30-4-24

The electrical properties of materials:-

Alignment is in insulators.

"Electrodynamics"

"The branch of physics in which we study charges in motion."

Types of materials:

metals * conductors] Basic
* insulators

Copper, Silver, Gold

silicon, germanium
* semi conductor
* super conductors.

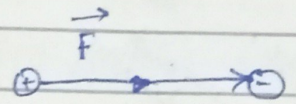
The ability of material to conduct electricity depends upon conditions like temperature & pressure

Conductor in electric field:

* (Static Conditions) → having boundry

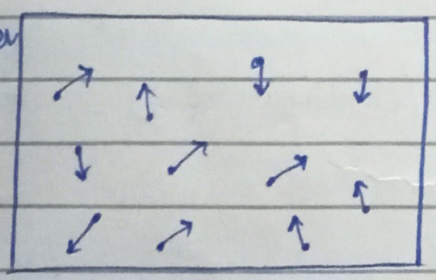
Under static conditions, electric field in interior of conductor is zero

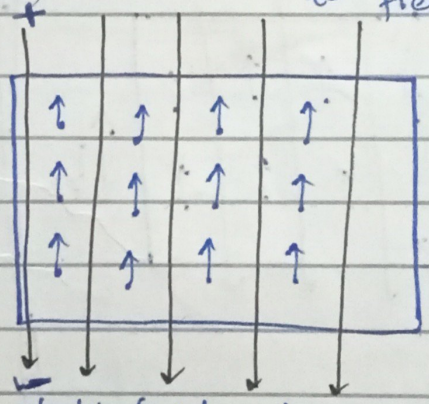
(relative motion) align in opposite direction to field



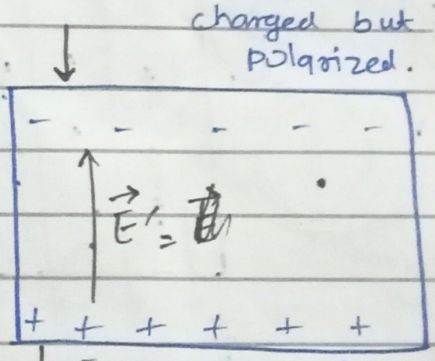
slab is not charged but polarized.

copper slab





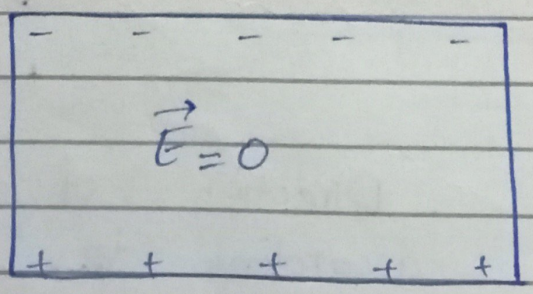
electric field = downward
e⁻ motion = upward.



Deficiency of e⁻

* electric field inside the insulator is not zero
→ electric dipoles

(Polarization field)
But it is basically due to insulators



Conducting slab
-ve lie + ve lie charge.

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

Total field $\vec{E} = \vec{E}_{ext} - \vec{E}'$

In static conditions
$E' = E_{ext}$
So
$\boxed{E = 0}$

$\vec{E}'$ is due to build up of charges.

$\vec{E}'$ is established due to $\vec{E}_{ext}$

$E' \propto E_{ext}$

The surface of a conductor is an equipotential

Electronic current
Conventional current] only direction change

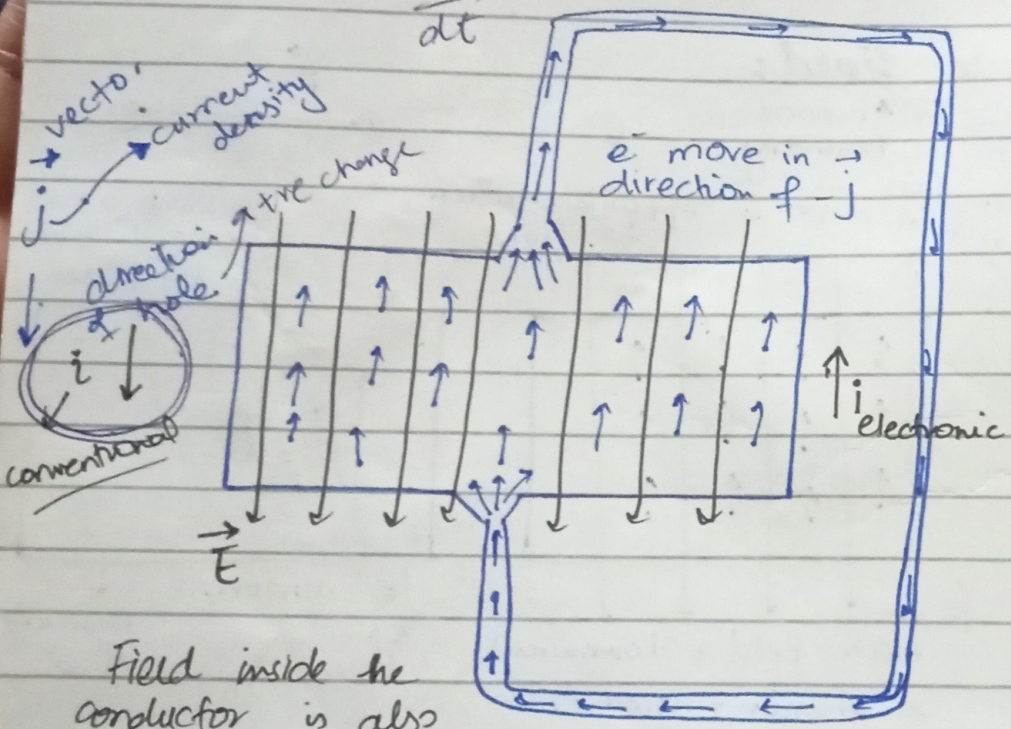
Conductor in electric field:

