MAGNETIC PROPERTIES OF MATTER

Diamagnetic
Paramagnetic
Ferromagnetic
Susceptibility

JEE MAIN
CONCEPT

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TOPICS COVERED

1. Magnetizing Field, Intensity of Magnetization, Susceptibility
2. Diamagnetic and Paramagnetic Material
3. Ferromagnetic Material
4. Curie's Law
5. Magnetic Hysteresis
6. Hysteresis Curve of Soft Iron and Steel

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1. $\vec{H}$, $\vec{I}$, $\vec{B}_{net}$, χ

(a) $\vec{H}$, Magnetizing Field

For external magnetic field $\vec{B}_{ext}$, $\vec{H}$ is defined.

$\vec{B}_{ext} = \mu_0 \vec{H}$, unit of $\vec{H}$ is A/m.

(b) $\vec{I}$ (A/m), Intensity of Magnetization

Total magnetic moment of material per unit volume.

$\vec{I} = \frac{\vec{M}}{V}$

(It tells how much a material is magnetized)

(c) χ, Magnetic Susceptibility

Tells about the ease with which a material can be magnetized.

$\chi = I/H$

$\vec{B}_{ext} = \mu_0 \vec{H}$

$\vec{B}_i = \mu_0 \vec{I}$

$\vec{B}_{net} = \vec{B}_{ext} + \vec{B}_i$

$\Rightarrow \mu_0 \mu_r \vec{H} = \mu_0 \vec{H} + \mu_0 \vec{I}$

$\Rightarrow \mu_r \vec{H} = \vec{H} + \chi \vec{H}$

$\therefore \boxed{\mu_r = 1 + \chi}$

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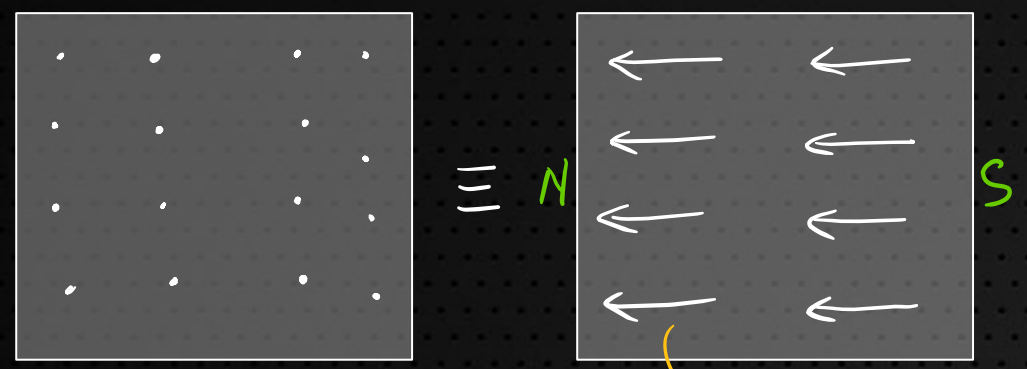
2. DIAMAGNETIC AND PARAMAGNETIC MATERIAL

