E_0 produces the potential at
E' is zero within side is +ve charges
of electrons stop.

Chapter # ... ics)

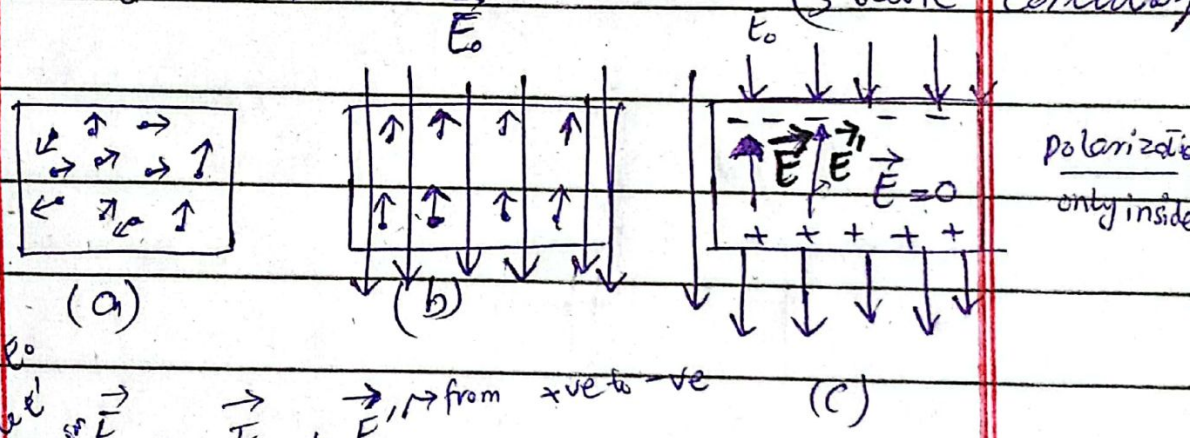
The Electric properties of materials

Types of materials:-

* Insulators (no free lym ove electron)
* Semiconductor → natural form (insulator) (make conduction by doping p-N junction)
* Conductors
* Superconductor: "once the current started to flow from such materials, then it will never stop" (whose ressistance = 0)
  * challange
    (1) room temperature
    (2) low cost.

A Conductor in an electric field:-

$E' = E_0$ (static condition)



polarization only inside

double E_0
double E'
→ more electron building up
↓ produces

$\vec{E} = \vec{E}_0 + \vec{E}'$ → from +ve to -ve

$E = E_0 - E'$ (two fields are opposite in direction)

In conductors
Inside conductors ① Electric field is in downward direction (E_0)
② the second field E' upward direction.

$E' = E_0$

$\vec{E} = 0$ Total field inside conductors is zero.

Electronic current :- produce due to electrons.
current passed when path is closed

⇒ When electron move in one direction then there must be some vacancy.

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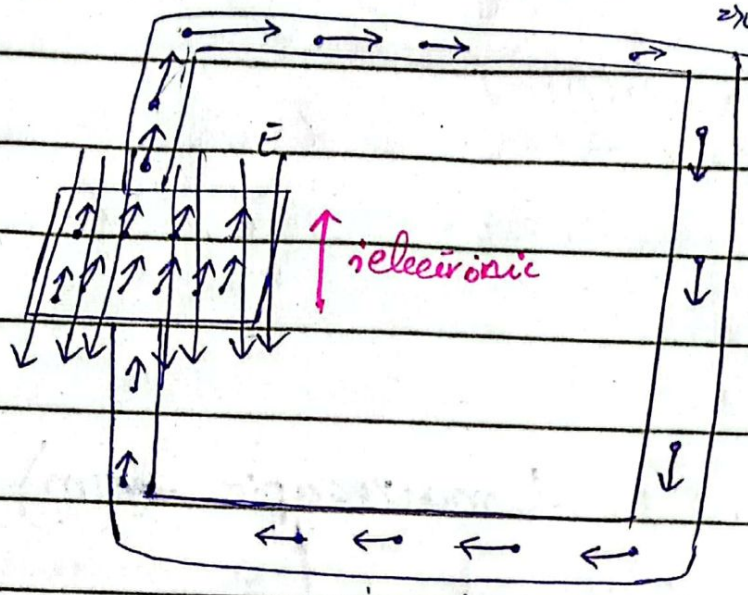
Logical mistake

conductor side field. no current flow || static condition $\vec{E}$

Dynamic condition :-



electric current :-
→ unidirection flow of charges called electric current (i)
(•) current flow when path is closed.

$i = \frac{q}{t}$ F → It is a ratio of total charge with it to total time.