(Dynamic Conditions) Electric Current

→ Production of current.

"Unidirectional flow of charges is called current"

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



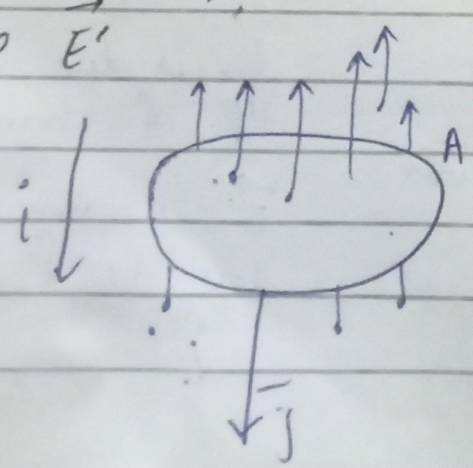
Current don't obey law of vector so it is not vector

Field inside the conductor is also equal to $\vec{E}$ (external field)

Vector has 4 properties
- magnitude
- direction
- Unit.
- Vector laws.

Total field = Applied field.

No $\vec{E}'$



Direction of current will be according to direction of flow of positive charges

j, i, E has same direction

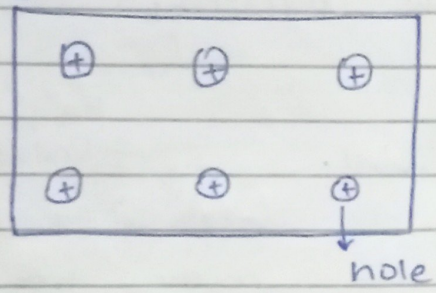
Unit = ampere = Cs^{-1}
μA

$i = \frac{q}{t} = \frac{dq}{dt}$ Part of charge flow in part of time through any cross section

e^- density = Number of e^- per unit volume

Current

Conducting Slab



The current passing through any surface can be determined by integrating current density over the surface

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

$v = \frac{L}{t}$ $t = \frac{L}{v_d}$

current per unit area

Current density & Drift velocity:

$j = \frac{i}{A}$ Current per unit area

Direction according to direction of flow of +ve charge

wire cross-sectional area = πr^2

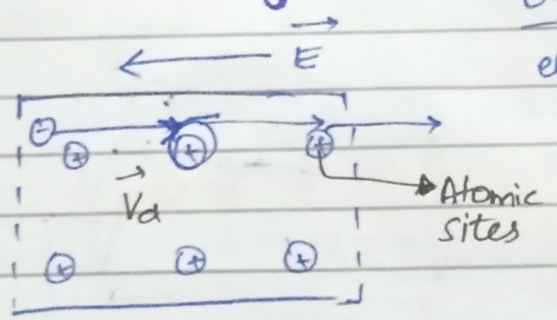
$i = jA$

* Vector Quantity and its direction is in the direction of conventional current.

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

Dot product of 2 vectors is equal to scalar.

V_d depend upon
* temp.
* electric field
* Path Provided



Electric Current

electronic + conventional

opposition offered to flow of e^- is called resistance R.

R depend upon temperature

Velocity of e^- under the influence of applied electric field is called drift velocity (average velocity)

drift velocity remains same when e^- pass through resistor.

mean free path $\propto$ Conductivity

Pg 672 MCQs 1, 2, 4, 5, 11, 12
7, 8, 13

12(c)

Average

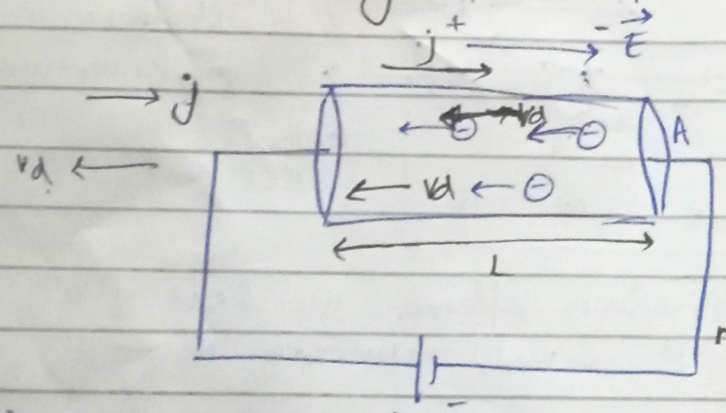
Mean free path	Mean free time
path difference between two collisions	Time taken b/w successive collisions.

