FREE NOTES · NCERT + JEE/NEET LEVEL

Magnetism & Matter

Bar magnet, magnetic field lines, magnetic dipole, Gauss's law for magnetism, Earth ka magnetism, magnetisation aur dia-, para-, ferromagnetic materials. Tables aur solved numericals ke saath.

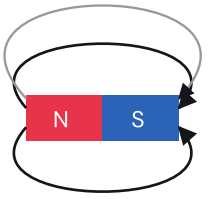
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01 Bar magnet

- Latkaao toh North pole geographic north ki taraf.
- Same poles repel, ulte attract.
- **Isolated pole (monopole) nahi hota**: magnet todo toh har tukda ek naya poora magnet (N aur S dono).
- Bar magnet aur current wala solenoid ka field bilkul same jaisa.

02 Magnetic field lines

- Bahar N se S, magnet ke andar S se N: **band loops** (electric field lines ke ulta, jo + se − pe khatam).
- Do lines kabhi nahi katati.
- Ghani lines = tez field.
- Tangent = field direction (compass ki sui).



Bahar N → S, andar S → N

03 Bar magnet as magnetic dipole

Magnetic moment $m = q_m \times 2l$ (S se N ki taraf), unit $A \cdot m^2$

Axial line: $B = (\mu_0/4\pi)\, 2m/r^3$

Equatorial line: $B = (\mu_0/4\pi)\, m/r^3$ (m ke ulta)

Electric dipole jaisa hi, bas k ki jagah $\mu_o/4\pi$ aur p ki jagah m.

Electrostatics	Magnetism
$1/\varepsilon_o$	μ_o
Dipole moment p	Magnetic moment m
E (axial) = $2kp/r^3$	B (axial) = $(\mu_o/4\pi)2m/r^3$
$\tau = p \times E$, $U = -p \cdot E$	$\tau = m \times B$, $U = -m \cdot B$
Monopole (akela charge) hota	Monopole nahi hota

04 Dipole in uniform field

Torque $\tau = mB \sin\theta$, $U = -mB \cos\theta$

$$\text{Oscillation: } T = 2\pi \sqrt{(I / (mB))}$$

Compass ki sui ko thoda hilao toh SHM. Isse B naap sakte hain (I = sui ka moment of inertia). 0° se 180° ghumane ka work = 2mB.

05 Gauss's law for magnetism

STATEMENT

$\oint B \cdot dA = 0$

Kisi bhi closed surface se net magnetic flux zero, kyunki jitni lines andar aati, utni bahar jaati. Matlab **magnetic monopole nahi hota**.

06 Earth ka magnetism

Earth ek bade bar magnet jaisa, par uska magnetic **South pole geographic North ke paas** hai (isliye compass ka N udhar). Field Earth ke core me ghoomte pighle metal ke currents se (dynamo effect).

Element	Matlab
Declination (D)	Geographic meridian aur magnetic meridian ke beech angle
Dip / inclination (I)	Total field ka horizontal se angle. Equator pe 0°, poles pe 90°
Horizontal component	$B_H = B\cos I$, $B_V = B\sin I$, $\tan I = B_V/B_H$

Poles pe $B_H = 0$, isliye compass ki sui wahan kisi bhi direction me ruk sakti.

07 Magnetisation & magnetic intensity

Magnetisation $M = m_{net}/V$ (A/m)

Magnetic intensity $H = B_0/\mu_0$ (A/m)

$$B = \mu_0 (H + M)$$

Susceptibility $\chi = M/H$, $\mu_r = 1 + \chi$, $\mu = \mu_0\mu_r$

08 Magnetic materials

	Diamagnetic	Paramagnetic	Ferromagnetic
χ	Chhota negative	Chhota positive	Bahut bada positive
μ_r	< 1	> 1 (thoda)	$\gg 1$ (hazaaron)
Magnet ke paas	Thoda door bhaagta (strong se weak field ki taraf)	Thoda kheencha jaata	Tezi se kheencha jaata
Field lines	Bahar dhakel deta	Thoda andar kheenchta	Bahut andar kheenchta
Temperature	Asar nahi	$\chi \propto 1/T$ (Curie law)	Curie temperature ke upar paramagnetic
Examples	Bismuth, copper, paani, superconductor	Aluminium, sodium, O_2	Iron, cobalt, nickel

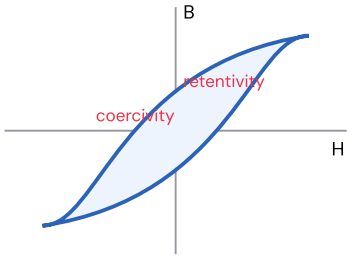
YAAD RAKHO

Superconductor **perfect diamagnet** ($\chi = -1$): field ko poora bahar kar deta (Meissner effect), magnet uske upar hawa me tair jaata. Ferromagnet me **domains** hote hain jo field me ek line me aa jaate.

