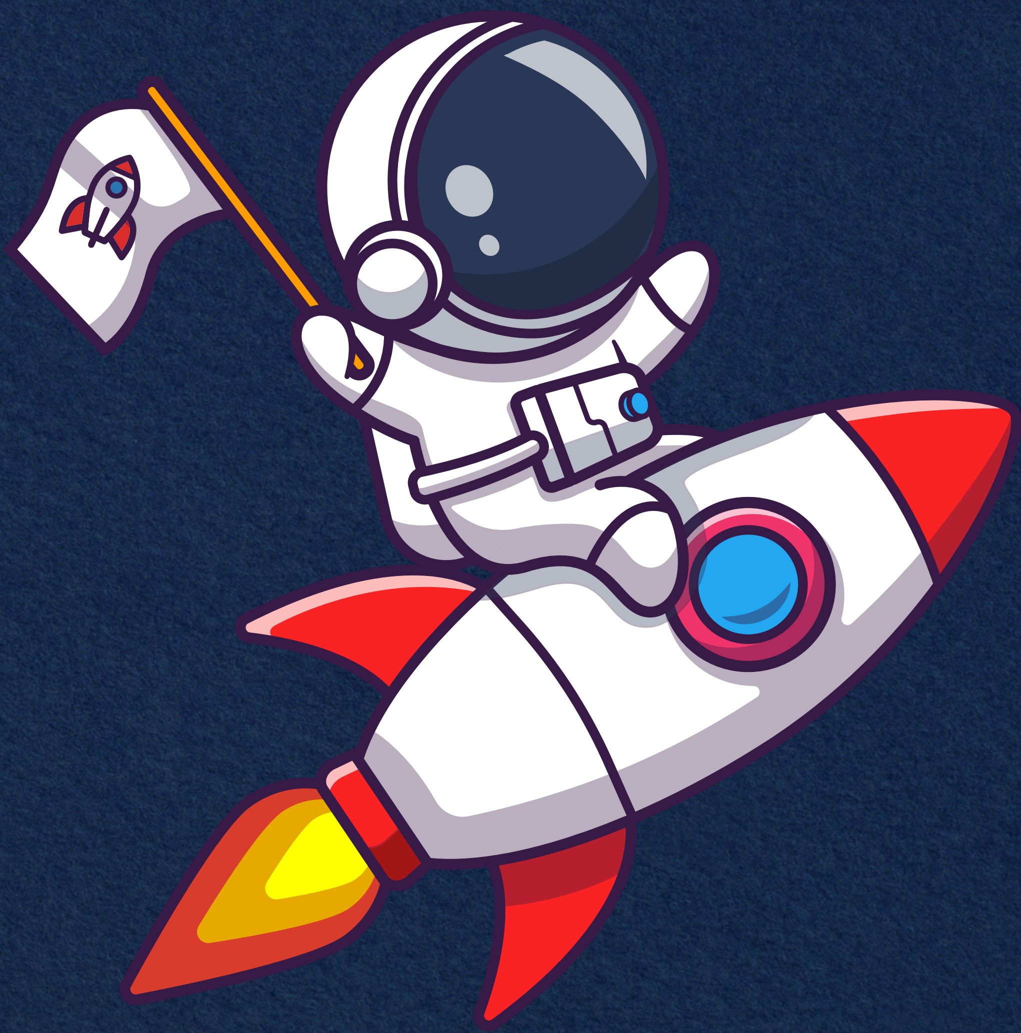
Class 12

BOARD ZONE

PHYSICS

SHORT NOTES



Chapter-5
Magnetism & Matter

✯. Information of Magnet :-

Magnesia ⟶ Magnetite → Iron, Nickel, Cobalt, Steel

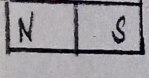
(Before 2000 years)

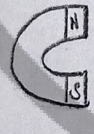
- Natural Magnet → Fe_3O_4 (ferrosferic oxide)
  → Weak & Irregular.

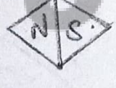
✯. Types of Magnet :-

- Natural Magnet
- Artificial Magnet

- Artificial Magnet :- piece of iron or steel show magnetic properties when rubbed with magnet
  - Bar Magnet
  - Horshoe Magnet
  - Magnetic Needle







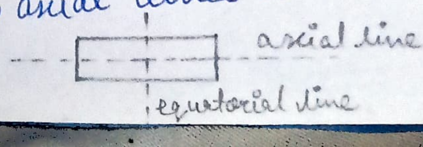
✯. Properties of Bar Magnet :-

- Attractive :- Magnet attract magnetic substance like iron, cobalt, nickel and steel.