They are material dependent.

M.F.P کم ہوگا
insulator میں

Conductor A has greater mean free path than B so A is better conductor.

Current Density & Drift Velocity.



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

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

number density

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

volume bcz it has both area and length

$N = nAL$

$$j = \frac{nLe}{t}$$

$$j = ne\frac{L}{t}$$

$$\vec{j} = ne\vec{v}_d$$

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

$$n = \frac{N}{AL} \Rightarrow N = nAL$$

$$\frac{nALe}{At} = \frac{nLe}{t}$$

$$nev_d$$

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

$$j \propto v_d$$

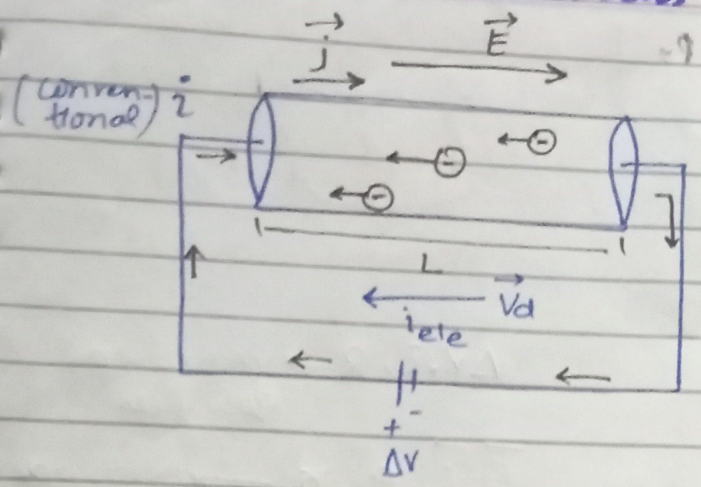
$$\vec{j} = -ne\vec{v}_d$$

Two vectors are in opposite direction

02-05-2024

conductors → ohmic
Semi-conductor → not ohmic

Ohmic Materials



$i \propto \Delta V$ Proportionality + Linearity.

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

R → Resistance

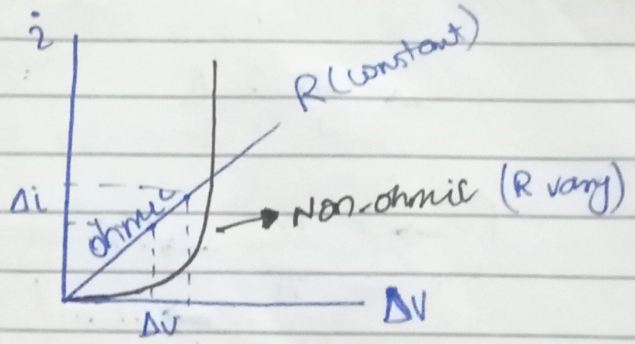
$\boxed{\Delta V = iR}$ → Also for non-ohmic

$R = \frac{\Delta V}{i} = \frac{Volt}{Ampere} = Ohm = VA^{-1}$

This is ohm law only if resistance is constant.

$\Delta V = iR$ → (1)

eq (1) is a general expression to find ΔV, i or R for any kind of material whether that is an ohmic material or not.



"Resistance is an independent of applied voltage. i.e it is constant bcz when we double the voltage current also ~~remain~~ ~~constant~~ doubled so resistance remain same." (Macroscopic form) **MCQ.5**

Microscopic form of ohm law:

forward bias = low resistance

$j = nev_d$

$j \propto v_d$

$v_d \propto E$

Where σ is conductivity of material

MCQ.5

$\sigma = \frac{1}{\rho}$ (resistivity) → microscopic — no depend on shape

$\sigma \Delta V$ → $j \propto E$

$\boxed{j = \sigma E}$

j — Current same Macroscopic Property does not depend upon area.

Resistance → macroscopic depend upon shape

Large value of σ → good conductor.

$\boxed{j = \sigma E} \rightarrow (2a)$

j, E same direction

σ → SI unit $\frac{\text{siemen}}{\text{meter}}$

1 siemen = $1\ AV^{-1}$

1 ohm = $(1 \text{ siemen})^{-1}$

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

$E = \rho j$

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

$\vec{E}, \vec{j}$ same direction

no -ve sign

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

* Resistivity is independent of applied field.