Amp = columb / sec

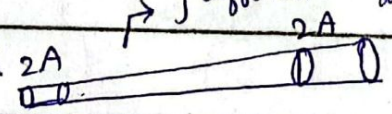
$i = \frac{dq}{dt}$ → part of charge flow in part of time

unit = $C s^{-1}$

Macroscopic :-

→ largest.

(current) i remains same through this

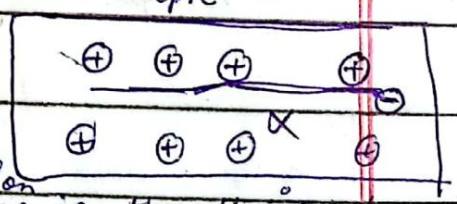


→ $\vec{j}$ different at different point as area changes

Conventional current :-
It flows from +ve to -ve. (Core)
Fact: +ve just vibrate actually electrons move.

Electronic current :- flow of electrons

→ is a macroscopic ∝

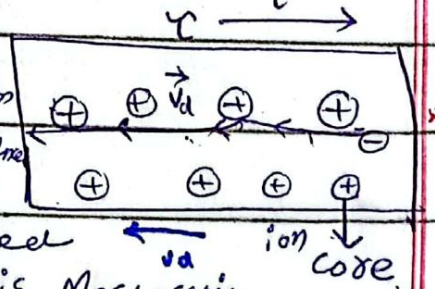


Drift velocity : $\vec{V_d}$

vector quant → Current Density : $\vec{j}$ → direction will be in the direction of conventional current.

Microscopic : $\vec{j} = \frac{i}{A}$ → $\frac{Amp}{m^2}$

Current Density $\vec{j}$	Drift velocity
current per unit area is called current density denoted $\vec{j}$ (conventional current) It is microscopic	→ velocity of electron under the influence of applied field is called Vd. It is Macroscopic.



⊖ apni direction collision ky bad change nhi krta

because E is still present. ←

M T W T F S

Date:

Mean free time:- τ (tow) (scalar)

time taken b/w the two successive collisions is called meanfree time.

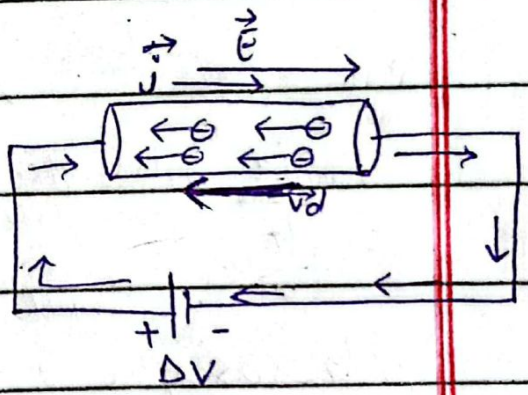
Meanfree path:-

Path covered b/w the two successive collisions called meanfree path.

Ohm's law:- (macroscopic form)

$i \propto \Delta V$

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



$\Delta V = iR$

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

$\frac{\text{volt}}{\text{Amp}} = \text{ohm}$

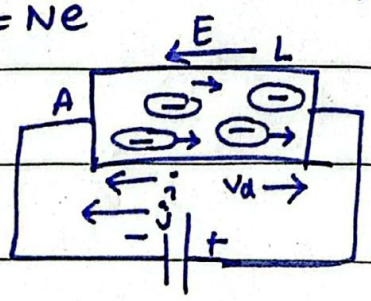
Lecture 2

Relation b/w current & density:-

$$j = \frac{i}{A} \qquad i = q/t$$

N: total No. of charges

$$j = \frac{q}{tA} \qquad \therefore q = Ne$$



$$j = \frac{Ne}{tA} \rightarrow (i)$$

Number density: No. of charges per unit area/volume.

$$n = \frac{N}{V} \qquad \therefore V = LA$$

$$n = \frac{N}{LA} \Rightarrow N = LAn$$

put it in (i)

velocity = $\frac{\text{dist}}{\text{time}}$

(4)

$$j = \frac{LAne}{tA} = \frac{Lne}{t} \qquad \therefore v_d = \frac{L}{t}$$

$$j = env_d$$

$$j = env_d$$

In vector form

$$\vec{j} = -(en)\vec{v}_d$$

current density is in opposite direction of the drift velocity.

The current → conventional current.

