Chapter-5

Magnets :- A magnet is a material which produced magnetic field around it

Natural Magnet | Artificial Magnet

* Magnets Exists with two poles

m_2 [N S] m_1

Let pole strength be m_1 & m_2

So

$F \propto m_1 m_2$ — Force of attraction is $\propto$ to the pole strength

$F \propto \frac{1}{r^2}$

$F \propto \frac{m_1 m_2}{r^2}$

$$\boxed{F = \boxed{\frac{\mu_0}{4\pi}} \frac{m_1 m_2}{r^2}}$$

Magnetic permiability for free space

10^{-7} value

Q Two poles one of which is 5 times as strong as other exert on each other a force equal to 0.8×10^{-3} kg weight when placed 10cm apart in ~~air~~ air find the strength of each pole?

⇒

$F = 0.8 \times 10^{-3}$ kg weight

$F = 0.8 \times 10^{-3} \times 9.8$ N

$r \Rightarrow 10cm = 10^{-1}$ m

$\mu_0 = 4\pi \times 10^{-7}$

$F = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{r^2}$

$F = \frac{10^{-7} \times m \cdot 5m}{10^{-2}}$ | $F = \frac{10^{-7} \, 5m^2}{10^{-2}}$

$$0.8\times10^{-3} = 10^{-7+2}\times 5m^2$$

$$\frac{0.8\times10^{-3}\times 9.8}{10^{-5}} = 5m^2$$

$$0.8\times10^{-3}\times9.8\times10^{5} = 5m^2$$

$$\frac{0.8\times9.8\times10^{2}}{5} = m^2$$

$$\frac{7.84\times10^{-2}}{5} = m^2$$

$$m = \sqrt{\frac{7.84\times10^{-2}}{5}}$$

$$\boxed{m = 12.52 \text{ Ampere meter}}$$

* Bar Magnet

⇒ The Bar magnet has two poles of similar magnetic pole strength

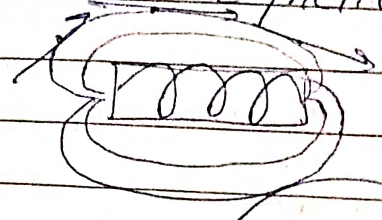
$$m_1 = m_2$$
or
$$m = m$$

* Two poles always exist where single poles doesn't exist
* Magnetic field strength is maximum at poles.

⇒ If we ~~are~~ will sprinkle iron fillings on a bar magnet than

Magnetic field lines

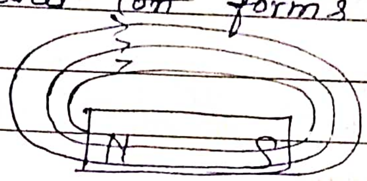
⇒ The magnetic field lines in a magnetic field are those imaginaray line which tangent continuously represent the direction of net magnetic field.



Properties

+q   −q or at Infinity for $\vec{B}$

★ Magnetic field lines ~~con~~ forms continuous closed loops for.



The dirn of field lines in outside the magnet is North to South but Inside the magnet it flows from south to North.

★ The tangent to the field line at a given point repr-sent the diren of the net magnetic field at that point.

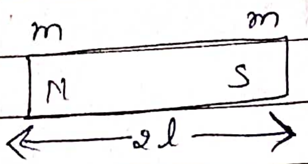
★ Magnetic field lines donot intersect each other. because if they do so then their will be two diren at one point which is not possible.

★ Strength of pole ~~that~~ is directly propotional to no. of field lines. that's why magnetic field is maximum at poles.

★ In bar magnet the magnetic field lines are uniform and parallel to each other.

Magnetic Dipole

⇒ A magnetic dipole is an arrangement of two magnetic poles of equal and opposite strength separated by a small distance.



magnetic ~~Dipole~~ moment :- $m2l$
⇒ $2ml$.

Magnetic moment

It is defined as the product of pole strength and distance b/w two pole.