$E\uparrow \quad i\uparrow \quad j\uparrow$ so ρ remains constant

$\Delta V, i, R$ → macroscopic quantities

$\vec{E}, \vec{j}, \rho, \sigma$ → microscopic quantities material properties

$\rho = \Omega m$

$= \frac{\Delta V/d}{i/A}$

$\rightarrow \frac{\Delta V}{d} \times \frac{A}{i}$

$\Delta V = Ed$

$E = \frac{\Delta V}{d}$

$\rho \rightarrow \frac{V \cdot m^2}{m \cdot A} \rightarrow VA^{-1}m$

$\boxed{\rho \rightarrow \Omega m}$

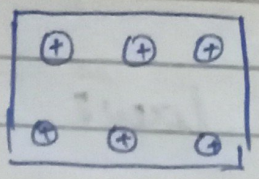
not equal to but its unit

A perfect insulator would have $\rho = \infty$ or $\sigma = 0$. Even good insulators are weekly conducting

Resistivity is independent of magnitude and direction of applied field

Properties of ohmic material (metals)

① Homogeneous



(same composition)

② isotropic (same electrical properties in all directions)

$j = \sigma E$

$E = \rho j$

conductivity, resistivity, resistance } should be constant

In these materials j will always in same direction as $\vec{E}$

Ohmic
Friendly

$R = \frac{\Delta V}{i}$ R is independent of ΔV

ΔV, i

MCQ: 1 – 13

Semiconductor are non-ohmic.

Applied Physics Lab

Dependence of R on geometry:

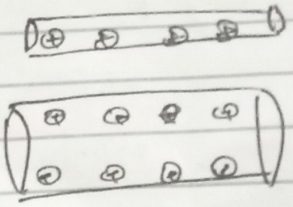
→ characteristic of object

R Depend on A and L (geometry) ρ – characteristic of material.

ρ not depend on A and L

↳ material property.

ρ depend upon temperature.



(1st diagram) $\rho = \frac{E}{j} = \frac{\Delta V / L}{i / A} = \frac{\Delta V}{i} \frac{A}{L}$

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

$\boxed{R = \rho \frac{L}{A}} \Rightarrow R \propto L$, $R \propto \frac{1}{A}$

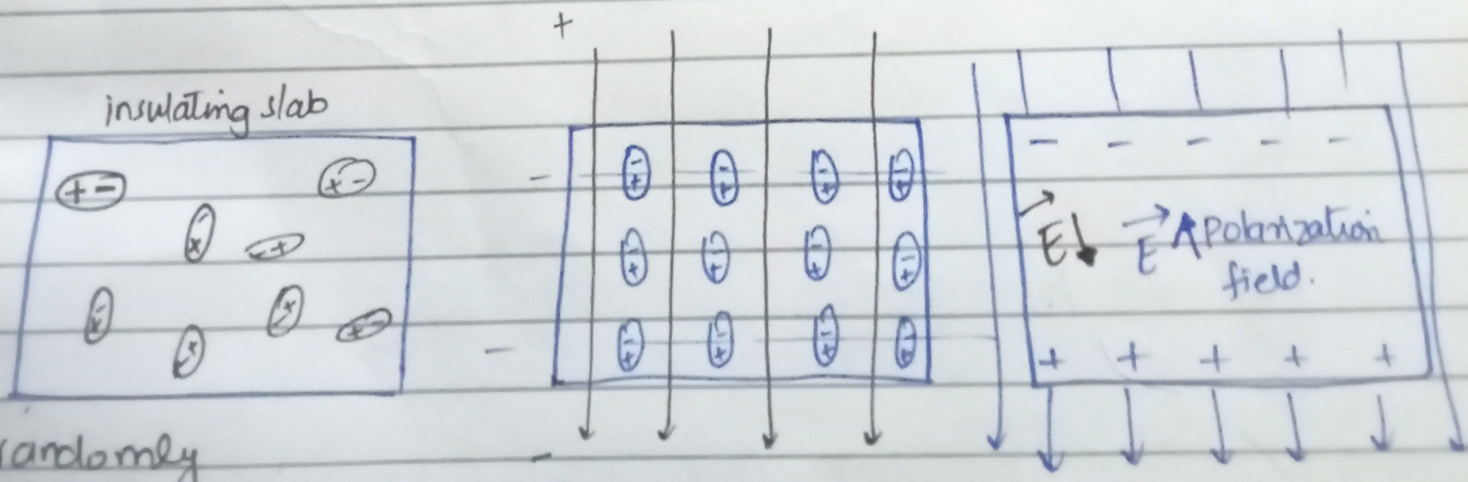
A ↑ Freepath ↑

A ↑ R ↓

Insulator in an electric field:

no free e^-

$E' < E_{ext}$ (in insulator / dielectric)



randomly oriented dipoles

$E_{(external)}$ dipoles will align themselves.