Check Point electron move leftword

the current ⇒ i Rightward

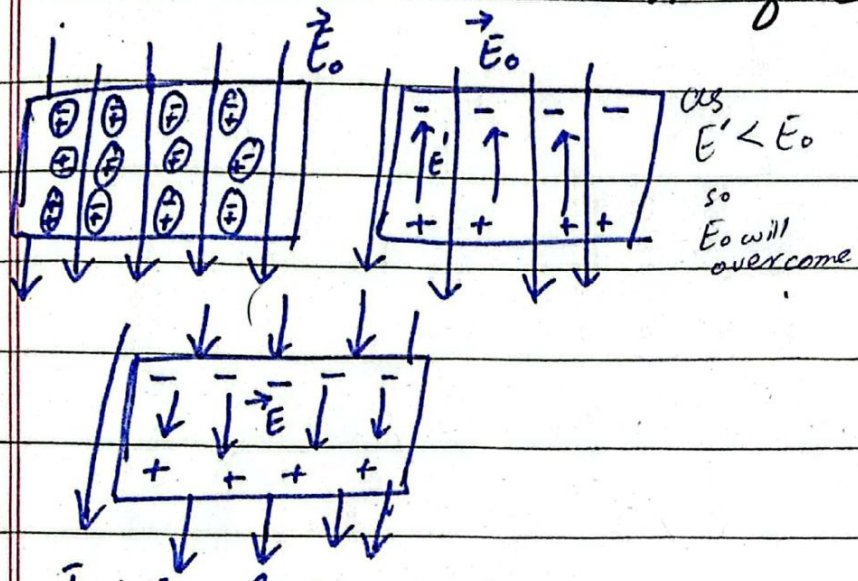
current density j rightward

Electric field E → rightward

] → conventional current.

Day: Date:

Insulator in an electric field:-



In insulator, Electrons are tightly bound with their atomic sites.

In insulator $E' < E_0$

$$E = E_0 - E'$$

E is not equal to zero.

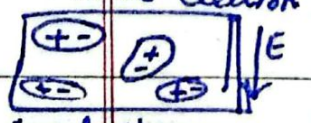
$E' \rightarrow$ produced, $E_0 \rightarrow$ cause

~~cause~~ produced is less than cause.

(5) under static condition result

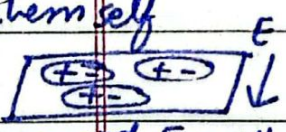
* inside field of a conductor, it is zero
* inside an insulator, net electric field is not equal to zero.

randomly move electron



insulator.
electrons bond

* dipole can only allign themself



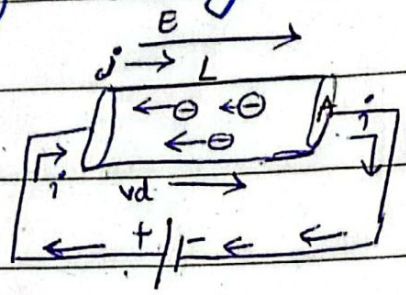
downward E will exert a force on electron on upward direction.

* dipole will rotate it self
* +ve downward
  − do upward
* Just allign not more.
* central dipoles are not contributing in surface elec

Day:

Relation b/w current density & Drift velocity :-

$E \rightarrow$
$j \rightarrow$
$i \rightarrow$
$\leftarrow v_d$
$\leftarrow i_e$



$j = \frac{i}{A}$ $\therefore i = \frac{q}{t} \Rightarrow j = \frac{q}{At}$

charge is always no. of electrons

Quantization $Q = Ne$ $\therefore N$: total no. charges

$j = \frac{Ne}{At} \rightarrow (1)$

Number density (n) :- (cylinder) → volume

↳ no. of charges per unit volume.

denoted n. $\boxed{n = \frac{N}{V}}$ volume $= LA$

$n = \frac{N}{LA} \rightarrow N = LAn \rightarrow (2)$

putting (2) in (1)

$\therefore V = \frac{s}{t}$ $j = \frac{LAne}{At} = \frac{L}{t}ne$ $\therefore v_d = \frac{L}{t}$

velocity = $\frac{\text{dist}}{\text{time}}$ ↳ distance covered in unit of time

(6) $j = env_d$

In vector form :-

$\vec{j} = -(en)\vec{V_d}$ - sign shows that $\vec{j}$ and $\vec{V}$ are in opposite direction.

$$\boxed{\vec{j} = -(en)\vec{V_d}}$$

$\vec{i}$ = Macro ↳ independent

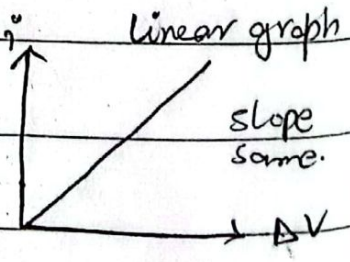
$\vec{j}$ = micro ↳ depend upon area

Ohm's law :-

$i \propto \Delta V$ → current established due to the applied field.