DIA



Each atoms dipole moment is zero

$\vec{B}_i = \mu_0 \vec{I}$

(i) Weakly magnetized

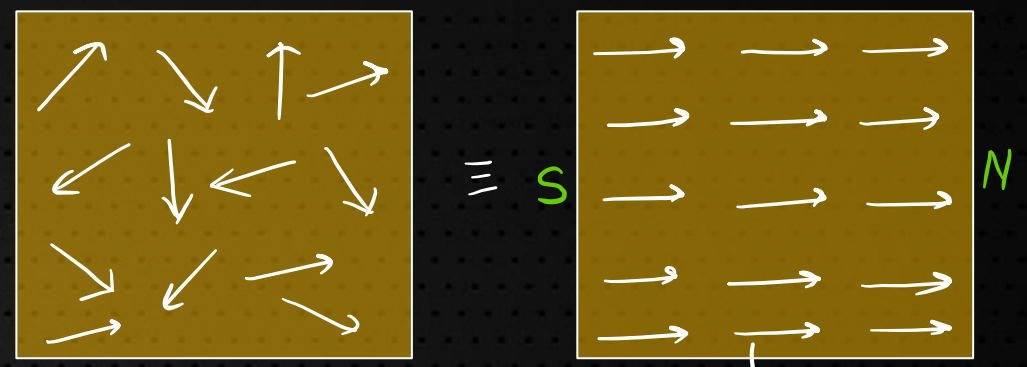
(ii) Material repels $\vec{B}_{ext}$

(iii) $\mu_r = 1 + \chi$

$\mu_r < 1$ and χ is −ve

(iv) Graphite, Bismuth

PARA



$\vec{B}_i = \mu_0 \vec{I}$

(i) Weakly magnetized

(ii) Material gets weakly attracted to $\vec{B}_{ext}$

(iii) $\mu_r = 1 + \chi$

$\mu_r > 1$ and χ is +ve

(iv) Al, Li, Mg

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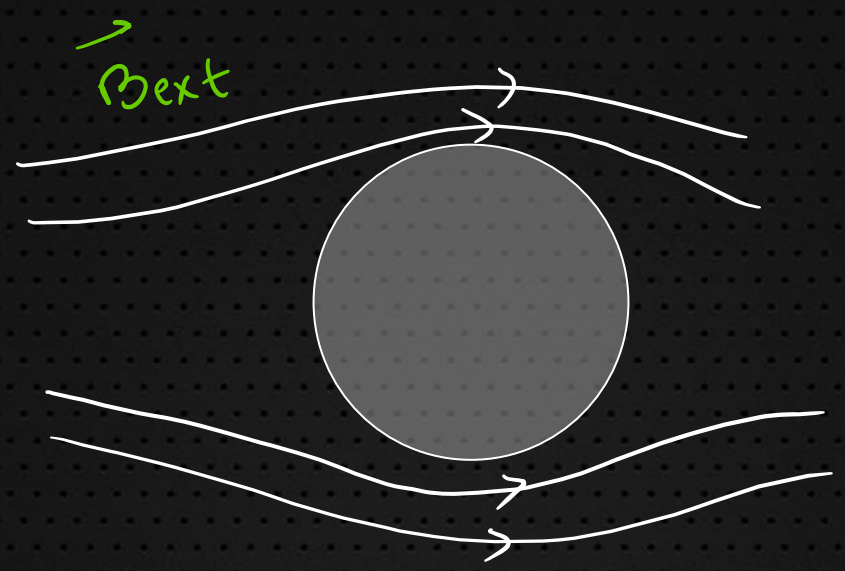

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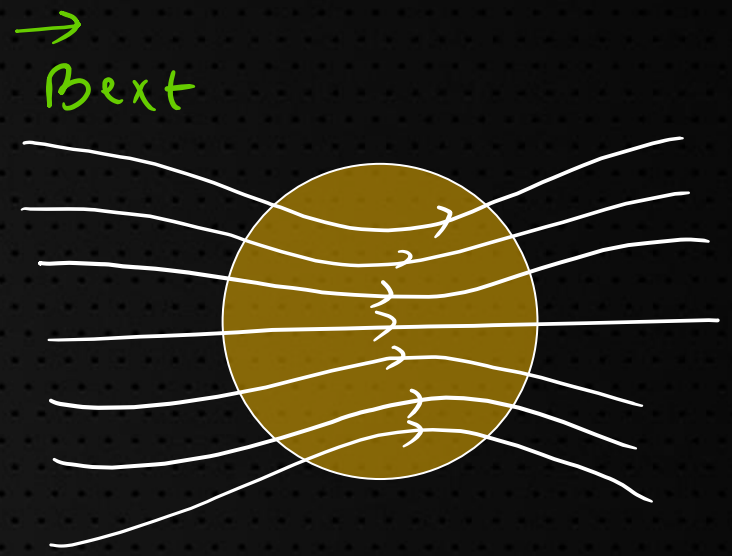