E_{ext}

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

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

MCQs 1, 2, 4, 5, 11, 8, 12, 13

Page 675 : ex 1-5

denominator always greater than 1

so

$K_e > 1$

$\vec{E}_{ext} > \vec{E}$

$E \propto E_{ext}$

$\vec{E} = \frac{1}{K_e} \vec{E}_{ext}$

reduced field inside the insulator

$K_e = 1$ (vacuum)

$= 1.00059$ (Air)

$= 3.5$ (Paper)

1-5-24

(1) (a) B (b) D

(2) D

(3)

(4) B

(5) (a) E (b) E (c) C

(8) C

(11) C

(12) C

(13) (a) A (b) C

$\varphi = E.A$

$= \rho j A$

$\varphi = \rho \frac{i}{A} A$

$\varphi = i$

9-5-2024

Chapter : 32

Causes of magnetic field
① Bar magnet
② moving charge

Magnetism "Magnetic Field"

Study of magnetic field $\vec{B}$ and magnetic interactions $\vec{F_B}$ due to bar magnet.

Magnetic Interactions and magnetic poles.

electric charge $\rightleftharpoons$ $\vec{E}$ $\rightleftharpoons$ electric charge

Q/ Can we write a similar expression for magnetic field?

Magnetic charge $\rightleftharpoons$ $\vec{B}$ $\rightleftharpoons$ Magnetic charge ✗

Magnetic pole $\rightleftharpoons$ $\vec{B}$ $\rightleftharpoons$ Magnetic pole ✗ mono-pole doesn't exist

Moving electric charge $\rightleftharpoons$ $\vec{B}$ $\rightleftharpoons$ Moving electric charge

$\vec{v}, q$

$\vec{F_B}$ q, v

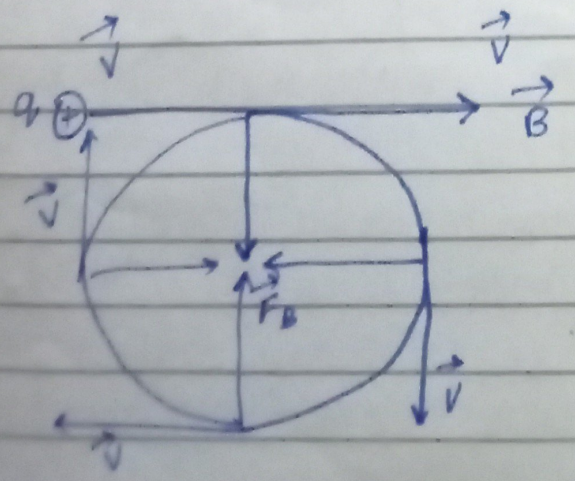
A static charge doesn't experience magnetic field.

Questions

① magnetic test charge doesn't exist.

② We can use electric test charge to detect magnetic field only if the charge is moving.

③ Moving charge produces magnetic field.



Magnetic force is sideway deflecting force.

$\vec{F_B} \perp \vec{v}$

"Magnetic Potential energy is not associated with a moving electric test charge." Bcz force that depend on velocity are not conservative forces

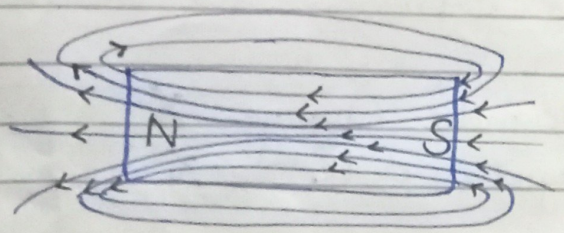
Frictional force is path dependent.

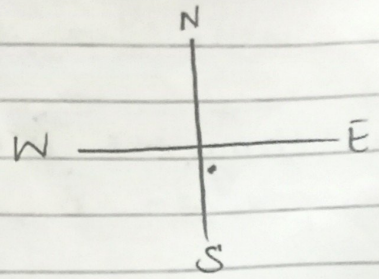
Earth's magnetic field is highly protective for us.

Auroras ?

"Magnetic force is velocity dependent force so it is non-conservative force".

Magnetic field of earth is due to its spin motion.

