LAKSHYA BATCH

JEE

MAGNETISM AND MATTER
MAGNETIC MATERIALS

LECTURE - 7

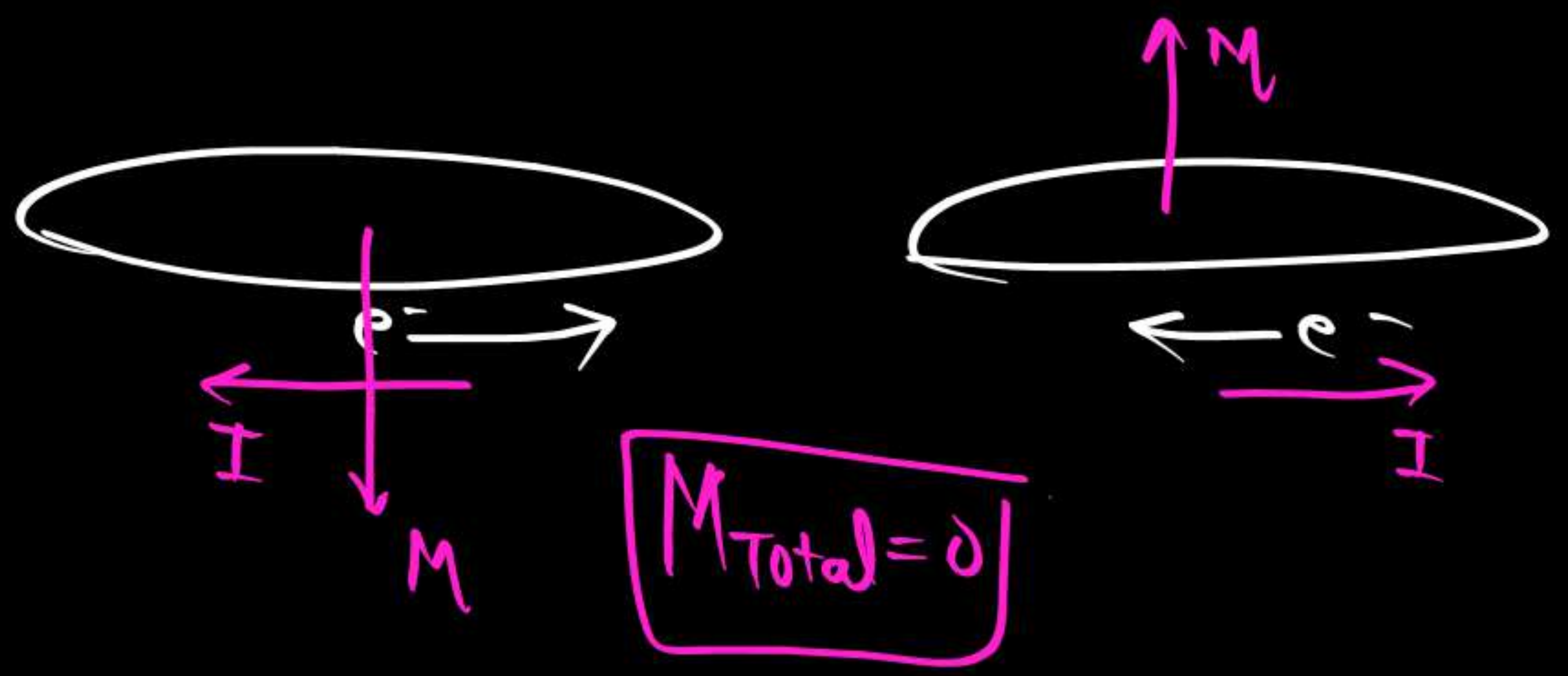
GOALS OF THE DAY

1. MAGNETIC MATERIALS
2. HYSTERISIS

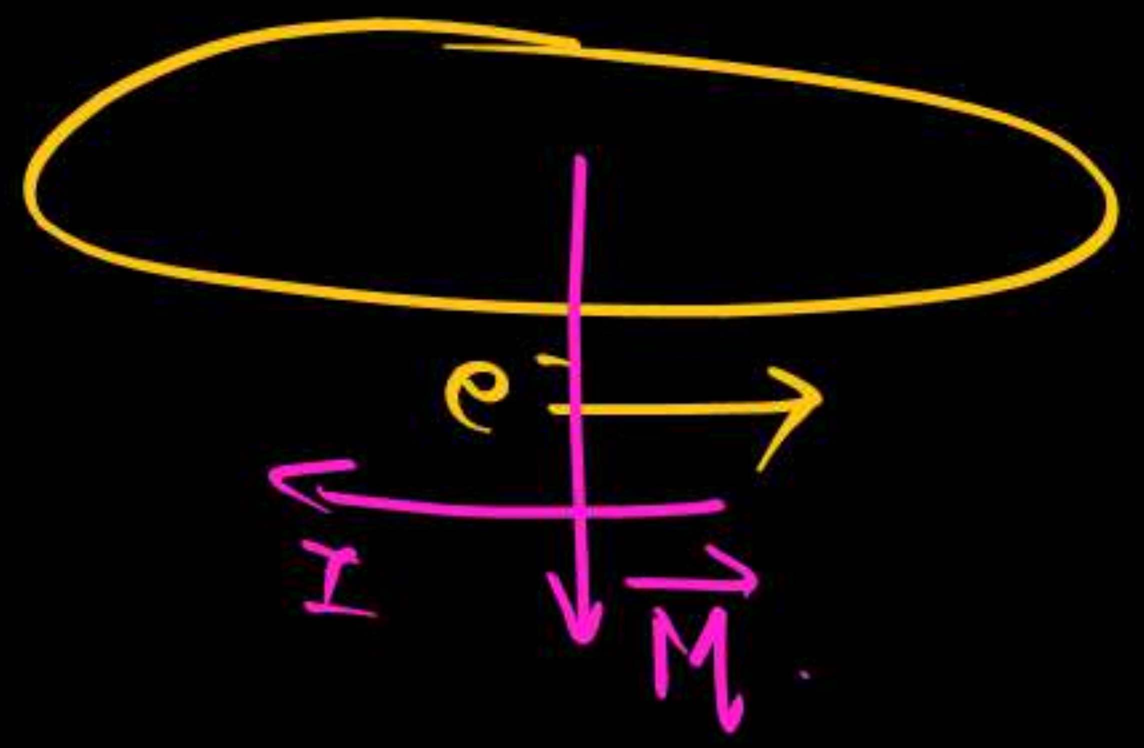
(*) Some Materials has Induced Magnetisation and some has Permanent Magnetisation :-

There are Certain Elements in which e^- are paired & Certain Elements in " " " not Paired up.

Paired up



unpaired



all e^- are paired up ← Diamagnetic

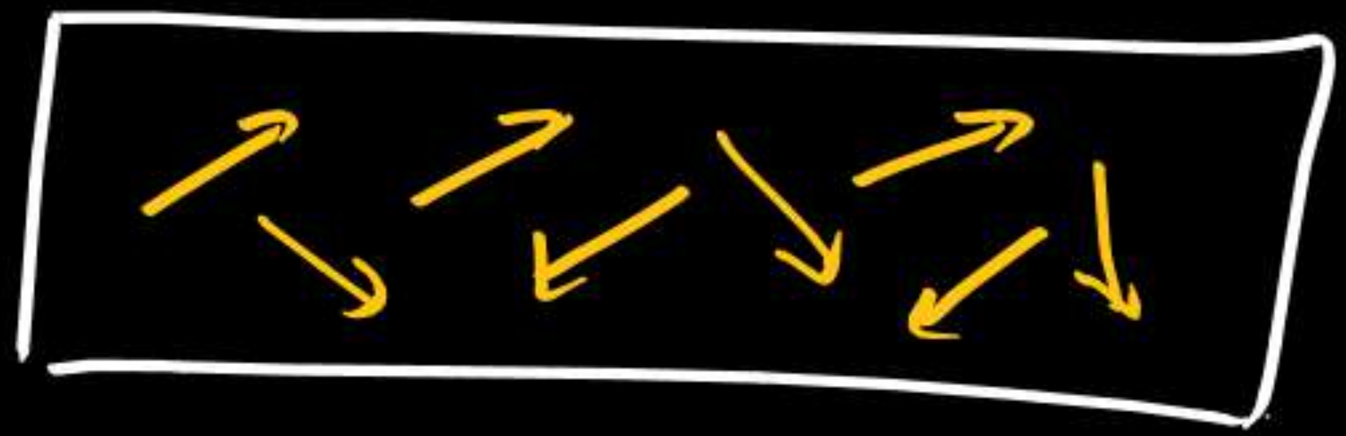
$B_{ext} = 0$

There will be no net Magnetic dipole Moment.

When B_{ext} is applied

Behaviour = ?

Paramagnetic → unpaired e^-



$B_{ext} = 0$

Randomly organised $\vec{M}$

hence $\vec{M_T} = 0$.

