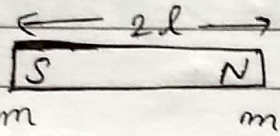
Chapter-5

Magnetism

Basic Properties of Magnets :-

Magnetic field at a point on the axis of a bar magnet (magnetic dipole)

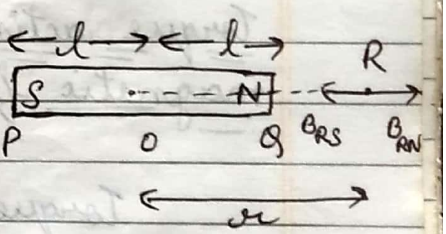


$m \rightarrow Am$

$M = q_m \cdot 2l$

$M \rightarrow Am^2$

$q_m \rightarrow$ pole strength.



B_r = Net magnetic field

$= B_{RN} - B_{RS}$

$= \frac{\mu_0}{4\pi}\frac{q_m}{RQ^2} - \frac{\mu_0}{4\pi}\frac{q_m}{RP^2}$

$B_r = B_{RN} - B_{RS}$

$= \frac{\mu_0 q_m}{4\pi}\left[\frac{1}{(r-l)^2} - \frac{1}{(r+l)^2}\right]$

$= \frac{\mu_0 q_m}{4\pi}\frac{4rl}{(r^2-l^2)^2}$ $\quad 2l \times q = M$

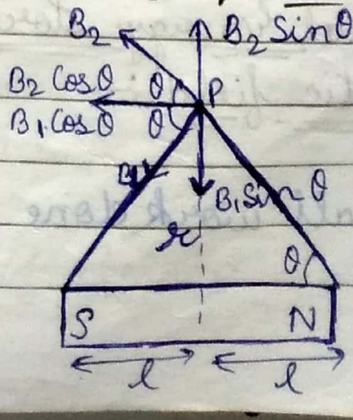
$= \frac{\mu_0}{4\pi}\frac{2Mr}{(r^2-l^2)^2} \approx \frac{\mu_0}{4\pi}\frac{2M}{r^3}$ for $r >> l$

$\frac{r}{r^4}$

Magnetic field at a point on the equatorial point of a bar magnetic :-

Net magnetic field at P is $B = B_1 \cos\theta + B_2 \cos\theta$

$2B_1 \cos\theta \quad \because B_1 = B_2$



Sun / 5 /

CoreHeat

= Sun's Heat

$$2 \times \frac{\mu_0}{4\pi} \frac{m}{SP^2} \cdot \frac{l}{SP}$$

$$= \frac{\mu_0}{4\pi} \frac{m2l}{(r^2+l^2)^{3/2}}$$

$$\boxed{B = \frac{\mu_0}{4\pi} \frac{M}{(r^2+l^2)^{3/2}}} \qquad \because M = m2l$$

Special Case :-

If $r >> l$

$$\boxed{B = \frac{\mu_0}{4\pi} \frac{M}{r^3}}$$

Torque acting on a magnetic dipole placed in a uniform magnetic field :-

→ Torque τ = Either force × $\perp^r$ distance

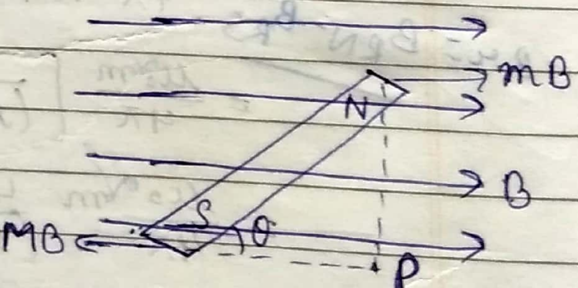
$= mB \times PN$

$= mB \cdot (SN \sin\theta)$

$= mB \cdot \cancel{E}\, 2 \cdot l \cdot \sin\theta$

$= (m2l)\, B \sin\theta$

$$\boxed{\tau = MB \sin\theta}$$



In vector form :-

$$\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$$

along area vector

where, $M = NiA$.

Loop area.

Potential Energy stored in a magnetic dipole in uniform magnetic field :-

Small work done, $dW = \tau\, d\theta$

$= MB\theta\, d\theta$

$$W = \int dW$$

$$= \int_{\theta_2}^{\theta_1} MB \sin\theta \, d\theta$$

$$= MB \left[-\cos\theta\right]_{\theta_1}^{\theta_2}$$

$$\boxed{U = MB(\cos\theta_1 - \cos\theta_2)} \quad , \Delta U = MB\left[\cos\theta_1 - \cos\theta_2\right]$$

Special Case :

If $\theta_1 = 90°$ & $\theta_2 = \theta$

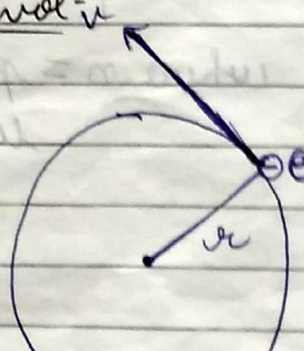
then, $U = MB(\cos 90° - \cos\theta)$

$$\boxed{U = -MB\cos\theta}$$

$$\boxed{\vec{U} = -\vec{M}\cdot\vec{B}}$$ → In vector form.

To be completed

Magnetic dipole moment of a revolving electron :-



$$T = \frac{2\pi r}{v} \qquad M = iA$$

$$= i(\pi r^2)$$

$$= \frac{e}{T}\pi r^2$$

$$= \frac{e}{2\pi r/v}(\pi r^2)$$

$$= \frac{ev}{2\pi r} \times \pi r^2$$

$$M = \frac{evr}{2} \rightarrow ①$$

According to the Bohr's theory, angular momentum of an electron,

$$L = mvr$$

where m = mass of electron

v = speed of the electron
r = radius of the electron.

$$\therefore \boxed{vr = \frac{L}{m}}$$

$$\therefore M = \frac{e}{2} \cdot \frac{L}{m}$$

$$\boxed{M = \frac{e}{2m} L} \longrightarrow ②$$

According to the Bohr's Theory,

$$L = \frac{nh}{2\pi}$$

∴ From ②

$$M = \frac{e}{2m} \cdot n \cdot \frac{h}{2\pi}$$

$$\boxed{M = n \frac{eh}{4\pi m}} \longrightarrow \text{Bohr Magneton}$$

where n = principal quantum number
μ_m = Bohr's Magneton
$= 9.27 \times 10^{-24}$ A meter^2

Classification of electric materials :

Diamagnetic materials :-
- Copper
- Gold

Paramagnetic materials :-
- Aluminium
- Oxygen

Ferromagnetic materials
- Nickle
- Iron.

Cause of Diamagnetism :-

Cause of Paramagnetism :