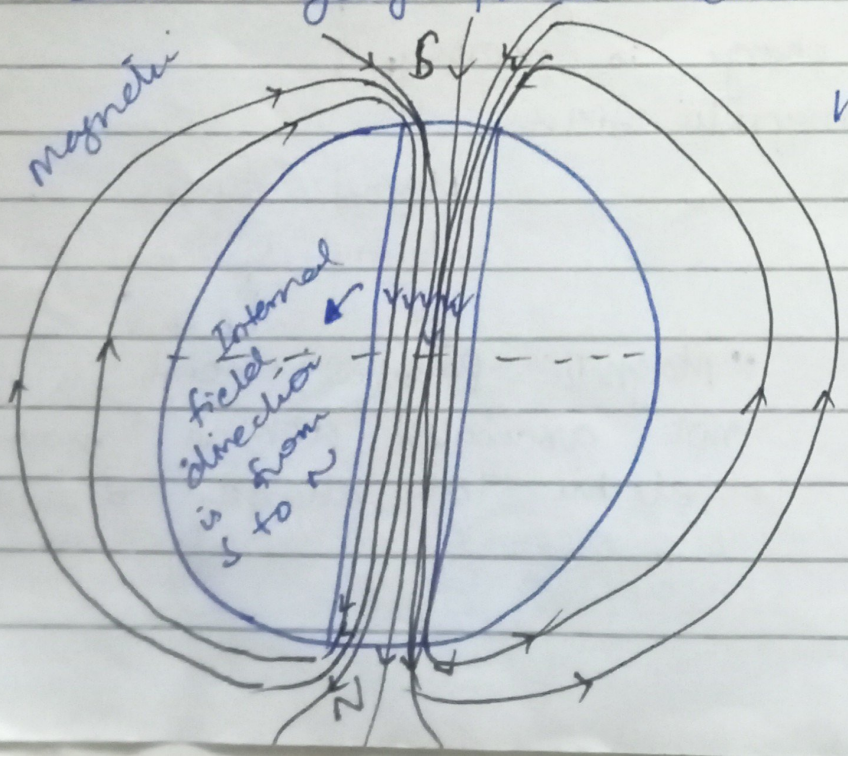


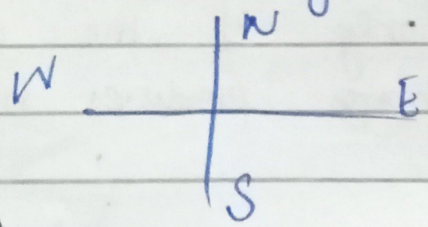


Q In magnetic field there's no source and sink bcz it is closed in nature. So, mono poles does not exist. and vice versa.

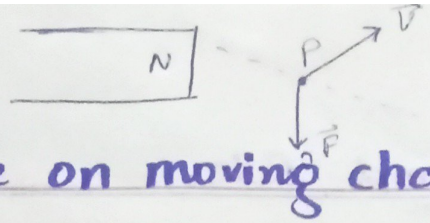
(1) Like poles repel each other and unlike poles attract each other.

Earth's geographical north is its magnetic south





Geographical



Magnetic force on moving charge

$F_B \rightarrow$ single charge

collection of moving charges = current.

Force always right angle to displacement so, do no work thus constant magnetic field can't change KE of moving charge

$F_B \propto q$

$F_B \propto v$

$F_B \perp v$

$F_B \propto qv \sin\theta$

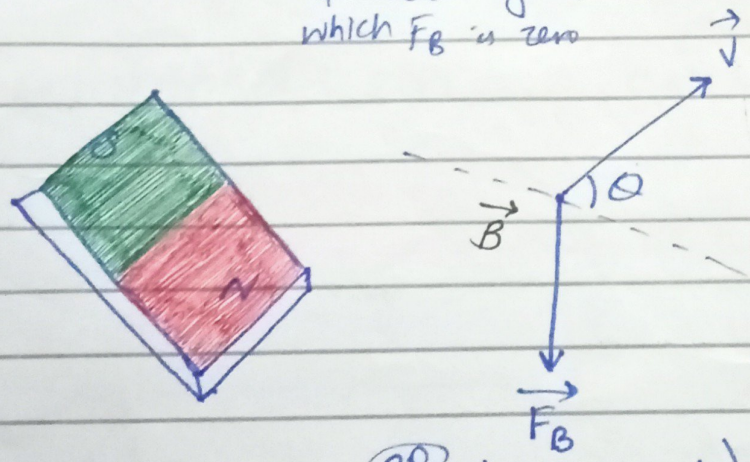
$F_B = qv \sin\theta$

$F_B = qvB \sin\theta$

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

$F_B \propto \sin\theta$. (where θ is the angle b/w velocity and that orientation of velocity for which F_B is zero

$B = \frac{F_{B\,max}}{|q|\,v}$



At some specific point so B is constant.

but actually B is not constant

$\vec{F}_B = 0$

30 (DOWNWARD)

Particle parallel to magnetic field, no force.

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

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

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

$1T = 10^4 G$

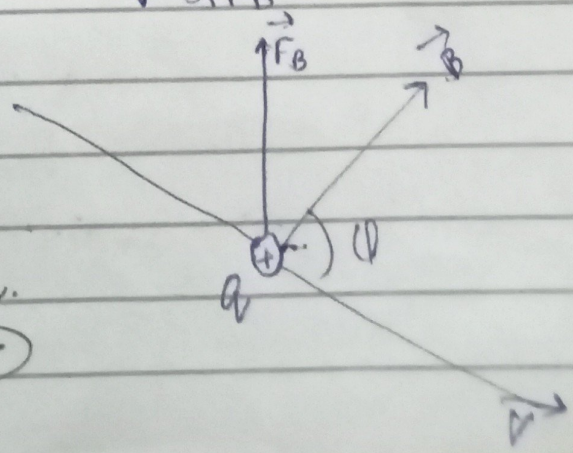
Non SI unit = Gauss

SI unit of B is Tesla

$\frac{N}{C\frac{m}{s}} = \frac{N}{\left(\frac{C}{s}\right)m} = \frac{N}{Am} = \text{Tesla}$

mT

$v \propto F_B$



Right hand Rule.

cross product.

