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Chapter 5

Magnetism and Matter

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Magnetism and Matter

BOARD:- 2013 (SUPP.)

1. A short bar magnet has a magnetic moment of 0.40 J/T. Calculate the magnitude of the magnetic field at a point 20 cm apart from the centre of the magnet if this point is on - [1+1=2]
   (i) Axis of the magnet
   (ii) Normal bisector of the magnet

⇒ $M = 0.40$ J/T

$r = 20$ cm $= 20 \times 10^{-2}$ m

(A) Magnetic field in axial Position -

$$B_{ax} = \frac{\mu_0}{4\pi}\left(\frac{2M}{r^3}\right)$$

$$B_{ax} = \frac{10^{-7} \times 2 \times 0.40}{(20 \times 10^{-2})^3}$$

$$B_{ax} = \frac{8 \times 10^{-8}}{8 \times 10^{-3}}$$

$$B_{ax} = 1 \times 10^{-5}\ T$$

(B) Magnetic field in equitorial Position -

$$B_{eq} = \frac{\mu_0}{4\pi}\left(\frac{M}{r^3}\right)$$

$$B_{eq} = \frac{B_{ax}}{2}$$

$$B_{eq} = 0.5 \times 10^{-5}\ T$$

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BOARD:- 2014

2. If magnetic monopoles would have existed, how would the Gauss' Law of magnetism be modified? [1 Mark]

⇒ According to Gauss Law for magnetism -

" Magnetic flux linked with any closed surface is always 0".

$$\phi = \int \vec{B} \cdot d\vec{A} = 0$$

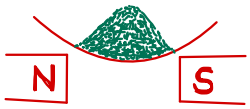
If single poles existed then -

$$\phi = \int \vec{B} \cdot d\vec{A} = \mu_0 \Sigma m$$

↳ Total pole strength

3. What are diamagnetic substances? Give one example. [1 Mark]

⇒ Diamagnetic substances are those which develop weak magnatization in the opposite direction of magnetic field. Such substances are weakly repel by magnets & tend to move from strong to weaker magnetic field in non-uniform Magnetic field.



Eg:- Diamond
Air
H_2O

BOARD:- 2017 (SUPP.)

4. A short bar magnet has a magnetic moment of 0·48 J/T. Calculate the magnitude of the magnetic field at a point 20 cm apart from the centre of the magnet if this point is on - [1+1=2]
   (i) Axis of the magnet
   (ii) Normal bisector of the magnet

$M = 0.48\ J/T$
$r = 20\ cm = 20 \times 10^{-2}\ m$

(A) Magnetic field in axial Position -

$$B_{ax} = \frac{\mu_0}{4\pi}\left(\frac{2M}{r^3}\right)$$

$$B_{ax} = \frac{10^{-7} \times 2 \times 0.48}{(20 \times 10^{-2})^3}$$

$$B_{ax} = \frac{9.6 \times 10^{-8}}{8 \times 10^{-3}}$$

$$B_{ax} = 1.2 \times 10^{-5}\ T$$

(B) Magnetic field in equitorial Position -

$$B_{eq} = \frac{\mu_0}{4\pi}\left(\frac{M}{r^3}\right)$$

$$B_{eq} = \frac{B_{ax}}{2}$$

$$B_{eq} = 0.6 \times 10^{-5}\ T$$

BOARD - 2018

5. An electron is revolving will velocity v in a circular orbit of radius r. Find its magnetic moment.

⇒ Electrons revolve around the nucleus in an atom. Due to which each orbit of the atom behaves like a magnetic dipole. Magnetic moment of current carrying coil-

$$M = NIA \quad \{N = 1,\ A = \pi r^2$$
$$M = I(\pi r^2)$$
$$M = \frac{e}{t}(\pi r^2) \quad \{I = q/t$$

$$M = \frac{\pi r^2 e}{2\pi r/v} \quad \left\{t = \frac{2\pi r}{v}\right.$$

$$\boxed{M = \frac{1}{2} evr}$$

$A x m^2$

BOARD:- 2019

5. The pole strength of the poles of a bar magnet of effective length 0.1 m is 40 Axm. Calculate its magnetic moment.

⇒ $M = m \times 2l$

$M = 40 \times 0.1$

$M = 4\ Am^2$

BOARD:- 2020

6. The magnetic moments of two bar magnets are M_1 and M_2. If the angle b/w them is θ then write the value of the resultant magnetic moment.

⇒ $M = \sqrt{M_1^2 + M_2^2 + 2M_1M_2\cos\theta}$

BOARD:- 2020 (Supp.)