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

$\Delta V = iR$ (ohm's law)



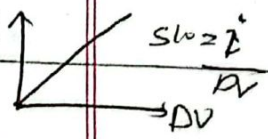
linear graph

slope same.

Date:

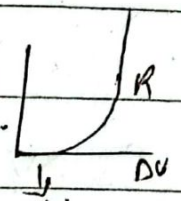
$\Delta V = iR \rightarrow \propto$ is a general relation
↳ only if Resistance is constant. → (ohm's law)
$\propto$ whether it is ohmic or non-ohmic
used to find any of these values (V, i, R)

Linearity:- (resistance remains same)
if increase the V by 2 factors, i also increases with 2 factors. ratio same. Resistance constant.
↳ linear relation, graph linear.
Slope at any point constant



(●) ΔV increase and current dose not increase with the same rate.

Like	DV	i	
R ↑ ↓ (resistance varies)	↑ 3	1.7 ↑	→ Resistance is new for every turn
	2	1.5	→ Resistance is not constant.
	1	1.2	



silicon
↓
(resistance varies, slope is not same)
↓
non-ohmic after 0.7V become a good conductor)

Ohmic :- obey's ohm law. ΔV & I have the same ratio → linear behaviour.

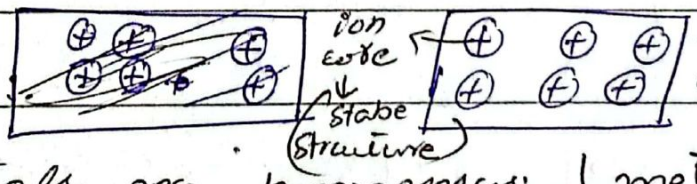
Non-ohmic :- The ratio of ΔV & i does not remain same.

Properties (for ohmic meterial)

1) Homogenous
2) Isotropic

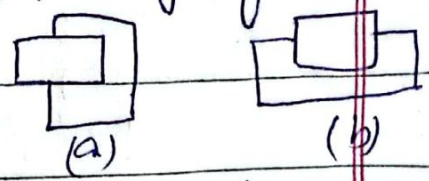
Homogenous:- same composition of elements throughout the material.

(7)



* metals are homogenous. (metal are ohmic materials)

Isotropic:- Same electrical properties in all direction. (conductor, passing of current)
i.e iron block, iron wire, ...

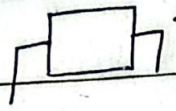


* (a) & (b) both cases current passes. (at every side current passes. electrical properties are same)

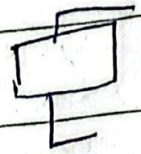
Date:

Day:

Non-isotropic:- Such materials that allow to pass current at such location and do not allow at some location. Some place conductor, and some are insulator.



→ conductor (pass current) (Macroscopic)



insulator (not allow to pass current)

statement :-

Macroscopic ⇒ ↳ Resistance same

"Resistance of a material is independent of applied voltage/potential"

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

V. increase, i increase both cancle out.

Microscopic:-

∴ δ conductivity

$j = env_d$

$j \propto V_d$

$V_d \propto E \Rightarrow j \propto E$

$j = \delta E$ → (a) Microscopic form

↳ conductivity

$\rho = \frac{1}{\delta}$

$\delta = \frac{1}{\rho}$ → resistivity

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

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

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

$E = \rho j$ → (1b)

$\rho = \frac{V}{A/m^2}$

Inverior form

$\rho = \frac{V}{A} \cdot m$

$\vec{j} = \delta \vec{E}$

$\vec{E} = \rho \hat{j}$

$j = \delta E$

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

$\rho = \Omega \cdot m$

$\rho = \Omega \cdot m$

$\delta = \frac{1}{\Omega m}$

δ = simen m^{-1}

$\frac{1}{\Omega}$ = simen

δ = mho m^{-1}

statement :- "Resistivity & conductivity is independent of applied field."

Day: Date:

Dependence of Resistance on geometric:-

* R, ρ both depends upon temperature.

Ristance depends on ~~temperature~~ geometry (dimension i.e, area, length, volume)

* while resistivity is independent of geometry.