Unit :- Ampere metre^2

$M = IA$
⇒ Ampere metre × metre

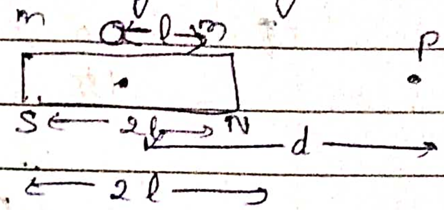
Magnetic moment ← M ⇒ Ampere metre^2

Magnetic field Strength at a point due to a bar magnet

as Electric field Intensity
$E = \frac{F}{q}$ for magnetic field Intensity $\boxed{B = \frac{F}{m}}$

(i) When point lies on axial line of Bar magnet

$\Rightarrow$ Lets 2l be the length of bar magnet with centre O we are trying to find magnetic field intensity or strength at a point on axial line at distance d. from the centre of magnet.



$$\Rightarrow \quad B = \frac{F}{m} = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{r^2}$$

But here

Magnetic field Intensity.

$$B \Rightarrow \frac{F}{m'} = \frac{\mu_0}{4\pi} \frac{m}{r^2}$$

for

$$B_1 = \frac{\mu_0}{4\pi} \frac{m}{(d-l)^2} = +x \text{ dirn}$$

$$B_2 = \frac{\mu_0}{4\pi} \frac{m}{(d+l)^2} \quad -\text{ve dirn}$$

then total magnetic field will be than

$$B = \bar{B}_1 + B_2$$

$$B = \frac{\mu_0}{4\pi} \frac{m}{(d-l)^2} - \frac{\mu_0}{4\pi} \frac{m}{(d+l)^2}$$

$$B = \frac{\mu_0}{4\pi} \cdot m \left(\frac{1}{(d-l)^2} - \frac{1}{(d+l)^2} \right)$$

$$B = \frac{\mu_0 m}{4\pi} \left(\frac{(d+l)^2 - (d-l)^2}{(d-l)^2 (d+l)^2} \right)$$

$$\cancel{B = \frac{\mu_0 m}{4\pi} \left(\frac{(d+l)^2 - (d-l)^2}{d} \right)}$$

$$B = \frac{\mu_0 m}{4\pi} \left[\frac{d^2 + l^2 + 2ld - d^2 - l^2 + 2dl}{[(d-l)(d+l)]^2} \right]$$

$$B = \frac{\mu_0 m}{4\pi}\left[\frac{4dl}{(d^2-l^2)^2}\right]$$

magnetic moment

$$B = \frac{\mu_0}{4\pi}\frac{2\cdot(2ml)\,d}{(d^2-l^2)^2} = \frac{\mu_0}{4\pi}\frac{2Md}{(d^2-l^2)^2}$$

$$\boxed{B = \frac{\mu_0}{4\pi}\frac{2Md}{(d^2-l^2)^2}}$$

(i) if $d >> l$

So $l = 0$

$$B = \frac{\mu_0}{4\pi}\frac{2M\cancel{d}}{d^4}$$

$$\boxed{B = \frac{\mu_0}{4\pi}\frac{2M}{d^3}}$$

$B = +ve$ {same}

means Resultant magnetic field direction is towards right.

magnitude of

Q What is the magnetic field axial field due to a bar magnet of length 5 cm at a distance of 50 cm from its midpoint the magnetic moment of bar moment is 0..

⇒ as 5 cm <<< 50 cm

$l << d$

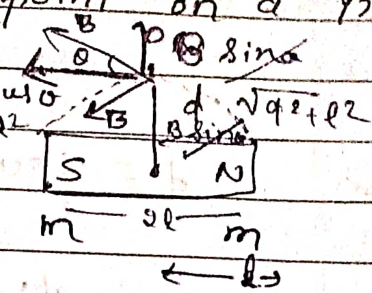
So $B = \frac{\mu_0}{4\pi}\frac{2M}{d^3}$

$$\Rightarrow \frac{10^{-7} \times 2 \times 0.4}{(50\times10^{-2})^3}$$

$$\Rightarrow \frac{10^{-7+2} \times \cancel{2} \times 4}{10 \times \cancel{50}\,25} \Rightarrow \cancel{10^{-8} \times 4} \quad 6.4\times10^{-7}$$