Diamagnetic substances

Those Materials in which e^- are paired up, $\vec{M}_{Total} = 0$ Initially in absence of B_{ext}

$B_{ext} = 0$

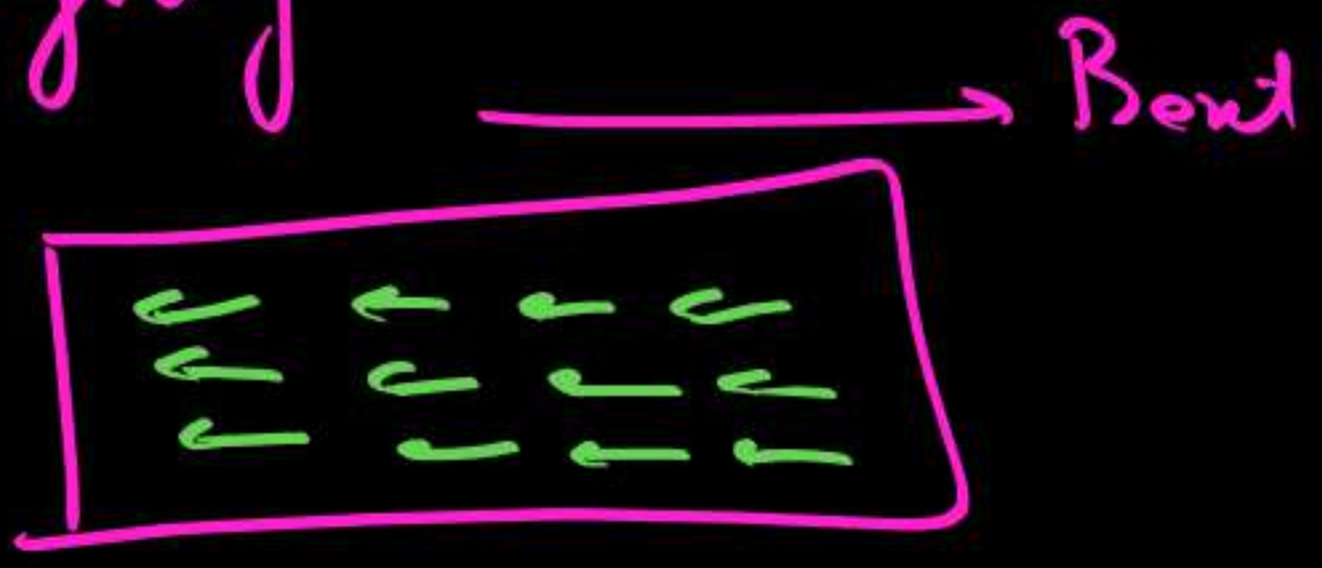
$M_T = 0$

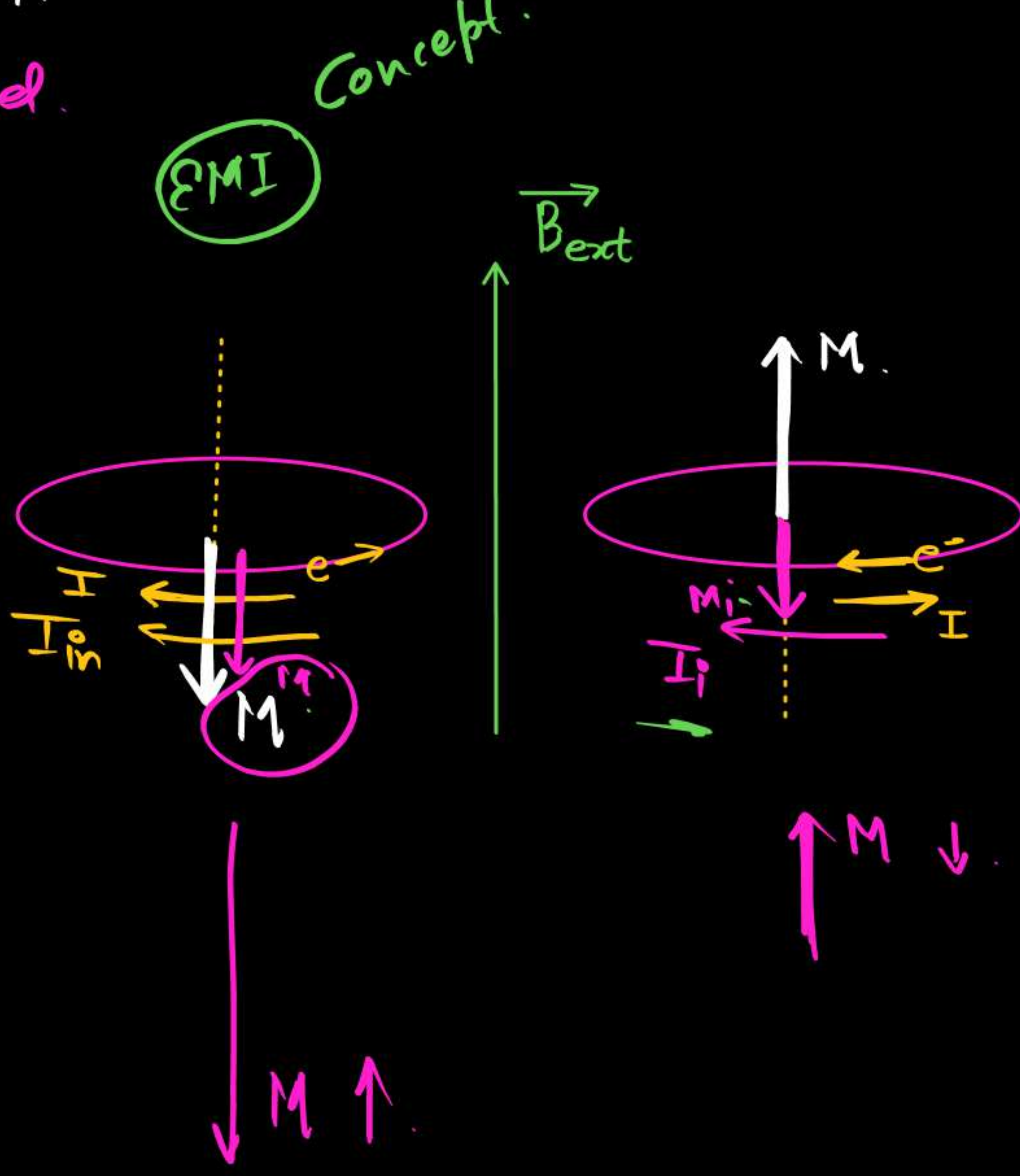
What happen when External field is applied:-

When External field is applied.

The Net $\vec{M}$ will be opp to External field.

hence they Repel the External field Slightly





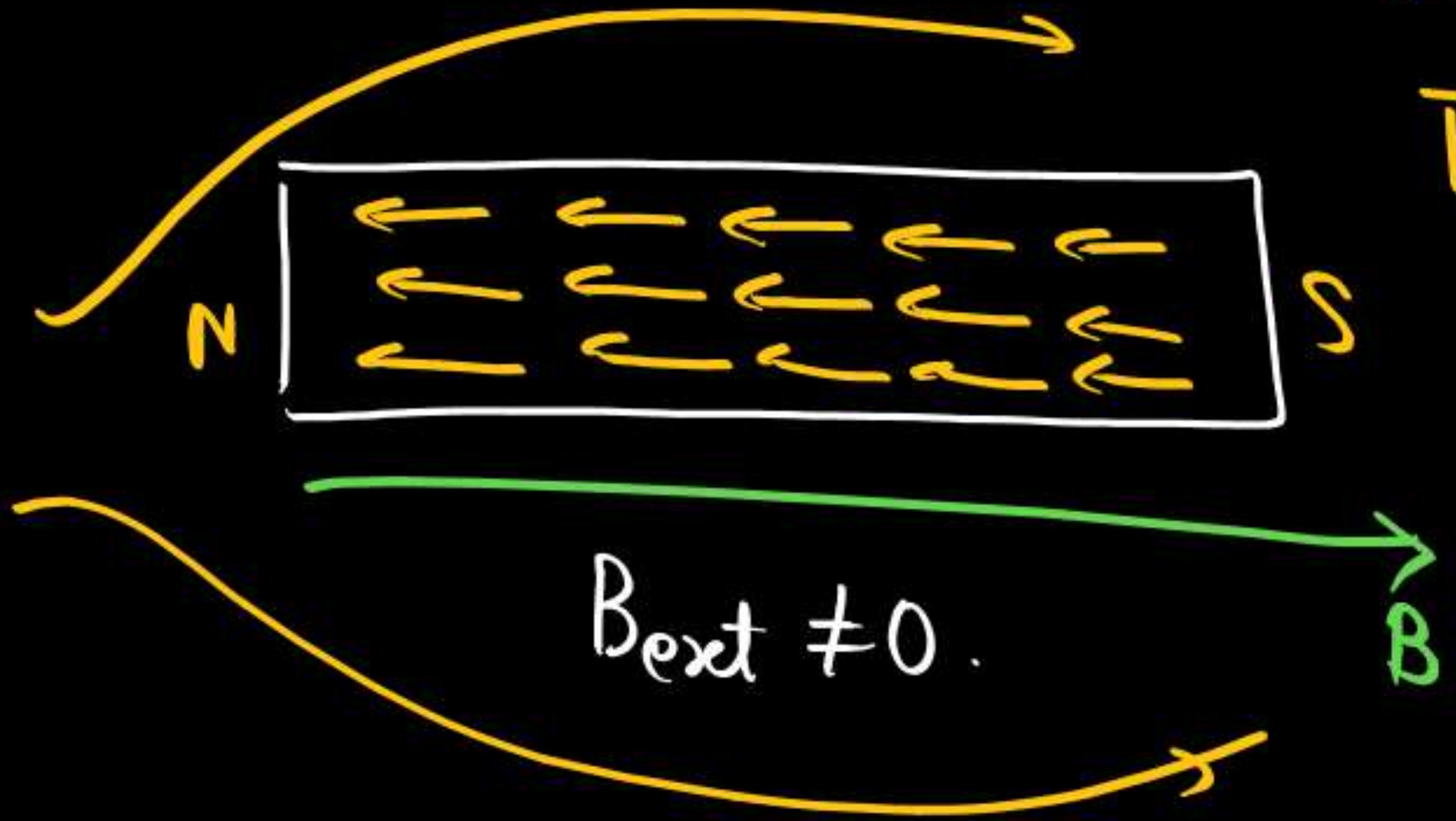
hence,

Diamagnetic Substance

Case-1

$B_{ext} = 0$

Case-2



Initially

$M_T = 0$

They donot have any Net dipole Moment.

When $B_{ext} \neq 0$

There will be induced Magnetic Moment opp to dir of field.