7. What is Magnetic Susceptibility (χ)? write the value of Magnetic Susceptibility for superconductor.

⇒ Ratio of Intensity of Magnetization (I) and magnetization field (H) is known as Magnetic susceptibility.

$I \propto H$

$I = \chi H$

$\chi = \frac{I}{H}$ → Unitless

$-$ ⇒ Diamagnetic

$+$ ⇒ Paramagnetic & Ferromagnetic.

→ for superconductor χ is -1.

BOARD:- 2023

8. Select two paramagnetic substances from the following-
Na, Bi, Cu, Al, Pb.

⇒ Na, Al - Paramagnetic Substance
Bi, Cu, Pb - Diamagnetic Substance

BOARD:- 2024

9. The resultant magnetic moment produced per unit volume of a substance is called _____.

⇒ Magnetic Intensity (Intensity of Magnetization)

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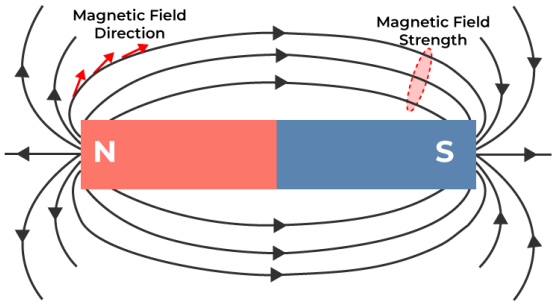
10. write properties of magnetic field line.

⇒



1. Magnetic field lines are imaginary closed curve.
2. Direction -
   outside = N to S
   Inside = S to N
3. Tangent drawn at any point on the closed curve gives the direction of magnetic field at that point.
4. Magnetic field line never intersect each other.
   Reason - At intersection point there may be two possible direction of magnetic field, which is not possible.
5.

Uniform magnetic field

Non-uniform magnetic field

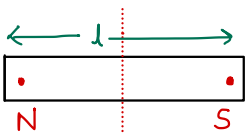
Extra points -

Properties of Bar Magnet

1. If bar magnet suspend freely by an inextensible string, then it rests in geographical north-south direction.
2. Bar magnet has two poles, always occurs in pairs. Single pole can't exists.
3. Like pole repel and opposite poles attracts with each other.
4. Magnetic Moment (M) = m × l

   Note - l = effective length
   ↳ 5/6 × Actual length

5.

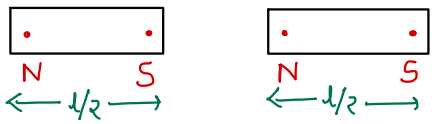


No effect on pole strength (m).

$M = ml$

$M' = \frac{ml}{2}$

$M' = M/2$



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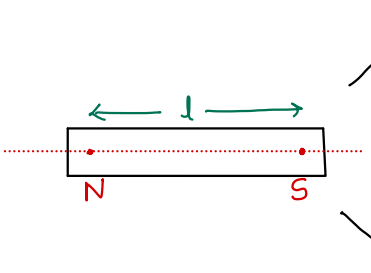

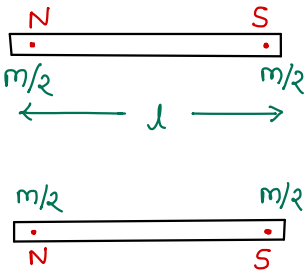

→ pole strength becomes half.

→ $M' = \left(\frac{m}{2}\right) l$

$M' = M/2$

2. I, H, χ, μ_r -

I ⇒ Magnitude of magnetic moment developed per unit volume of substance is known as intensity of Magnetization.

$I = M/V$ unit - A/m

H ⇒ Ratio of magnetic induction in free space and permeability of free space is known as Magnetising field.

$H = B_0/\mu_0$ Unit - A/m

for medium

$H = B/\mu$

μ_r ⇒ Ratio of permeability of medium and permeability of free space is called Relative Permeability.

- Unitless
- $\mu_r = \frac{\mu_m}{\mu_0}$

χ_m ⇒ Ratio of I & H is known as Magnetic susceptibility.

$\chi_m = I/H$

- Unitless

Relation b/w μ_r & χ_m -

$B = B_0 + B_i$ B_0 = Due to free current

B_i = Due to Bound current

$\mu H = \mu_0 H + \mu_0 I$

$\mu H = \mu_0 H (1 + I/H)$

$\frac{\mu}{\mu_0} = 1 + \chi_m$

$\mu_r = 1 + \chi_m$

or

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

3. Difference b/w
paramagnetic
Diamagnetic
ferromagnetic

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