Tesla

(ii) When point lies on Equitorial point on a bar magnet?



$$B = \frac{\mu_0}{4\pi}\frac{m}{r^2}$$

B sinθ will be cancel because It is in opposite dire^n.

the $B = 2B\cos\theta$ —①

we know

$$B = \frac{\mu_0}{4\pi}\frac{M}{r^2}$$ —②

so $r = \sqrt{d^2+l^2}$. put B on eq^n ①

$$B = 2\frac{\mu_0}{4\pi}\frac{M}{d^2+l^2}\cos\theta$$

$$\cos\theta = \frac{\text{Base}}{\text{hypo}} = \frac{l}{\sqrt{d^2+l^2}}$$

$$B = 2\frac{\mu_0}{4\pi}\frac{m}{(d^2+l^2)} \times \frac{l}{\sqrt{d}}$$

$$B = \frac{2\mu_0}{4\pi}\frac{ml}{(d^2+l^2)^{3/2}} = \frac{\mu_0\, 2ml}{4\pi(d^2+l^2)^{3/2}}$$

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

than $d \gg l$

$$B = \frac{\mu_0}{4\pi}\frac{M}{d^{2\times 3/2}} = \boxed{\frac{\mu_0}{4\pi}\frac{M}{d^3}}$$

Direction will be −ve x axis because of equito-

Q. Determine the magnitude of the Equitorial field of a bare magnet at a distance 60cm from its mid point. The magnetic moment of bare magnet is 0.6 Am

n^2)

$\Rightarrow$ $d = 60 cm$ $2l = 6 cm$
$l = 3 cm$

$d >> l$ $M = 0.6 \, Am^2$

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

$$\Rightarrow \frac{10^{-7} \times .6}{10 \times (60 \times 10^{-2})^3}$$

$$B \Rightarrow \frac{10^{-7} \times 6}{10 \times 216000 \times 10^{-6}} \Rightarrow 2.7 \text{ Tesla}$$

Bar magnet as an Equivalent Solenoid

⇒ * If we will suspend the solenoid freely then it will stop in the direcⁿ of North & South like the bar magnet.

* If we brings two solenoids together than it also attract and repel each other like Bar magnet

* We have checked from compass needle then we have seen that ~~may~~ Inside the solenoid magnet field lines moves from south and north and outside the magnet it moves from north to south.

* If we break solenoid from b/w then also there will be two poles North to south like a bar magn

Main language

→ ① A current carrying solenoid which suspended freely always comes to rest in north south dirⁿ.

② Two current carrying solenoid exhibit mutual attraction and repulsion when brought closer to one another like a bar mangnet.

③ If we move a small compass needle in the naval root of bar magnet and the current carrying solenoid we shall find the deflection of the needle are similar in two cases.

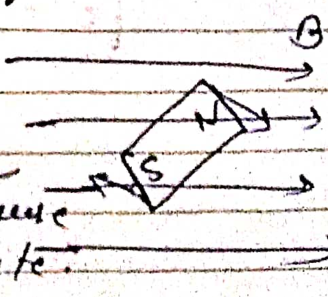
④ Cutting a bar magnet in half is like cutting a solenoid. we get smaller solenoid with weaker magnetic property and with two poles north and south like a bar magnet.

⑤ The magnetic field of both the bar magnet and the current carrying solenoid at any far away axial point given by the same expression.

$$B_{axial} = \frac{\mu_0}{4\pi} \frac{2m}{d^3}$$

Torque on a Magnetic dipole in a Uniform magnetic field

⇒ Magnetic field will align the bar magnet in its own dirⁿ by applying force so while applying force torque will produced because both force are equal and opposite.



Then

$F_{net} = 0$ {both force are equal but in opposite direction} and both force are ∥ to each other.

as we know

$F_{net} = 0$

then τ will generate.