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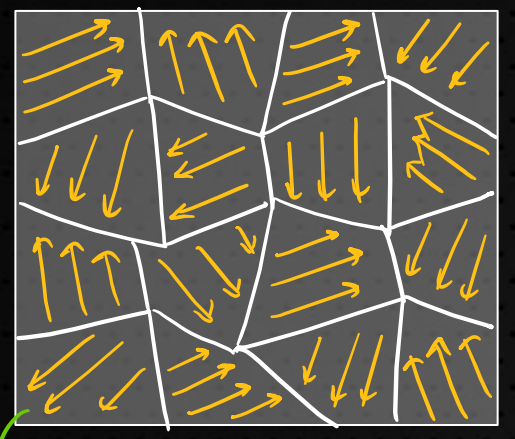
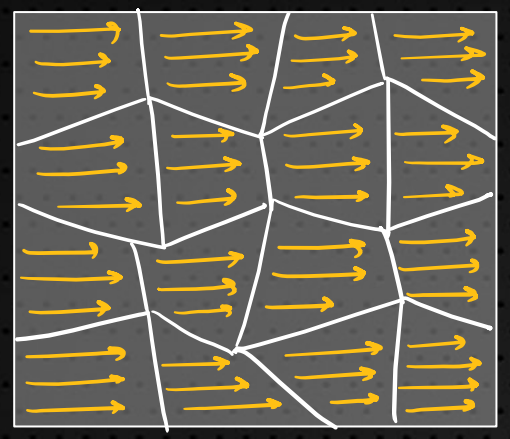
3. FERROMAGNETIC MATERIAL

(Fe, Ni, Co)



Domains

$\longrightarrow \vec{B}_{ext} = \mu_0 \vec{H}$



$\vec{B}_{net} = \vec{B}_{ext} + \vec{B}_i$

Here, $B_i >> B_{ext}$

$\Rightarrow I >> H$

$\therefore \chi >> 1$

4. CURIE'S LAW

If $T\uparrow$, due to thermal agitation, the alignment of dipoles gets disturbed and overall $I\downarrow$ for a given H.

$\because I\downarrow \Rightarrow \chi\downarrow$

(a) FOR PARAMAGNETIC MATERIAL

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

C: Curie Const.

T: Abs Temp°

(b) For Ferromagnetic material

ON heating it to T_c, it changes to Paramagnetic. on further $\uparrow T$

$$\chi = \frac{C'}{T - T_c}$$

T_c: Curie Temp°

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5. MAGNETIC HYSTERESIS

(i) $O \rightarrow A$: On $\uparrow H$, $I \uparrow$ and gets saturated for $H = H_0$.

(ii) $A \rightarrow B$: On $\downarrow H$ to zero, still I is retained.

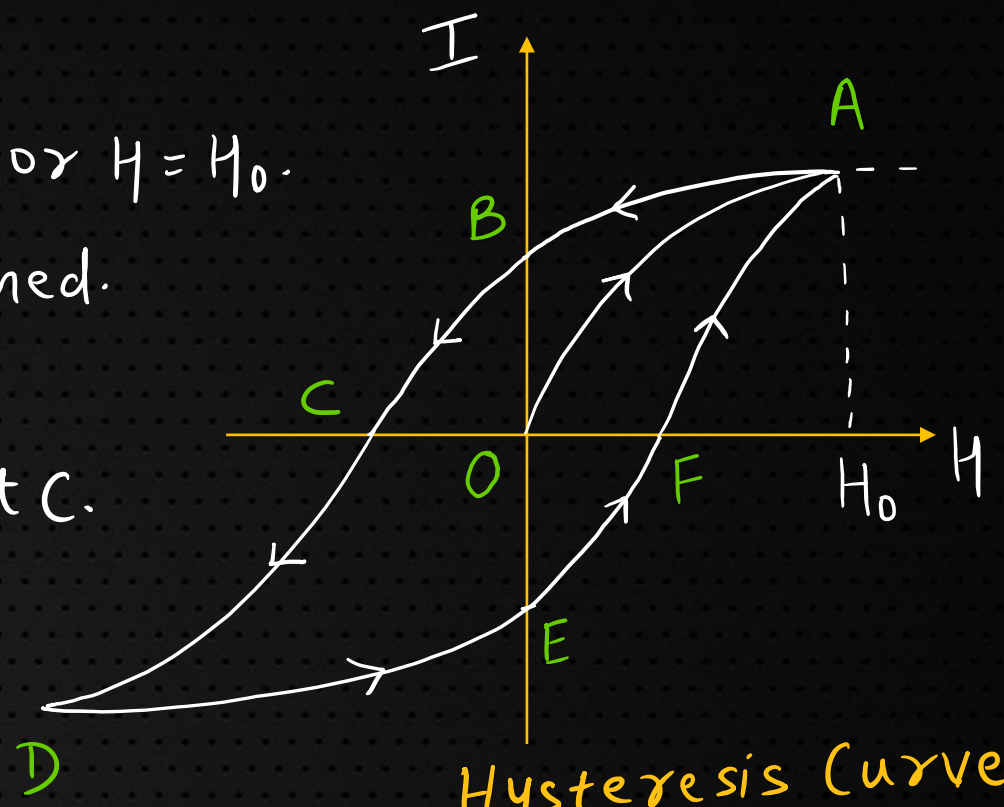
OB is called "RETENTIVITY".