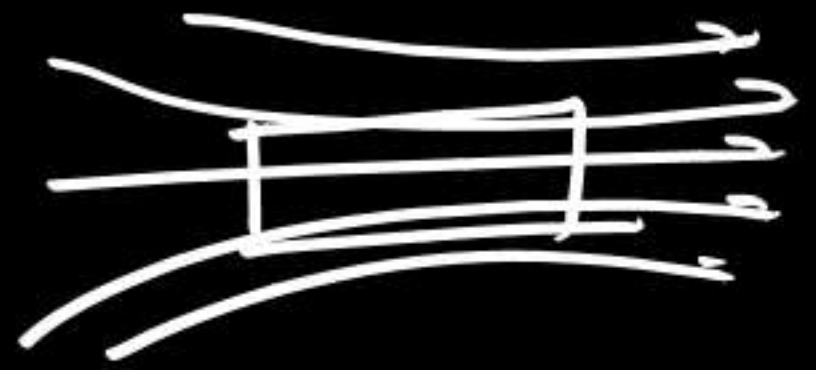
$\mu_r < 1$

$\chi = -ve.$ (Constant)

$\mu_r = 1 + \chi$

& independent of temp.

Paramagnetic substances



Those Materials which donot have Paired e^-.

$\mu_r = 1 + \chi$

When $B_{ext} = 0$, there is Permanent dipole Moments. but they are randomly organised $\boxed{M_T = 0}$.

$\mu_r > 1$

$\chi = +ve.$

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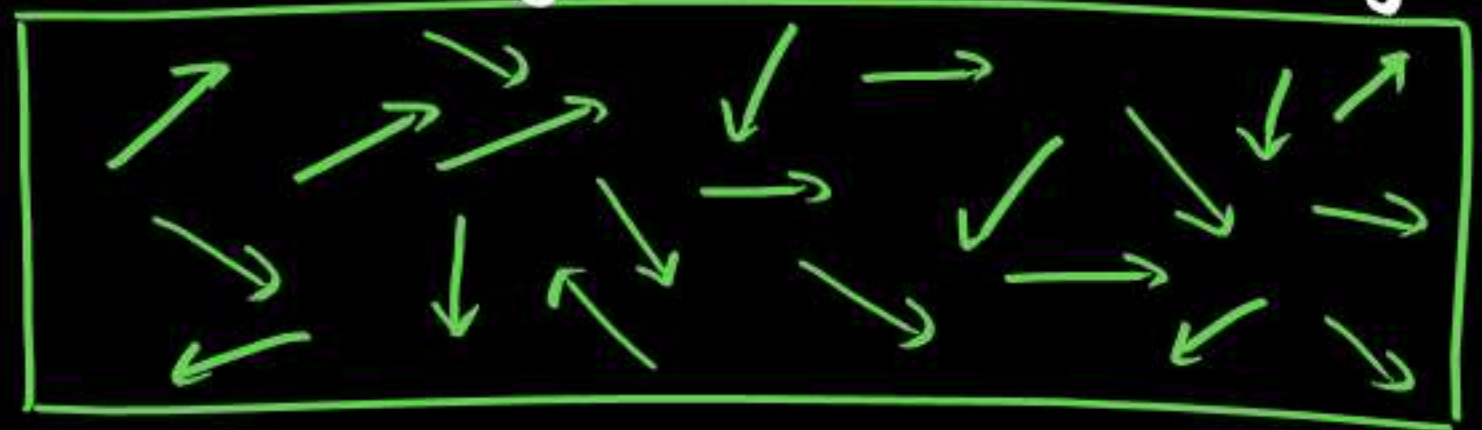

When $B_{ext} = 0$.

When $B_{ext} \neq 0$

Torque acts on these dipoles hence they allign $\parallel^{el}$ to B_{ext}

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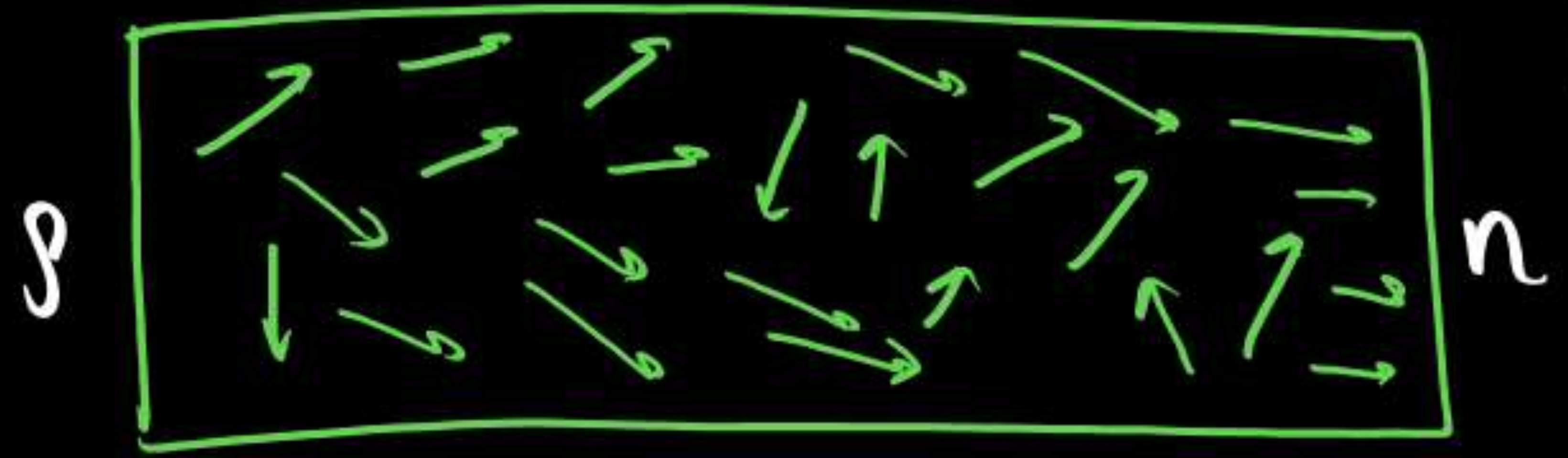

⊗ They are weakly attracted in $\vec{B}$.

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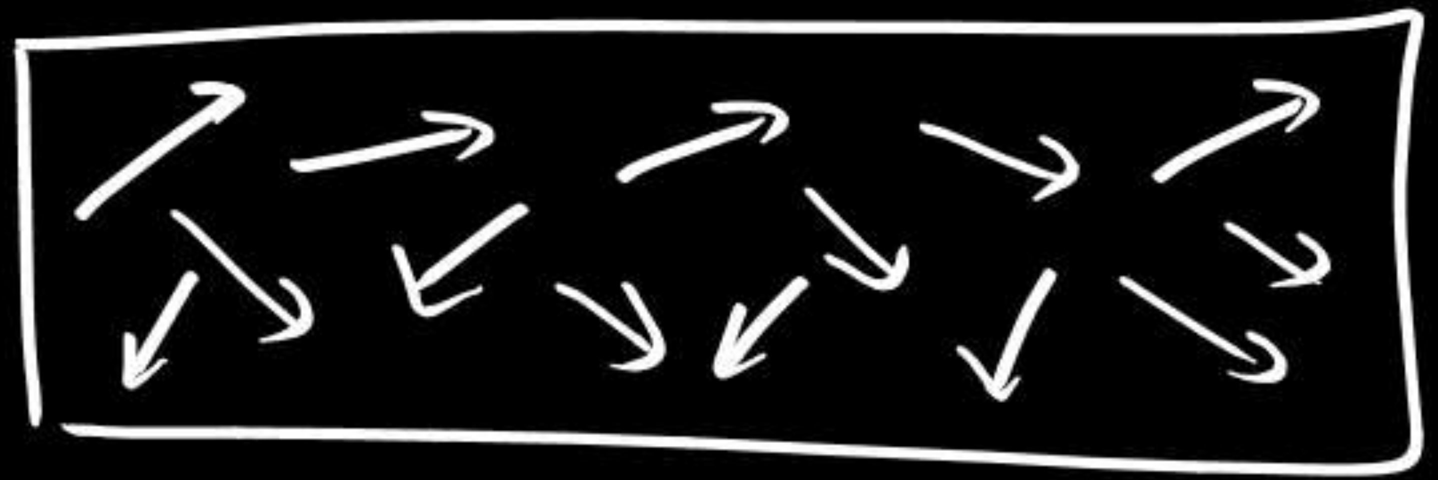
When B_{ext} is Removed.



The dipole Moments again become Random.

$$\boxed{M_T = 0}$$

Intensity of Magnetisation

$$I \propto \frac{1}{Temp}$$

$$I \propto B_{ext}$$

$$I \propto \frac{B_{ext}}{T}$$

Prop Const'