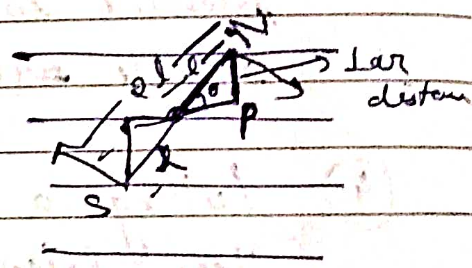
$\tau = F \times \perp \text{distance}$.

as $F = qvB$

for

$q = mB$

{⊥ar distance from the axis of rotation}



as $\sin\theta = \frac{P}{H} = \frac{NP}{l}$

So $\tau_1 = F \times \perp \text{distance}$

$= mB \times NP$

$\tau_1 = mBl\sin\theta$

then

$\tau_2 = mBl\sin\theta$

So

$\tau = \tau_1 + \tau_2$ {because both are rotating in same direcn i.e clockwise}

$\tau = 2(mBl\sin\theta)$

$\boxed{\tau = MB\sin\theta}$ {M = 2ml}

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

Q A short bar magnet placed with its axis at 20° with a uniform ~~magne~~ external magnetic field of 0.25 tesla experiences a τ of magnitude 4.5×10^{-2} Joule. What is the magnitude of magnetic moment of the magnet?

$\Rightarrow$ $\tau = 4.5 \times 10^{-2}$ $\quad \theta = 30°$

$B = 0.25$

$\tau = MB \sin\theta$

$\frac{4.5 \times 10^{-2}}{0.25 \sin 30°} =$

$\frac{4.5 \times 10^{-2} \times 2}{0.25 \times}$

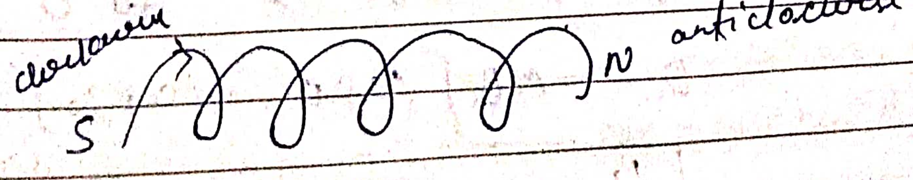
$\frac{\cancel{45}^{9} \times 10^{-2} \times 1\cancel{0} \times 2}{\cancel{25}_{5} \times 1\cancel{0}}$

$3.6 \times 10^{-2} \times 10$

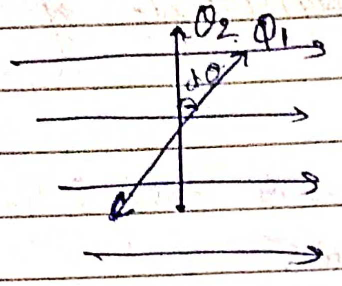
$3.6 \times 10^{-1} = 0.36$

Q How does circular loop carrying current behave as magnet?