→ Ends of magnet are called Poles.

- Directive :- When magnet suspend freely then come in rest along N & S direction.

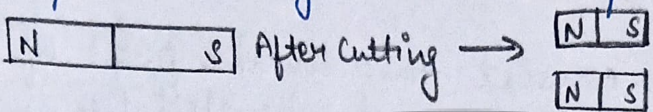
- For a bar magnet, equatorial line and axial lines are perpendicular to each other.



- Like poles repel and unlike poles attract each other.

Imp
- Inductive :- When a piece of magnetic material like soft iron etc. placed near the bar magnet then it acquire magnetism.

- Magnetic poles always exists in pairs (Monopole does not exists)



☆. Magnetic Field :- Space around the magnet in which magnetic effect can be experienced.

☆. Magnetic field Lines :- An imaginary curve, tangent to which at any point give direction of magnetic field at that point.

i) Uniform :- Constant Magnitude
Constant Direction

ii) Non-Uniform :- Either one different

- Properties :-

1) Inside a bar magnet, magnetic field lines move from South to North and outside from North to South.
Inside → S to N
Outside → N to S.

2) Magnitude of magnetic field at any point is represented by the number of magnetic field lines passing normally through unit area.

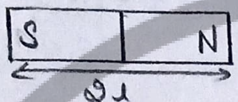
3) Two Magnetic field lines never intersect each other. If they do, then at that point $\vec{B}$ show two direction, which is not possible.

4) Magnetic field lines form continuous curve which are closed.

5) Near magnetic field lines $\longrightarrow$ strong $\vec{B}$

far $\longrightarrow$ Weak $\vec{B}$

☆. Magnetic Dipole :- consist two unlike poles of equal strength and seperated by small distance



$2\vec{l} \rightarrow$ Magnetic Length

☆. Magnetic Dipole Moment :-

$$\boxed{\vec{M} = m(2\vec{l})}$$

$m \downarrow$ Polestrength

→ product of strength of either pole (m) and the magnetic length $(2\vec{l})$.

→ $\boxed{\vec{M} = I\vec{A}}$ (From ch-4)

→ Unit - Am^2

→ determine strength of bar magnet.

☆. Note :-

→ Magnetic pole strength depend on nature and cross sectional area.

→ If bar magnet cut along length then,

$$\vec{M} = \frac{m}{2} \times 2\vec{l}$$

$$\boxed{\vec{M'} = \frac{\vec{M}}{2}}$$

→ If bar magnet cut perpendicularly,

$$\vec{M'} = ml$$

$$\boxed{\vec{M'} = \frac{\vec{M}}{2}}$$

☆ Bar Magnet as a equivalent to Solenoid:-

$$\boxed{B_{axial} = \frac{\mu_0}{4\pi}\frac{2M}{r^3}}$$ (in direction of Magnetic moment)

$$\boxed{B_{equatorial} = \frac{\mu_0}{4\pi}\frac{M}{r^3}}$$ (in opposite direction of Magnetic moment)

☆ Terminology:-

Electric field	Magnetic field.
$K_E = \frac{1}{4\pi\varepsilon_0}$	$K_B = \frac{\mu_0}{4\pi}$
Electric field $\rightarrow \vec{E}$ Dipole Moment $\rightarrow \vec{P}$	Magnetic field $\rightarrow \vec{B}$ $\vec{M}$
$\vec{E}$ at axial of dipole:- $E_{axial} = \frac{2P}{4\pi\varepsilon_0 r^3}$	$\vec{B}$ at axial of Dipole:- $B_{axial} = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$
At equitorial line:- $E_{equatorial} = \frac{-P}{4\pi\varepsilon_0 r^3}$	$B_{equatorial} = \frac{-\mu_0}{4\pi}\frac{M}{r^3}$
Torque:- $\vec{\tau} = \vec{P} \times \vec{E}$	$\vec{\tau} = \vec{M} \times \vec{B}$
Potential Energy:- $U_E = -P.E$	$U_B = -M.B$