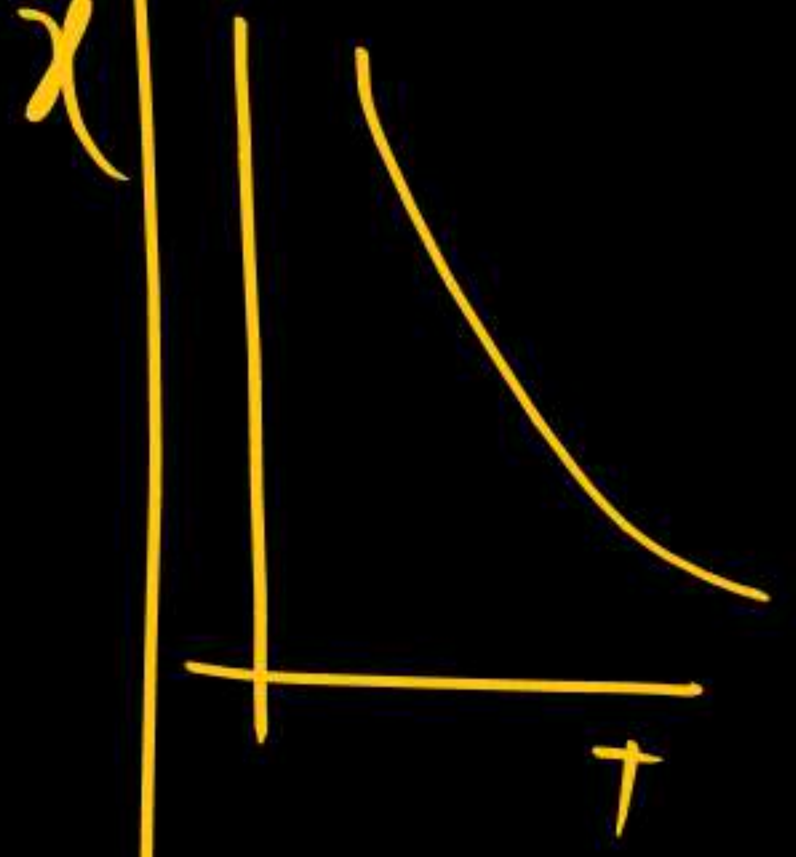
$$I = \frac{C B_{ext}}{T}$$

$$I = \frac{C \mu_0 H}{T}$$

$$\boxed{\chi = \frac{I}{H} = \frac{\text{Curies Const}}{Temp}}$$

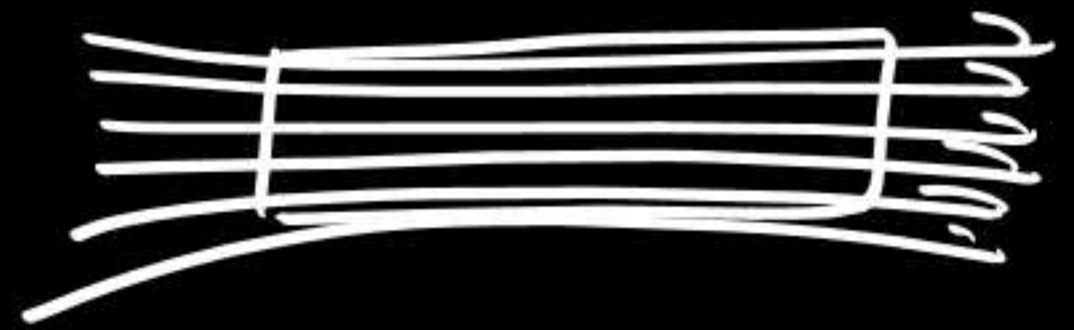
Imp

$$\boxed{\chi \propto \frac{1}{Temp}}$$



Ferromagnetic substances

Domain Theory :- The Coupled dipoles alligned in Same directions are Called domains.



These are better Paramagnetic Substances.

They also have unpaired e^-.

but dipoles Moments in Particular dir are Clubbed.

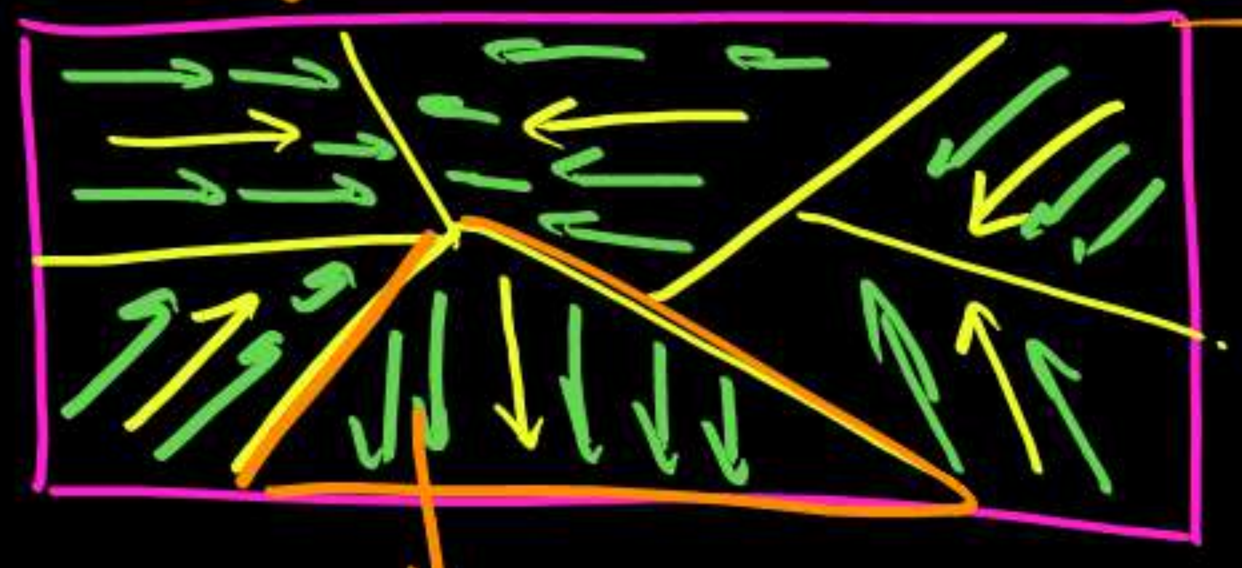
$\mu_r >>> 1$

χ = highly positive.

$\mu_r = 1 + \chi$.

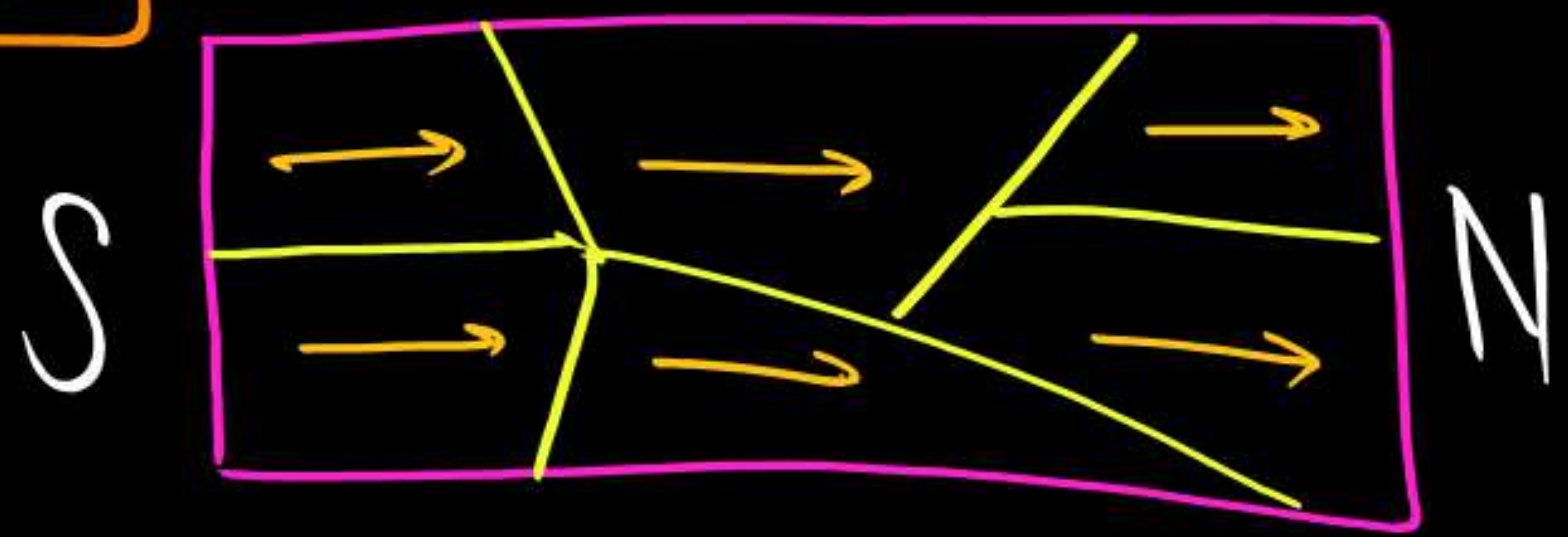
When $B_{ext} = 0$

Net Magnetisation inside Material = 0



domains.

When $B_{ext} \neq 0$



These domains allign $\|^{r}$ to $\vec{B}$.

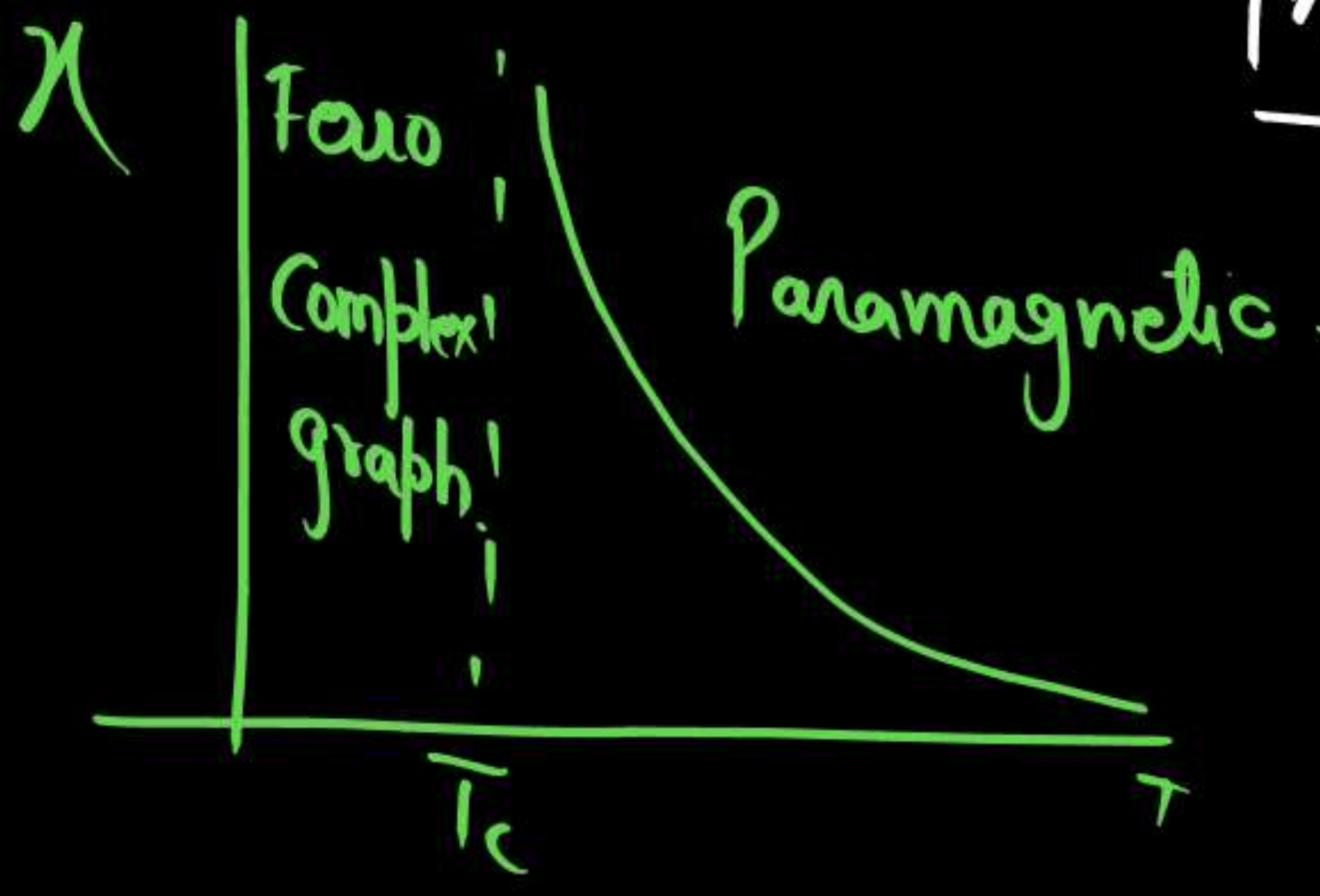
When Ferromagnetic Substances are heated up (Randomness ↑)