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

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

3 1 2

Thumb Finger Palm

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

⊗ inside

⊙ outside

Reverse direction for electron

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

$1 eV = (1.6\times10^{-19} C) V$
$= 1.6\times10^{-19} J$

16-05-2024

Sample problem 32.1

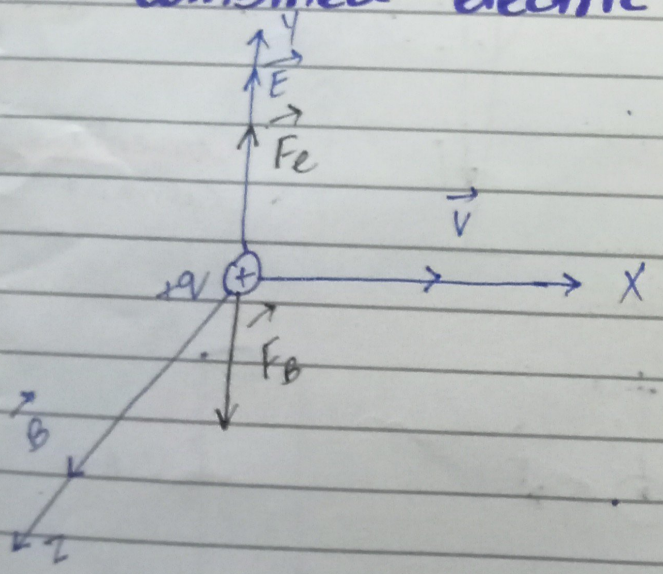
$B = 1.2 mT$
$K.E = 5.3 MeV$
$K.E = \frac{1}{2} m v^2$
$m_p = 1.67\times10^{-27} kg.$

$V = \sqrt{\frac{2K.E}{m}} = \sqrt{\frac{2(5.3\times10^{6})}{1.67\times10^{-27}}}$
$V = 3.2\times10^{7} ms^{-1}$

$F_B = qvB\sin\theta$
$= (1.6\times10^{-19})(3.2\times10^{7})(1.2\times10^{-3})\sin 90^\circ$
$= 6.1\times10^{-15} N$

$a = \frac{F}{m} = \frac{6.1\times10^{-15}}{1.67\times10^{-27}} = 3.7\times10^{12}$

Combined electric and magnetic field:



For negative charge

V, E, B are perpendicular to each other.
We have applied electric and magnetic fields perpendicular to the velocity of particle.
In this situation

$\vec{F} = \vec{F_e} + \vec{F_B}$ (Lorentz Force)

$0 = F_e - F_B$
$= qE - qvB\sin 90^\circ$
$qE = qvB$

$\boxed{V = \frac{E}{B}}$ velocity Selector

$\vec{L} \times \vec{B}$ is same as $\vec{V} \times \vec{B}$

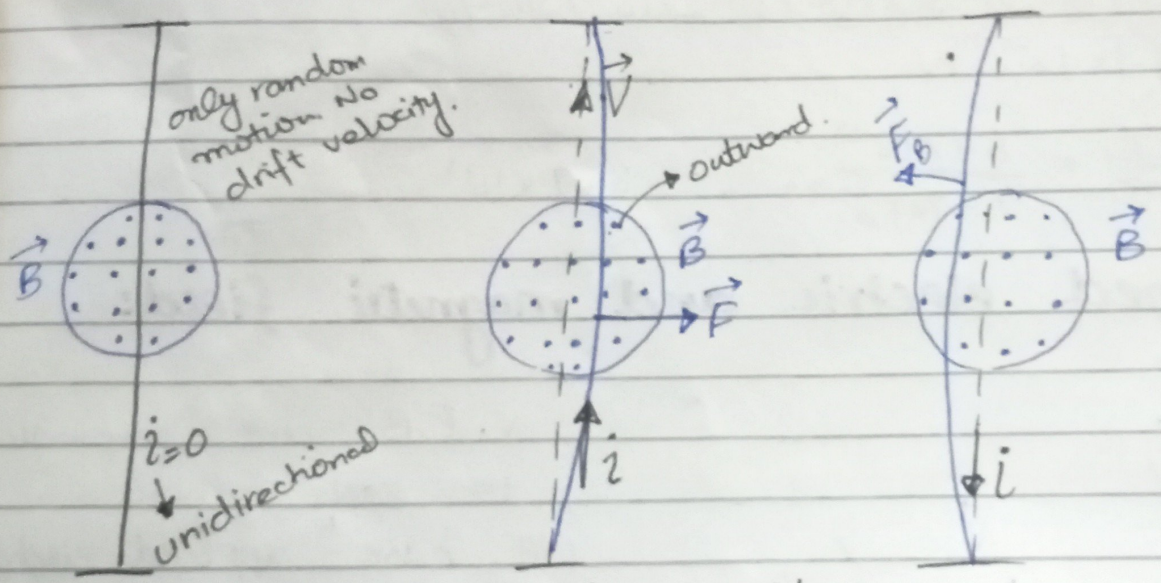
Magnetic force on current carrying wire

$N \rightarrow$ Total number of charges in wire.