☆ Potential Energy of a Magnetic Dipole in Magnetic Field:-

$$\boxed{U = -MB\cos\theta} \quad \text{or} \quad \boxed{U = -\vec{M}.\vec{B}}$$

· Cases:-

i) If $\theta = 0°$ then $U = -MB$ (Min.) (stable equilibrium)

ii) If $\theta = 90°$ then $U = 0$

iii) If $\theta = 180°$ then $U = MB$ (Max.) (Unstable)

☆ Gauss's Law for magnetism :-

$$\boxed{\phi_B = \oint \vec{B} \cdot d\vec{s} = 0}$$

→ Unit = Weber (Scalar)

→ Dimensional Formula = $[M^1 L^2 T^{-2} A^{-1}]$

☆ Magnetic Permeability (μ) :-

→ The ability of a material to permit passes of magnetic lines of force through it.

☆ Relative Magnetic Permeability (μ_r) :-

$$\boxed{\mu_r = \frac{\mu}{\mu_0}}$$

It is dimensionless

where $\mu_0 = 4\pi \times 10^{-7} \frac{Wb}{AM}$

→ In vaccum, $\mu_r = 1$.

→ Unitless and Depend on nature of material

$$\boxed{\mu_r = \frac{B}{B_0}}$$

where B_0 → External Magnetic field

B → Total Magnetic field.

☆ Magnetising force or Magnetising field :- (H)

$$\boxed{H = \frac{B_0}{\mu_0}}$$

Other form :-

$$\boxed{H = \frac{B}{\mu}}$$

→ Magnetic field induced in material

→ Unit :- A/m

→ Dimensional formula :- $[M^0 L^{-1} T^0 A^1]$

☆ Magnetisation Intensity (I) :-

$$\boxed{I = \frac{\text{Magnetic Moment}}{\text{Volume}}}$$

$$\boxed{I = \frac{M}{V} = \frac{m}{A}}$$

m → Pole strength

$$\boxed{I = \frac{B_m}{\mu_0}}$$

B_m → Magnetisation produce magnetic field (B_m)

→ Unit :- $\frac{A}{m}$

★ Magnetic Susceptibility :- (χ_m) (unitless & Dimensionless)

$$\boxed{\chi_m = \frac{I}{H}}$$

★ Relation b/w Magnetic Permeability & Magnetic Susceptibility :-

$$\boxed{\mu_r = 1 + \chi_m}$$

★ Note :-

$$\boxed{B = B_0 + B_m}, \quad \boxed{B = \mu_0\left(H + \frac{M}{V}\right)}$$

★ Classification of Magnetic Materials :-

Property	Diamagnetic	Paramagnetic	Ferromagnetic
Definition	Weakly repelled by a magnetic field.	Weakly attracted to a magnetic field.	Strongly attracted and retains magnetism after field is removed.
Examples	Bismuth, Copper, Water, glass, Organic Materials.	Aluminium, Platinum, Manganese, Oxygen.	Iron, Cobalt, Nickel, their alloys.
Magnetic Moment	No net moment in the absence of field.	Net moment due to unpaired electrons.	Large net moment from aligned atomic magnetic moments. (unpaired electron)
Direction in Uniform Field	Align opposite to the magnetic field	Aligns weakly in the direction of magnetic field	Align strongly in the direction of magnetic field
Direction in Non-uniform field	Moves from stronger to weaker region of the field	Moves from weaker to stronger region of the field.	Strongly attracted to stronger region of field.
Effect when placed in Field	Weakly repelled; no visible magnetism after removal.	Weakly attracted	Strongly attracted.
Susceptibility (χ)	Negative ($\chi < 0$)	Small positive ($\chi > 0$)	Very high +ve ($\chi >> 1$)
Permeability (μ)	$\mu_r < 1$	$\mu_r > 1$	$\mu_r >> 1$
Temperature	No change	Magnetism decreases at high temperature	Above Curie temperature ferromagnetism↓ Paramagnetism↑

Causes of Magnetic Behaviour	Opposing magnetic field from orbital electron motion.	Magnetic moments from unpaired electrons	Alignment of atomic magnetic moments in magnetic domains.

★ Types of Ferromagnets :-

① Soft ferromagnets :- When external magnetic field removed then magnetisation disapper in material, like soft iron.

② Hard ferromagnets :- Magnetisation persists after removal of $\vec{B}_{ext}$ field.

E.g → Alnico (alloy of Fe, Al, Ni, Co, Cu)

★ Note :-

→ As temperature increases, magnetisation of ferromagnetic substance decreases.

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