$\Rightarrow$



potential Energy of a magnetic dipole in a Magnetic field



~~for dipole~~

System के work होगा $U = W$
System पर work करेंगे $U = -W$

If we rotate $d\theta$ {θ_1 to θ_2} then

$$dW = \tau \times d\theta$$

$$W = \int_{\theta_1}^{\theta_2} \tau \, d\theta$$

{Force zero hai so τ gunate hoga isely $dW = \tau \times d\theta$

than

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

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

$$W = -MB[\cos\theta_2 - \cos\theta_1]$$

so

$$U = W$$

$$U = -MB[\cos\theta_2 - \cos\theta_1]$$

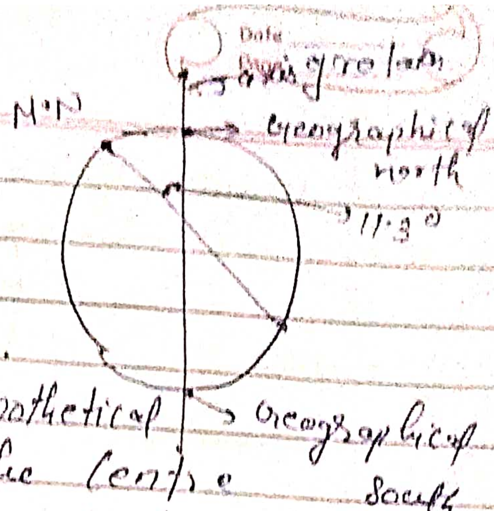
If $\theta_1 = 90$ $\theta_2 = \theta$

$$U = -MB[\cos\theta^\circ - \cos 90^\circ]$$

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

{sign - that means dipole field ki work karna hai

Earth magnetism



⇒ The magnetic field lines of earth resemble that it contains an hypothetical magnetic dipole located at the centre of Earth and the axis of magnetic dipole is presently ~~tifted~~ tilted at approximately 11.3° with respect to axis of rotation of earth.

Geographical ~~melodion~~ meridian

⇒ The vertical circular plane passing through the axis of ~~meridian~~ rotation is called geographical meridian.

Magnetic Meridian

⇒ The vertical circular plan passing through the ~~ar~~ magnetic north and magnetic South is called magnetic meridian.

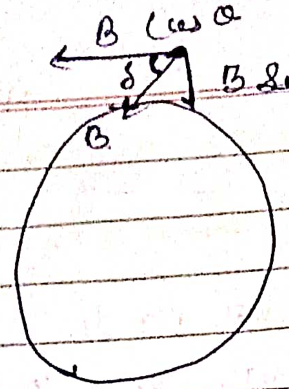
Magnetic Elements

(a) Magnetic declination

⇒ Magnetic declination at a plane is difined as the angle b/w the ~~geopher~~ geographical meridian and the magnetic meridian and it is represented by θ.

(a) Magnetic Inclination or dip

अगर एक point पर हम अपने magnetic needle को रख आए तो उससे vertical plane formed होगा और फिर उसका ~~एक~~ horizontal line draw करेंगे then

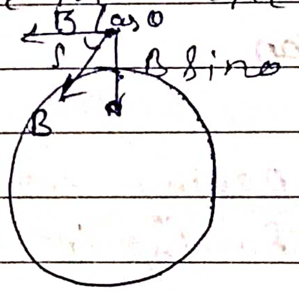


un dono के बिच का angle δ होता है उसी को बोलते है magnetic Inclination. then uski do components honge

Def :- It is defined as the angle made by the direction of total earth magnetic field at any place with the horizontal dirⁿ of the earth

Horizontal Component of Earth Magnetic field.

Let B_H be the Horizontal Component of the Magnetic fied & V_B be the vertical Component



$$B_H = B\cos\theta$$

$$B_V = B\sin\theta$$

Than

$$B = (B_H)^2 + (B_V)^2$$

$$\Rightarrow B^2{}_H{}^2 + B^2{}_V{}^2$$

$$B = B^2\cos^2\theta + B^2\sin^2\theta$$

$$B = B^2$$

than

$$\frac{B_V}{B_H} = \frac{\cancel{B}\sin\delta}{\cancel{B}\cos\delta}$$

$$\boxed{\frac{B_V}{B_H} = \tan\delta}$$

Q. The vertical component of the Earth magnetic field at a place is $0.24\sqrt{3} \times 10^{-4}$ tesla. find out the value of horizontal component of Earth M.F if angle of dip of at a place is $30°$

$$\Rightarrow \frac{B_V}{B_H} = \tan \delta$$

$B_V = 0.24\sqrt{3} \times 10^{-4}$ $\quad B_H = ?$

$$\tan 30° = \frac{1}{\sqrt{3}}$$

$$\frac{0.24\sqrt{3} \times 10^{-4}}{B_H} = \frac{1}{\sqrt{3}}$$

$$0.24 \times 3 \times 10^{-4} = B_H$$

$$0.72 \times 10^{-4} = B_H$$

Tesla