They lose their Magnetic Properties.

at particular Temp T_c = (Curie Temp)

$T > T_c$ Parama
$T < T_c$ ferro

Ferromagnetic ⟶ Paramagnetic.

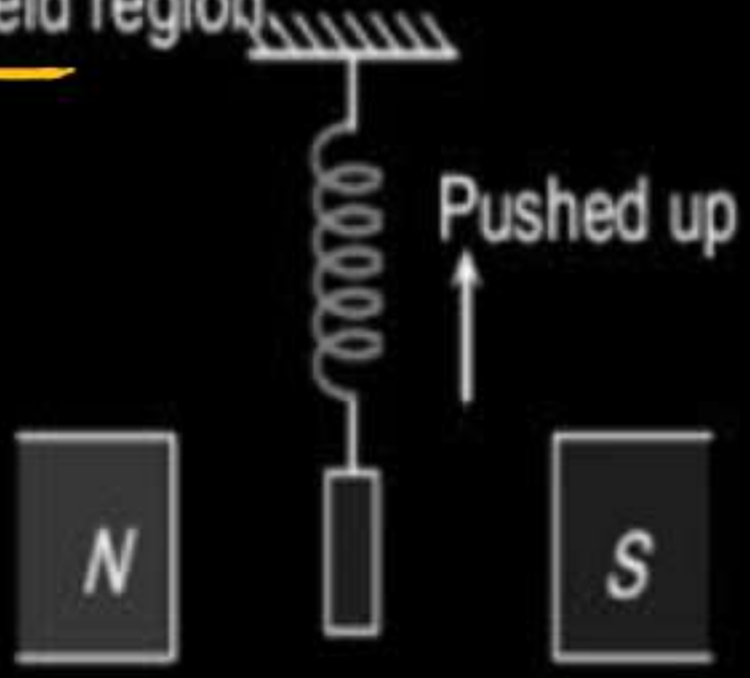
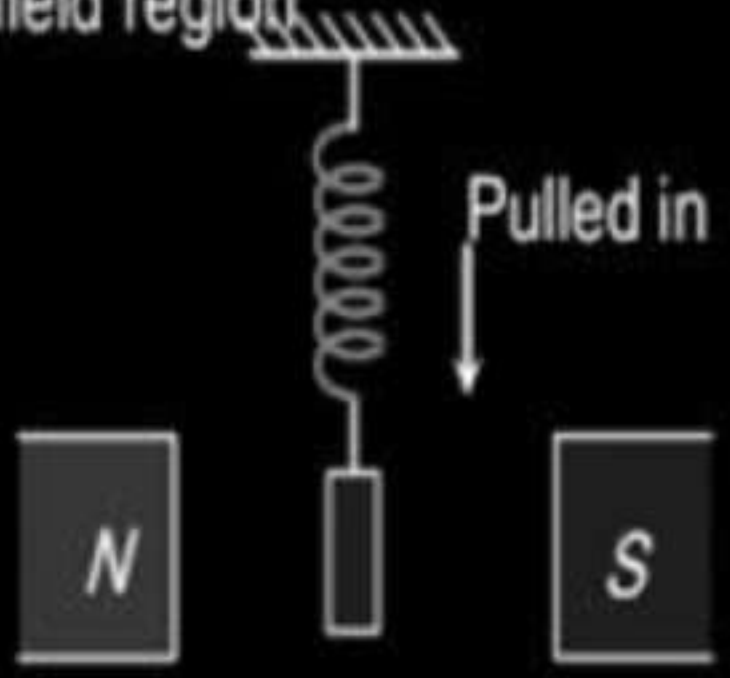
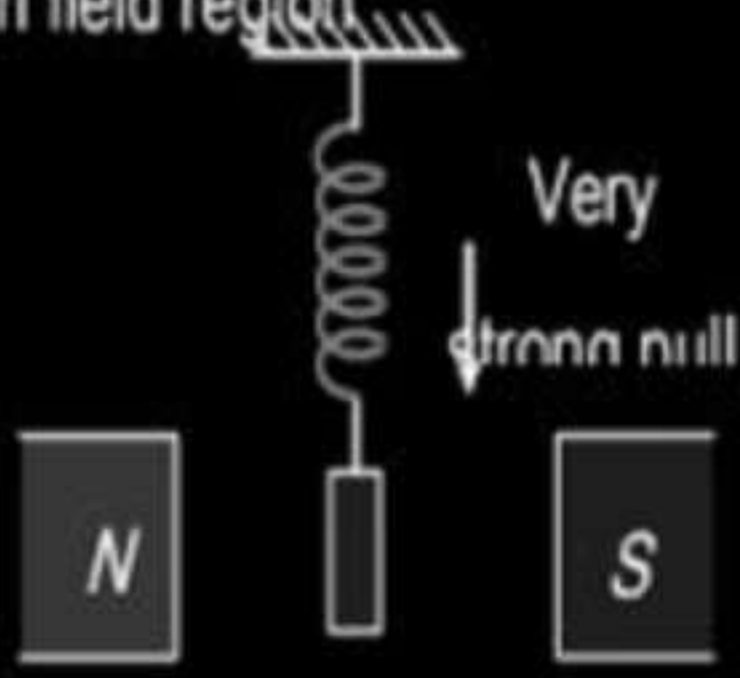


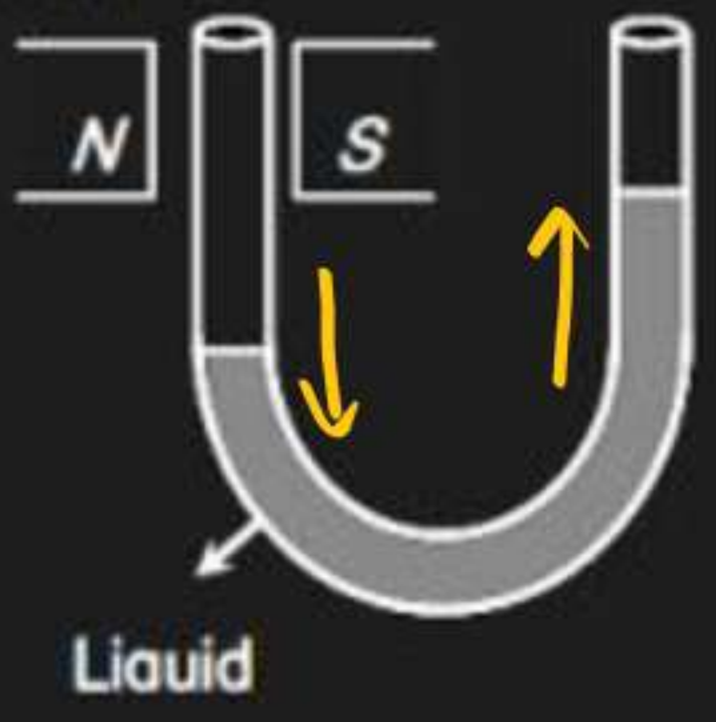
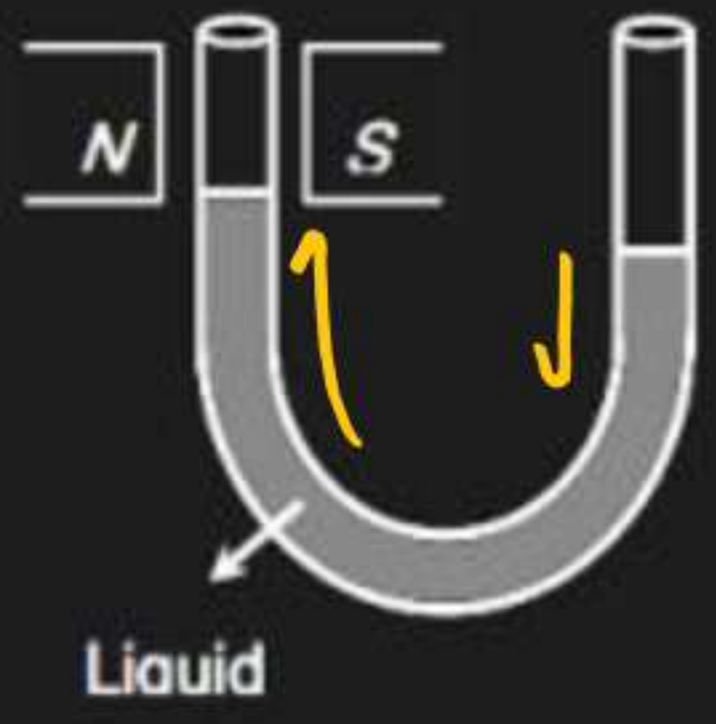
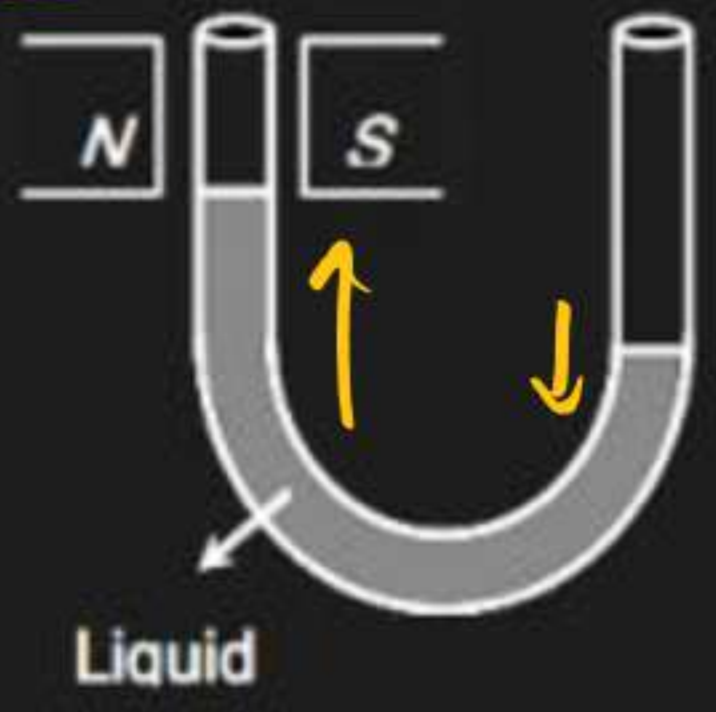
Modified Curies Law