(iii) $B \rightarrow C$: $\uparrow H$ in reverse direction, $I = 0$ at C.

OC is called "COERCIVITY".

(iv) $C \rightarrow D$: Further $\uparrow H$ and I again gets saturated at D.

and so on...



Hysteresis Curve

NOTE: (a) Area of Loop ABCDEFA shows thermal energy or heat produced / Volume in 1 cyc.

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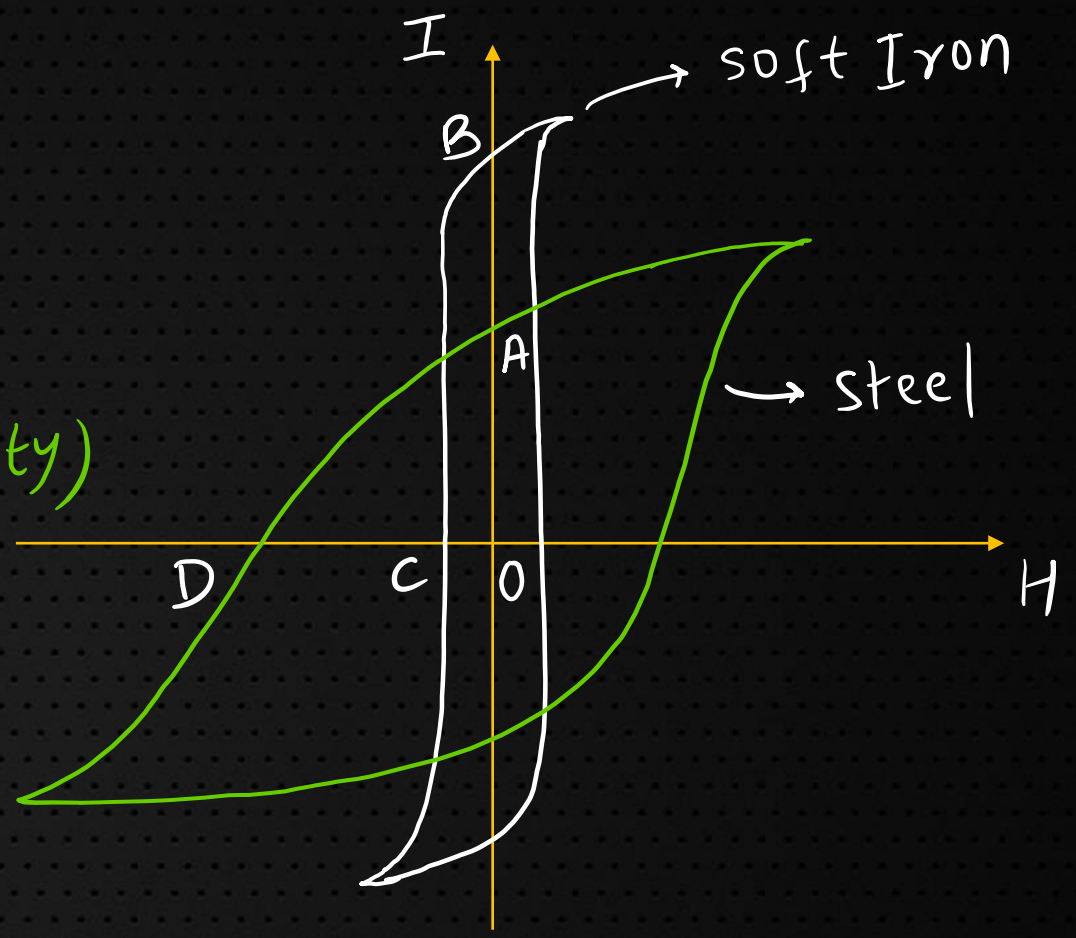
6. HYSTERESIS CURVE: SOFT IRON VS STEEL

(i) ∵ Soft Iron gets easily magnetized and Looses almost all magnetism easily (Low coercivity)
It is used for "Electromagnets".

(ii) ∵ Steel is difficult to demagnetize
(OD = coercivity)
it is used to make "Permanent Magnets".



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