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

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

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



Conventional current

$V=0$

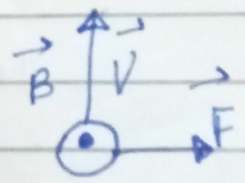
No deflection

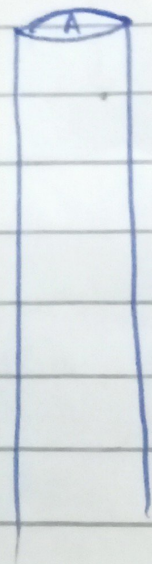
F = right side.

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

③ ① ②

Thumb Finger Palm





$V = A \times L$

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

$j = -ne\vec{v}_d$

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

$N = nAL$

$\vec{F}_B = -nALe\vec{v}_d \times \vec{B}$

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

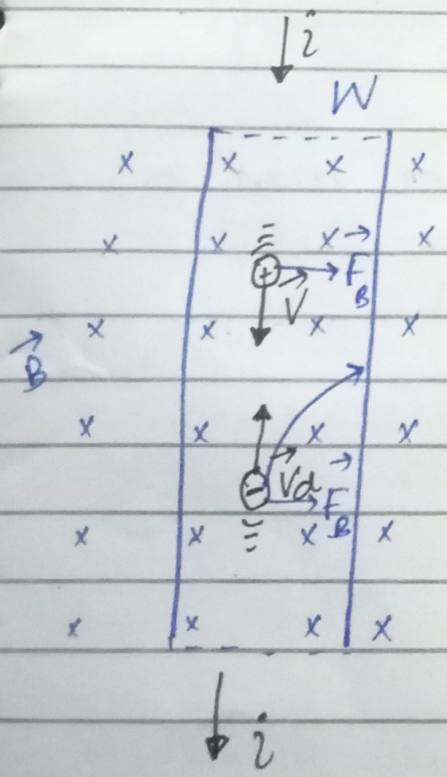
Direction of L is the direction of current.

We have made L a mathematical te

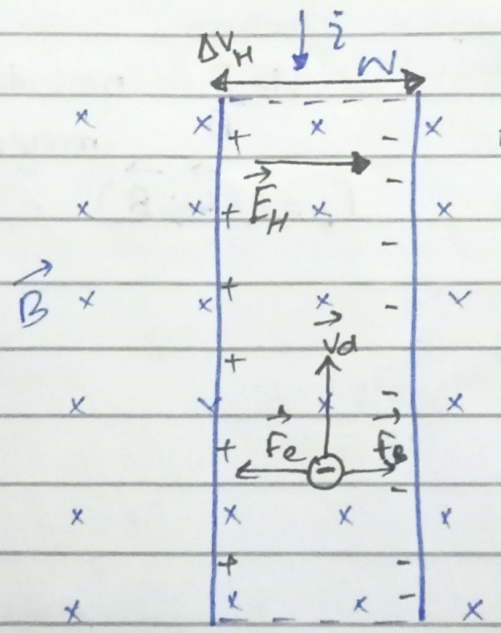
$$\vec{F}_B = q(\vec{v} \times \vec{B})$$
$$= i\cancel{t}\left(\frac{\vec{L}}{\cancel{t}} \times \vec{B}\right)$$
$$= i(\vec{L} \times \vec{B})$$

The Hall Effect

The Hall effect provides a way to determine both the signs and the density of the charges.



practical → $\bar{e}$ move.



Hall field.

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

$$\boxed{V = EL}$$

$$q\vec{E}_H - q\vec{V}_d \times \vec{B} = 0$$
$$\vec{E}_H = \vec{V}_d \times \vec{B}$$
$$\vec{E}_H = V_d B \sin 90^\circ$$
$$E_H = V_d B$$

$$\frac{\Delta V_H}{W} = V_d B$$
$$\frac{\Delta V_H}{W} = \frac{j}{ne} B = \frac{iB}{Ane}$$
$$n = \frac{iBW}{eA\Delta V_H}$$

Assignment : 3

Pg# 740 MCQs 1,2,12,14,15

$A = L \times W$ Pg# 743 Questions 1-8

(Number density) $n = \frac{iB}{eL\Delta V_H}$

material A (n) > material B (n).

$n = \frac{N}{V}$ material is good conductor.

MCQs

1. A+C $F_B \perp V$, $F_B \perp B$ $V \perp B$ No specific to be 90°.

2. (a) E

(b) D $V = \frac{E}{B}$ no depend on mass or magnitude

12. C $F_B = I(\vec{L} \times \vec{B})$ $F \propto L$