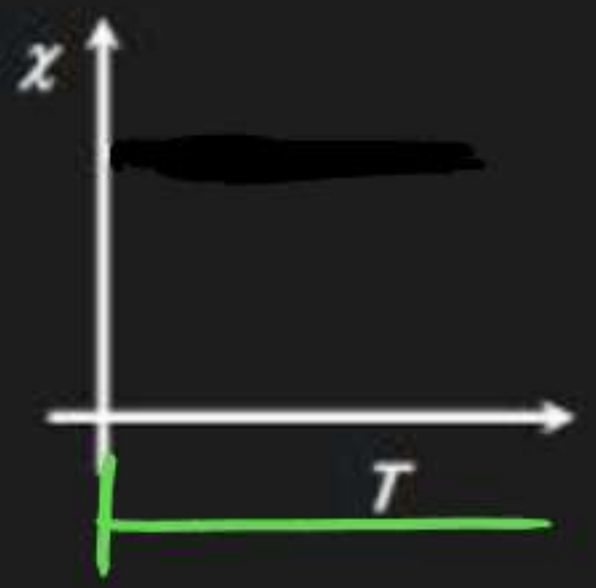
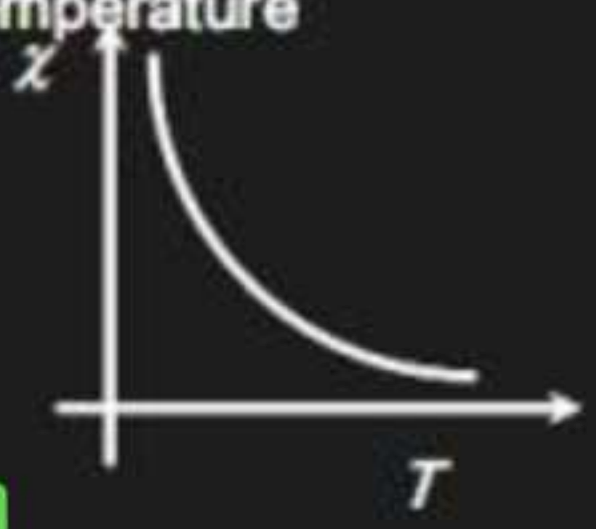
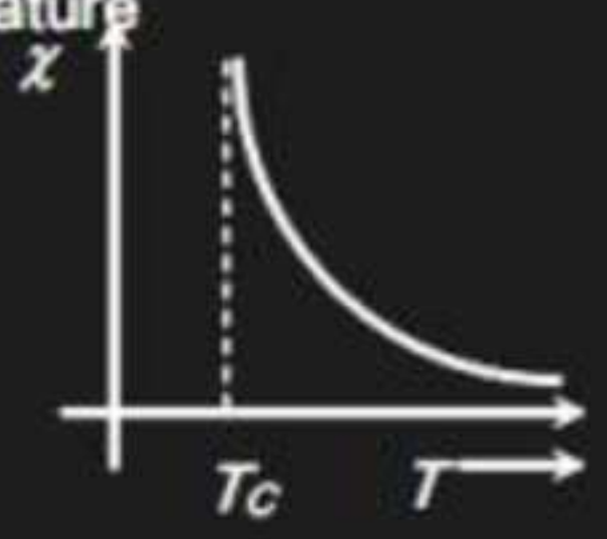
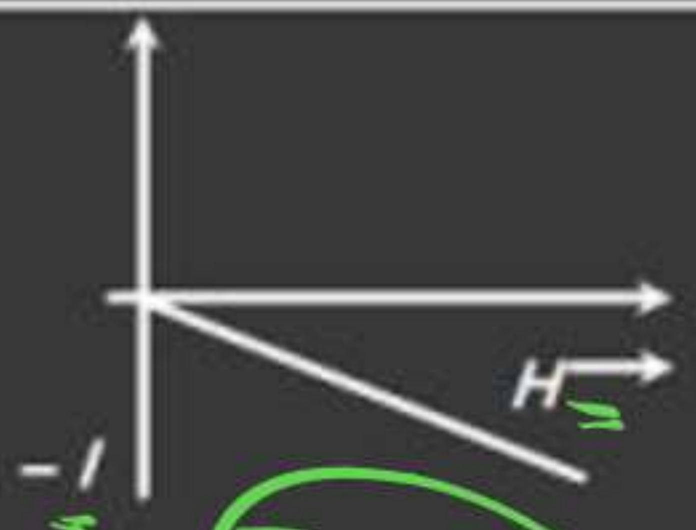
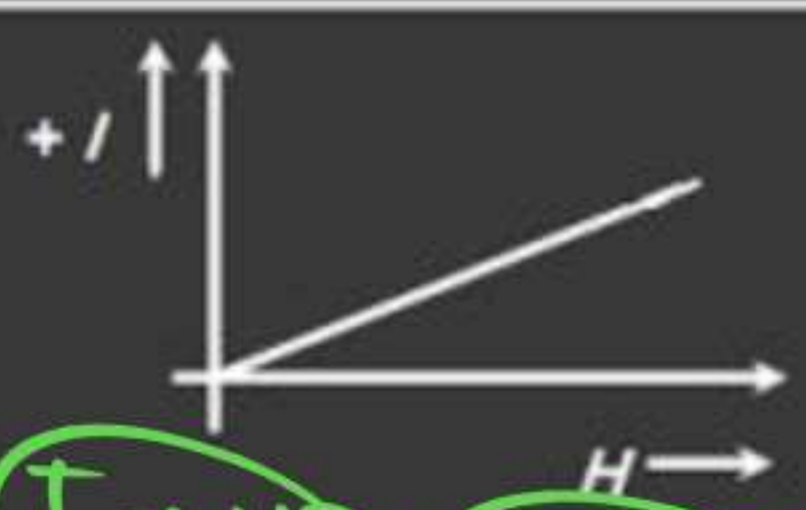
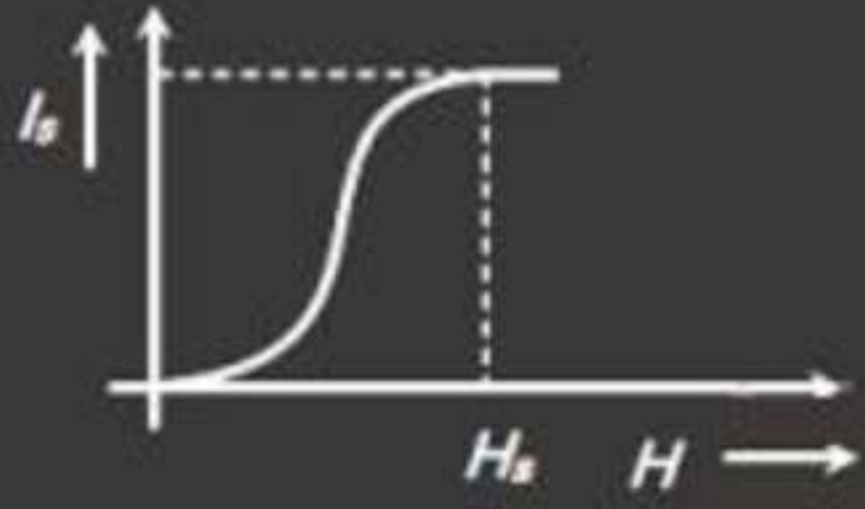
$$\chi = \frac{C}{T - T_c}$$

T_c = Curies Temp

COMPARATIVE STUDY OF MAGNETIC MATERIALS :

Property	Diamagnetic substances	Paramagnetic substances	Ferromagnetic substances
	all e^- are paired up	e^- are unpaired	unpaired e^- form domains
Explanation of magnetism	On the basis of orbital motion of electrons	On the basis of spin and orbital motion of electrons	On the basis of domains formed
Behaviour In a non-uniform magnetic field	These are repelled in an external magnetic field *i.e.* have a tendency to move from high to low field region 	These are feebly attracted in an external magnetic field *i.e.*, have a tendency to move from low to high field region 	These are strongly attracted in an external magnetic field *i.e.* they easily move from low to high field region 