09 Hysteresis

Ferromagnet ko magnetise aur demagnetise karne pe B, H ke peeche-peeche chalta (lag): **hysteresis loop**.

- **Retentivity:** H = 0 karne pe bacha B.
- **Coercivity:** B ko 0 karne ke liye ulta H.
- Loop ka area = har chakkar me energy loss (garmi).



Hysteresis loop

Use	Kaisa material	Example
Permanent magnet	Zyada retentivity, zyada coercivity	Steel, alnico
Electromagnet, transformer core	Kam coercivity, patla loop (kam energy loss), zyada permeability	Soft iron

10 JEE Extra + Tricks

JEE LEVEL

- Susceptibility: diamagnetic chhota negative; paramagnetic chhota positive (Curie law $\chi \propto 1/T$); ferromagnetic bada positive (Curie temperature ke upar paramagnetic).
- Soft iron: patla hysteresis loop, kam retentivity aur coercivity ⇒ electromagnets, transformer core. Steel: chauda loop ⇒ permanent magnets.
- Bar magnet: axial $B = 2kM/r^3$, equatorial $B = kM/r^3$ ($k = \mu_0/4\pi$).
- Earth ka field: $B_H = B\cos\delta$, $B_V = B\sin\delta$, $\tan\delta = B_V/B_H$ (δ = dip). Poles pe dip 90°, equator pe 0°.
- Superconductors perfect diamagnets (Meissner effect).

11 Solved numericals ($\mu_0/4\pi = 10^{-7}$)

Q1. Bar magnet m = 0.4 A·m², 20 cm door axial line pe B?
B = $10^{-7} \times 2 \times 0.4/0.008 = 10^{-5}$ T. **Ans: 10^{-5} T**

Q2. Magnet (m = 2 A·m²) 0.2 T field me 30° pe. Torque aur PE?
$\tau = 2 \times 0.2 \times 0.5 = 0.2$ N·m. $U = -2 \times 0.2 \times 0.866 \approx -0.35$ J. **Ans: 0.2 N·m, −0.35 J**

Q3. Kisi jagah B_H = 0.3 G aur dip 60°. Total field?
B = $B_H/\cos 60° = 0.6$ G. **Ans: 0.6 G**

Q4. Paramagnetic material ka χ 300 K pe 2×10^{-4}. 150 K pe?
$\chi \propto 1/T \Rightarrow 4 \times 10^{-4}$. **Ans: 4×10^{-4}**

12 Common mistakes

- Magnetic field lines ko open (N se nikal ke khatam) maan lena. Ye band loops hain.
- Earth ke geographic North pe magnetic North maan lena (wahan magnetic South hai).
- Diamagnetic ko "non-magnetic" maan lena: ye thoda repel karta.
- Curie law ferromagnet pe lagana (paramagnet ke liye hai).
- Transformer core ke liye steel chun-na (soft iron sahi).

13 Formula sheet

Dipole field	axial $(\mu_0/4\pi)2m/r^3$, equatorial $(\mu_0/4\pi)m/r^3$
Torque, PE	$\tau = mB\sin\theta$, $U = -mB\cos\theta$
Oscillation	$T = 2\pi\sqrt{(I/mB)}$
Gauss (magnetism)	$\oint B\cdot dA = 0$
Earth	$B_H = B\cos I$, $\tan I = B_V/B_H$
B, H, M	$B = \mu_0(H + M)$
Susceptibility	$\chi = M/H$, $\mu_r = 1 + \chi$
Curie law	$\chi = C/T$

14 Practice questions

1. Bar magnet ko beech se (length ke ⊥) do barabar tukdon me kaato. Har tukde ka magnetic moment?
2. Equator pe dip angle?
3. Kaun sa material magnet se thoda door bhaagta?
4. Magnet ko field me 0° se 180° ghumane ka work?

ANSWERS

1) m/2 (pole strength same, length aadhi) · 2) 0° · 3) Diamagnetic (jaise bismuth) · 4) 2mB

15 Quick revision: exam se pehle 5 minute

MAGNET

- Monopole nahi; lines band loop.
- Axial 2× equatorial field.
- $\tau = mB \sin\theta$, $T = 2\pi\sqrt{(I/mB)}$.

EARTH

- Geographic N ke paas magnetic S.
- Dip: equator 0°, poles 90°.
- $B_H = B \cos I$.

MATERIALS

- Dia χ −, para χ + (chhota), ferro $\chi \gg$.
- Para: $\chi \propto 1/T$.
- Superconductor: $\chi = -1$.

HYSTERESIS

- Permanent: zyada retentivity + coercivity.
- Electromagnet: soft iron, patla loop.

Doubt hai? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.