* At fixed temp R & ρ are different

$\rho = \frac{E}{j}$ $\therefore j = \frac{i}{A}$ $\therefore \Delta V = \int \vec{E} \cdot \vec{ds}$ $\therefore R = \frac{\Delta V}{i}$

$\therefore i = jA$ $\therefore \Delta V = EL$

$R = \frac{EL}{jA}$ $\therefore j = \frac{i}{A}$

$R = \frac{\Delta V}{i} \Rightarrow R = \frac{E \cdot L}{jA}$

$R = \frac{E}{j} \cdot \frac{L}{A} \Rightarrow \boxed{R = \rho \frac{L}{A}}$

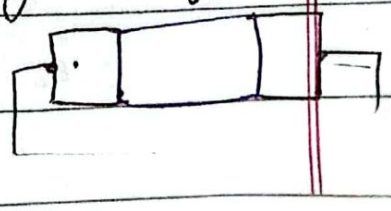
$R \propto L \rightarrow$ (chances of collision increase) (inc temp, collision increase as vibration)

$R \propto \frac{1}{A} \rightarrow$ (free spaces increase & collision decrease) $\rightarrow$ reduce resistance.

Class Task

Q A rectangular block of iron has dimensions $1.2cm \times 1.2cm \times 15cm$. Resistivity at room temperature is $\rho = 9.6 \times 10^{-8} \Omega m$. (a) Find resistance b/w two square ends

(b) Find R b/w two rectangular faces.



9 (a) square ends

$R = \rho \frac{L}{A}$ $L = 15cm$

$A = 1.2 \times 1.2$

$$R = \rho \frac{15cm}{(1.2 \times 1.2)}$$

(iii) b/w rectangular faces-

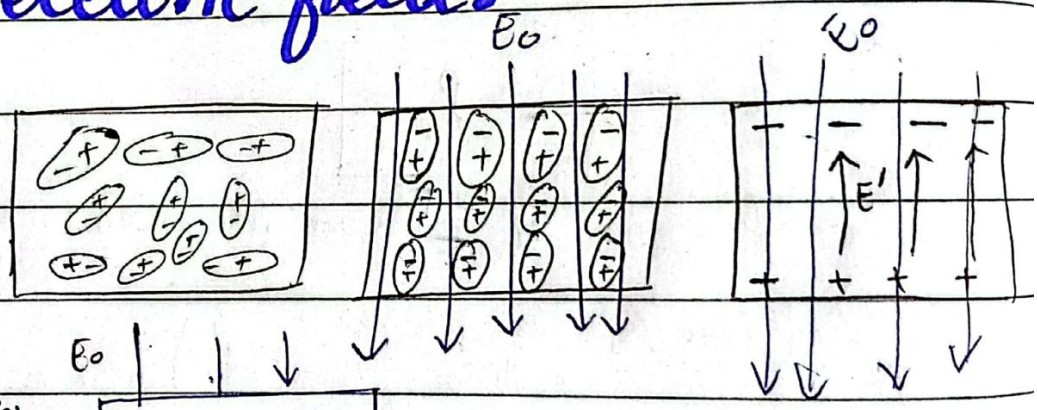
$$R = \rho \frac{L}{A}$$

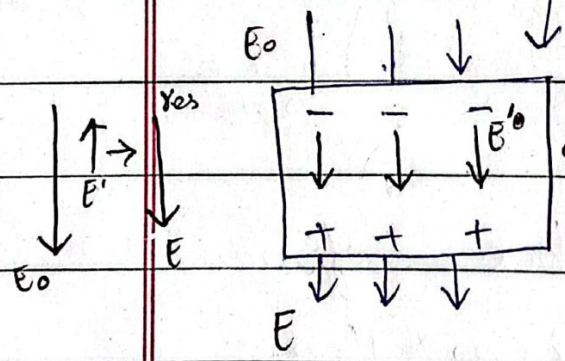
$L = 1.2cm$

Area $= 1.5 \times 1.2$

$$R = \frac{\rho (1.2)}{(15 \times 1.2cm)}$$

An insular in an electric field:-





as $E' < E_0$ • E' is weaker

So E_{net} would be toward E_0

$$E = E_0 + E'$$

(scalar form) $E = E_0 - E'$ (-ve, opposite dir)

* in insulator

$E' < E_0$ (just surface dipole take part)

Day:

* In insulator E_{net} reduces but not zero.

Reduction:-

$E' \propto E_0$ → cause of both E', E

$E \propto E_0$ K_e (cappa e) → dielectric constant.

total field inside insulator $E = \frac{E_0}{K_e}$

K_e for air (1.00059)

K_e for vaccum = 1

$K_e > 1$ for materials.

$\downarrow E = \frac{E_0}{\uparrow K_e}$ → $K_e > 1$ → E will be reduced

$E' < E_0$

E is always less than cause.

11