State of magnetisation	These are weekly magnetised in a direction opposite to that of applied magnetic field	These get weekly magnetised in the direction of applied magnetic field	These get strongly magnetised in the direction of applied magnetic field
When the material in the form of liquid is filled in the *U*-tube and placed between pole pieces.	Liquid level in that limb gets depressed 	Liquid level in that limb rises up 	Liquid level in that limb rises up very much 
On placing the gaseous materials between pole pieces	The gas expands at right angles to the magnetic field.	The gas expands in the direction of magnetic field.	The gas rapidly expands in the direction of magnetic field
The value of magnetic induction B	$B < B_0$ (where B_0 is the magnetic induction in vacuum)	$B > B_0$	$B >> B_0$

Magnetic susceptibility χ	Low and negative $\|\chi\| \approx 1$	Low but positive $\chi \approx 1$	Positive and high $\chi \approx 10^2$
Dependence of χ on temperature	Does not depend on temperature (except *Bi* at low temperature) 	On cooling, these get converted to ferromagnetic materials at Curie temperature  $\chi \propto \frac{1}{Temp}$	These get converted into paramagnetic materials at Curie temperature 
Relative permeability (μ_r)	$\mu_r < 1$	$\mu_r > 1$	$\mu_r >> 1$ $\mu_r = 10^2$
Intensity of magnetisation (I)	I is in a direction opposite to that of H and its value is very low	I is in the direction of H but value is low	I is in the direction of H and value is very high.
I-H curves	 $I = \chi H$	 $I \propto H$ $I = \chi H$	 $I = \chi H$ is not valid

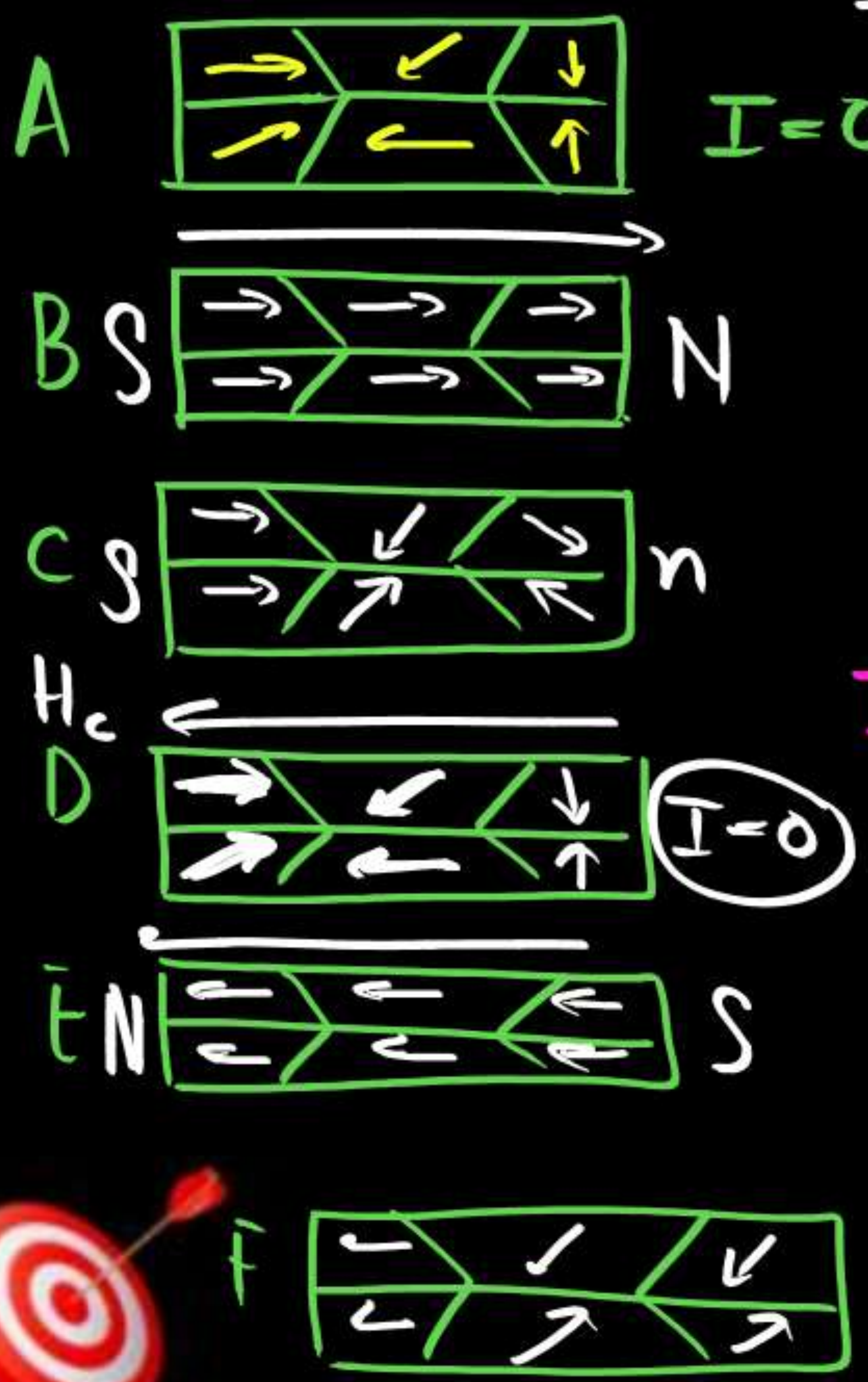
Magnetic moment (*M*)	Very low (≈ 0)	Very low	Very high
Examples	*Cu*, *Ag*, *Au*, *Zn*, *Bi*, *Sb*, *NaCl*, H_2O air and diamond *etc.*	*Al*, *Mn*, *Pt*, *Na*, $CuCl_2$, O_2 and crown glass	*Fe*, *Co*, *Ni*, *Cd*, Fe_3O_4 *etc.*

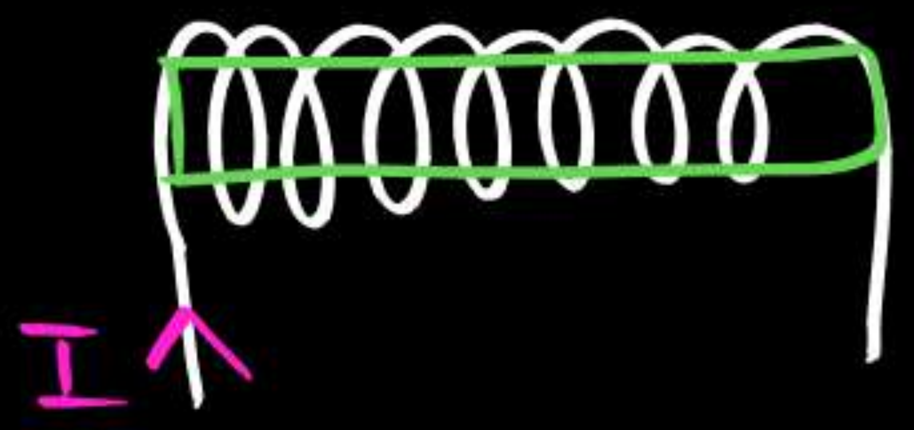
HYSTERISIS

(Ferromagnets)

↳ lagging of I when External field is applied over ferromagnets.

The graph between I & H is called hysterisis Curve.

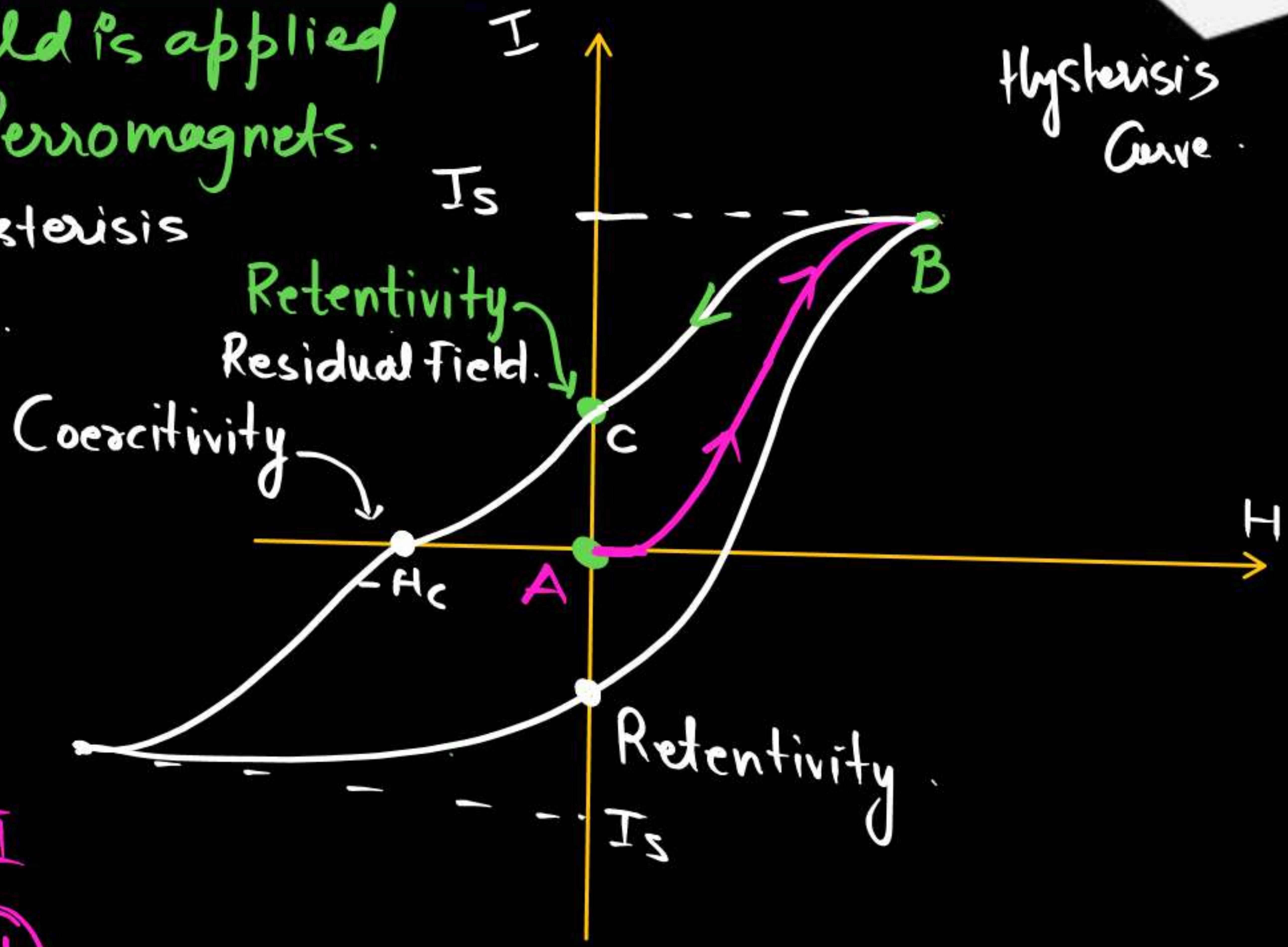




$B_{solenoid} = \mu_0 n I$

$= \mu_0 H$

H ↑ B_{net} ↑



Interpretation.

