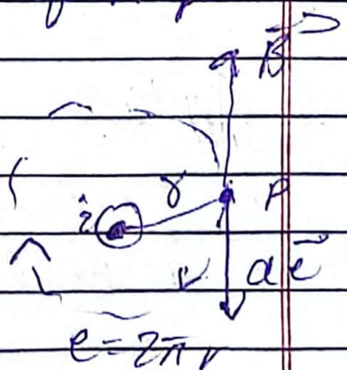
electronic only direction of $d\vec{l}$ change answer

Prove that the direction of Amperian loop $d\vec{l}$ is Arbitrary

$\vec{B}$ is fixed $d\vec{l}$ is an change

$$\oint_l B\,dl\cos 180^\circ = \mu_0(-i)$$

$d\vec{l}$ is opp to $\vec{B}$



$$-B\oint_l dl = -\mu_0 i$$

$$B(2\pi r) = \mu_0 i$$

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

②

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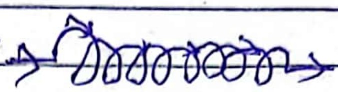
2- Solenoid $\qquad$ at external point $\vec{B}_{ext} \cong 0$

at internal point

cross sectional view 

right hand rule $\quad$ finger current $\quad$ thumb $\vec{B}$

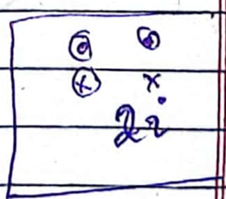
it is not dependant on R as field is uniform

$$\oint_l \vec{B} \cdot d\vec{l} = \mu_0 i_{enc}$$

$$\int_a^b B\,dl_1 \cos 0^\circ + \int_b^c B\,dl_2 \cos 90^\circ + \int_c^d B_{ext}\,dl_3 \cos 0^\circ +$$

$$\int_d^a B\,dl_4 \cos 90^\circ = \mu_0 (i_{enc})$$

$$B \int_a^b dl_1 = \mu_0 i_{enc}$$



$$Bh = \mu_0 N i$$

No of Turns enclosed in Amperian Loop $= N = nh$

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number per unit length

no. density $= n = \dfrac{N}{h}$

current enclosed $= i N = i n h$

$B h = \mu_0 (i n h)$

$B = \mu_0 i n$

To show $\vec{dl}$ is arbitrary loop direction opp 90 will be 90 and 0 will be 180

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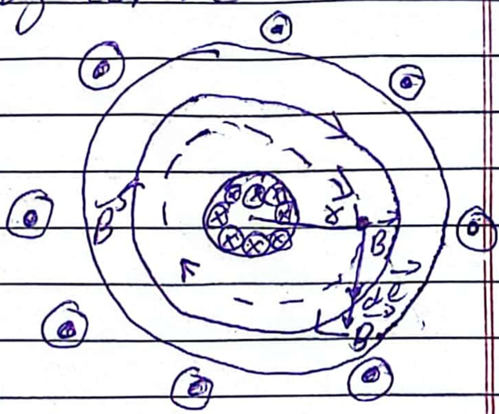
3- A current carrying Toroid

when curved and loop the solenoid

$\oint_l \vec{B} \cdot \vec{dl} = \mu_0 i_{enc}$



$\oint_l B\, dl \cos 0° = \mu_0 (N i)$

$B \, 2\pi r = \mu_0 N i$

$B = \mu_0 i \dfrac{N}{2\pi r}$

$n = \dfrac{N}{\text{circum}}$

$B = \mu_0 i n$

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

$$\phi_B = B \cdot A$$

$$\Delta V = \int \vec{E} \cdot \vec{ds}$$

emf in electromagnetic induction

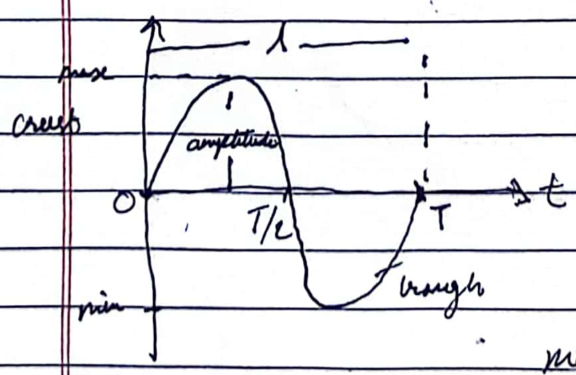
$$\mathcal{E} = \oint \vec{E} \cdot \vec{ds} = -\frac{d\phi_B}{dt}$$ change in flux in time

Lenz's law

opposes the cause that produces it

Optics

Time Period : Time taken to complete 1 cycle
Frequency : No of oscillation in 1 sec
λ Wave length : length of one cycle



0 -> max
0 -> min } amplitude

max -> min swing
peak to peak

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

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

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Sun -> Earth 8 min 20 sec

Reflection $\angle i = \angle r$

mirror Symbol

Refraction denser = air < water.

light rare to denser medium towards normal
light denser to rare medium away from normal

water reflect and Refract

Snell's law law of refraction :-

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

vacc = 1
air = 1.00
water = 1.33
crown glass = 1.5
flint = 1.66
general glass = 1.5

n_1 = incident index
n_2 = refractive index

Numerical

from water to air

$\angle i = 30^\circ$ $\angle r = ?$

$1.3 \sin 30^\circ = 1.00029 \sin \angle r$

$\frac{1.3 \sin 30^\circ}{1.00029} = \sin \theta r$

$\angle r = 41^\circ$

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Total internal Reflection

θ_C critical angle < $\angle i$

glass to air $\angle c = 41°$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$n_1 \sin\theta_C = n_2 \sin 90°$$
$$\theta_C = \sin^{-1}\frac{n_2}{n_1}$$

Critical angle : Incident angle where refraction ends and refracted ray makes 90° to

when 2 rays crest on crest Amplitude or Swing ↑
trough on trough
constructive interference

crest on trough Amplitude Swing ↓
trough on crest

Diffraction

Slit size ≅ λ of light then diffraction
comparable

Dark fringes → Destructive Interference
Light fringes → Constructive Interference

S_0 → diffraction
S_1 S_2 interference

Soap bubble Thin film concept reflection refraction

Light is an electromagnetic wave
components have oscilating characteristics

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crest

Phase difference?

Polarization

↕ shows oscilation

light separation of 1 component

to separate out one component E or B

If 2D → then 2 components
If 3D then 3 components.