1. $I_{saturation}$:- Maximum Intensity of Magnetisation in presence of External field.

2. Retentivity :- (H = 0, the Residual field inside Material)

3. Coercitivity :- That -ve value of External H in which Material is demagnetised.

4. Energy loss per Cycle per unit Volume = Area of I/H Curve.

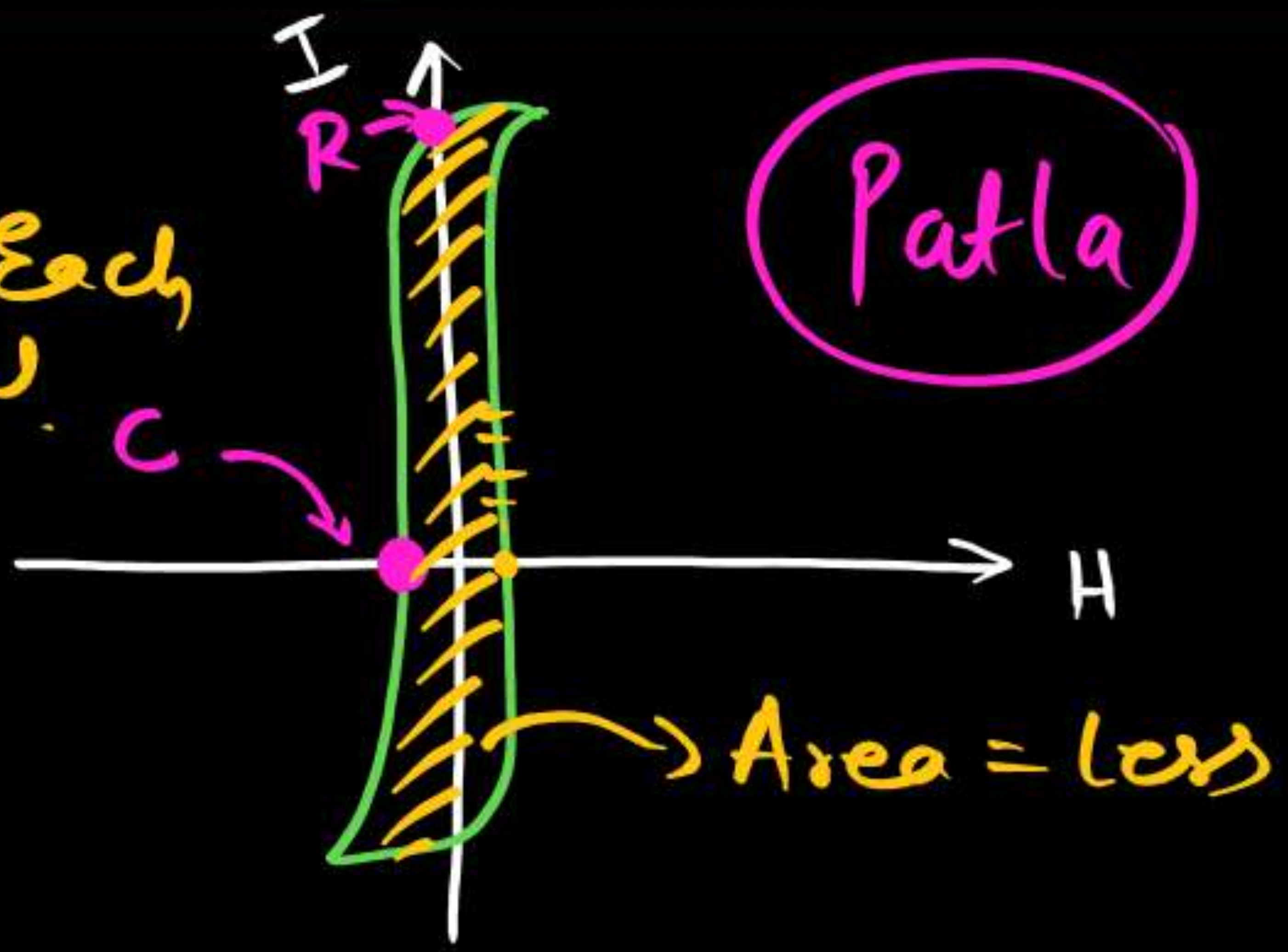
Soft and hard magnets

(ferromagnets)

Temporary

↑ is defined for Each Material

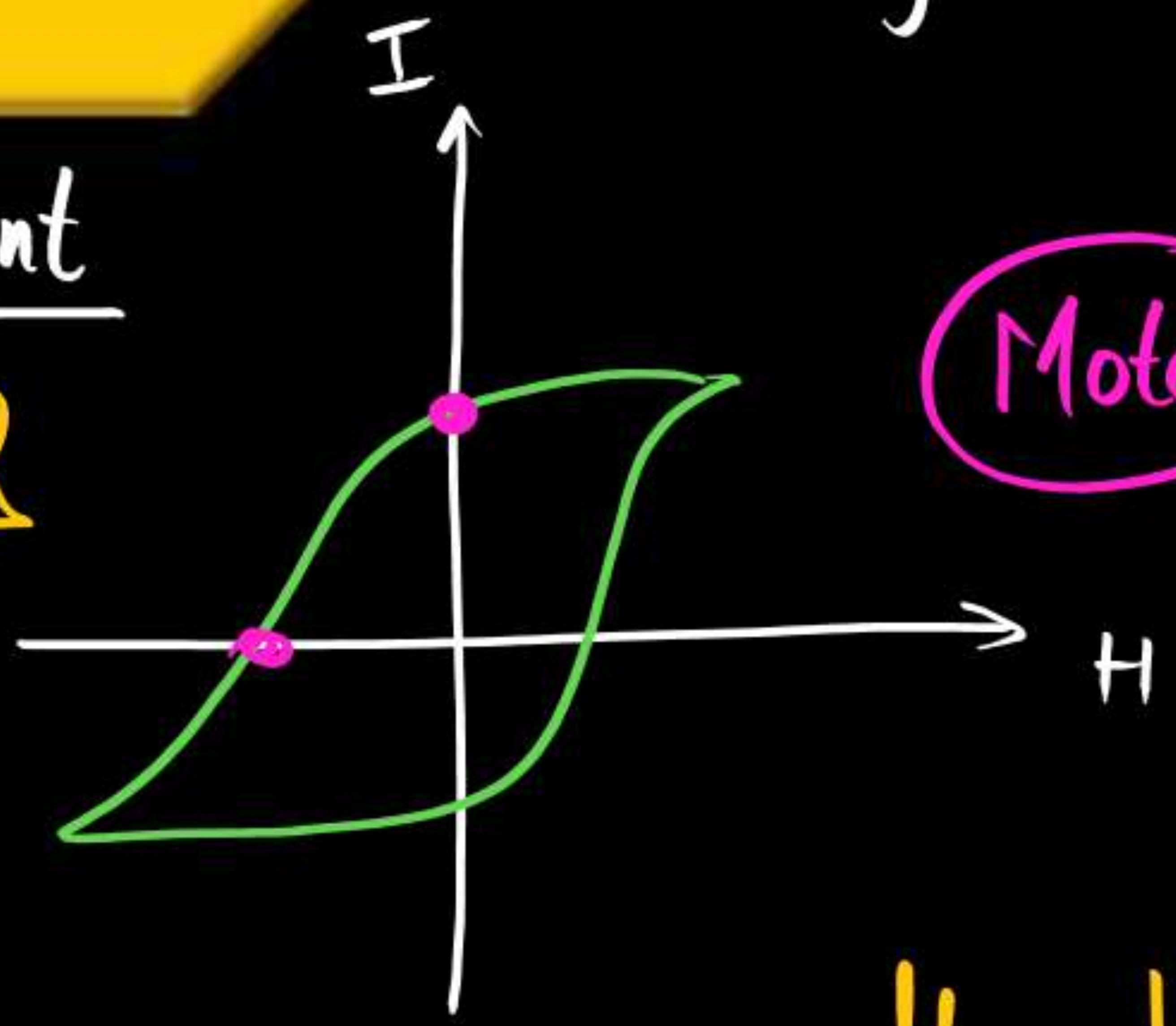
$\chi = \frac{\Delta I}{\Delta H}$ I↑ H↓



Patla

Permanent

Hard



Mote

$\mu_r = 1 + \chi$

- Retentivity = High ⟶ low
- Coercitivity = low ⟶ High
- Energy loss = less ⟶ High
- χ = Higher ⟶ lower
- μ_r = greater ⟶ lower
- Soft Iron Core. | Steel, AlNiCo.

Thank You Lakshyians