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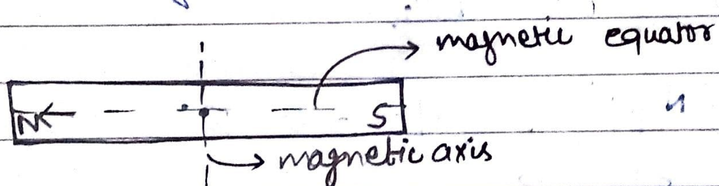
Magnetism & matter.

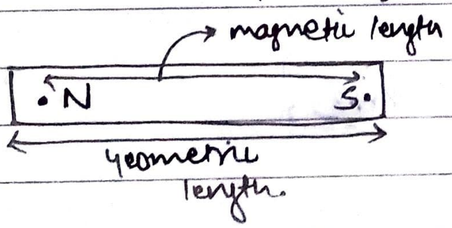
Basic Properties of magnet -

1. Attractive property
2. Directive Property → align itself geographical north-south pole.
3. Like poles repel and unlike poles attract.
4. magnetic poles always exist in pairs. → monopoles do not exist
5. magnetic Induction → A magnet induces magnetism in a magnetic substance near it.

Uniform magnetic field → same magnitude and direction at all points of that region

magnetic Poles → These are regions where in a magnet where magnetic strength is the maximum.





Coulomb's law of magnetic force

→ The force of attraction or repulsion between two magnetic poles is directly proportional to the product of their pole strength and inversely proportional to the square of distance between them.

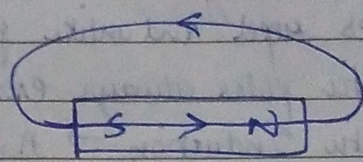
Pole strength.

$$F = \frac{\mu_0}{4\pi} \frac{q_{m1} q_{m2}}{r^2}$$

Magnetic Dipole & magnetic Dipole moment

$$\boxed{\vec{m} = q_m \times 2\vec{l}}$$

magnetic field lines:



Properties:

① closed curves unlike charges.

② $\vec{B}$ field lines does'nt intersect each other

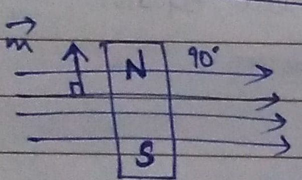
③ magnetic strength $\propto$ density

④ enters & exits normally from the magnet.

⑤ South $\longrightarrow$ North

Potential energy of a magnetic Dipole in a $\vec{B}$ field

$$\boxed{U = -mB(\cos\theta_2 - \cos\theta_2)}$$



$U = 0,\ \theta = 90°$

$$\boxed{U = -mB\cos\theta = -\vec{m}.\vec{B}}$$

Special cases:

1. when $\theta = 0°$, $U = -mB\cos 0° = -mB$

   P.E of dipole is minimum when $\vec{m}$ is parallel to B.

2. When $\theta = 90°$, $U = -mB\cos 90° = 0$

\# 3. When $\theta = 180°$, $U = -mB\cos 180 = +mB$

   P.E of a dipole is max when m is antiparallel to B [unstable equillibrium]

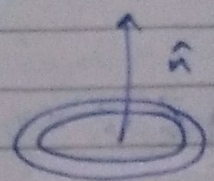
Current Loop as a Magnetic Dipole

The magnetic dipole moment of any current loop is equal to the product of its current and loop area.

$$\boxed{m = IA} \quad \text{or} \quad \boxed{m = NIA}$$

$\vec{m} = I\vec{A} = IA\hat{n}$

↳ direct^n → normal to the plane of the loop in the sense given by Right Hand Thumb Rule.



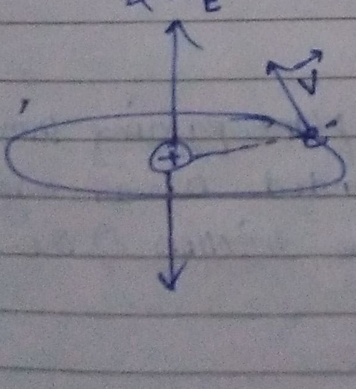
Magnetic Dipole Moment of a Revolving Electron.

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

→ velocity → radius

$$\boxed{m = \frac{evr}{r}}$$

$M = \frac{e}{2m_e} L$ amp m^2. [$L = m_e v r$ angular momentum]



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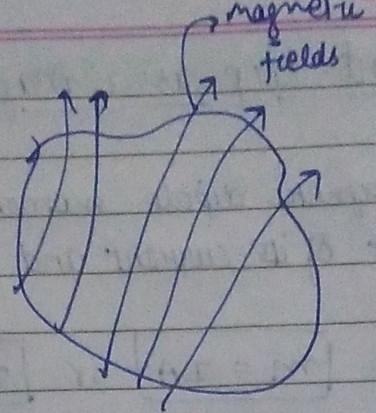
Gauss law in Magnetism



Gauss law indicates that the surface integral of the magnetic field $\vec{B}$ over a closed surface is always zero.

$$\boxed{\oint \vec{B} \cdot \vec{ds} = 0.}$$

Earth's magnetism

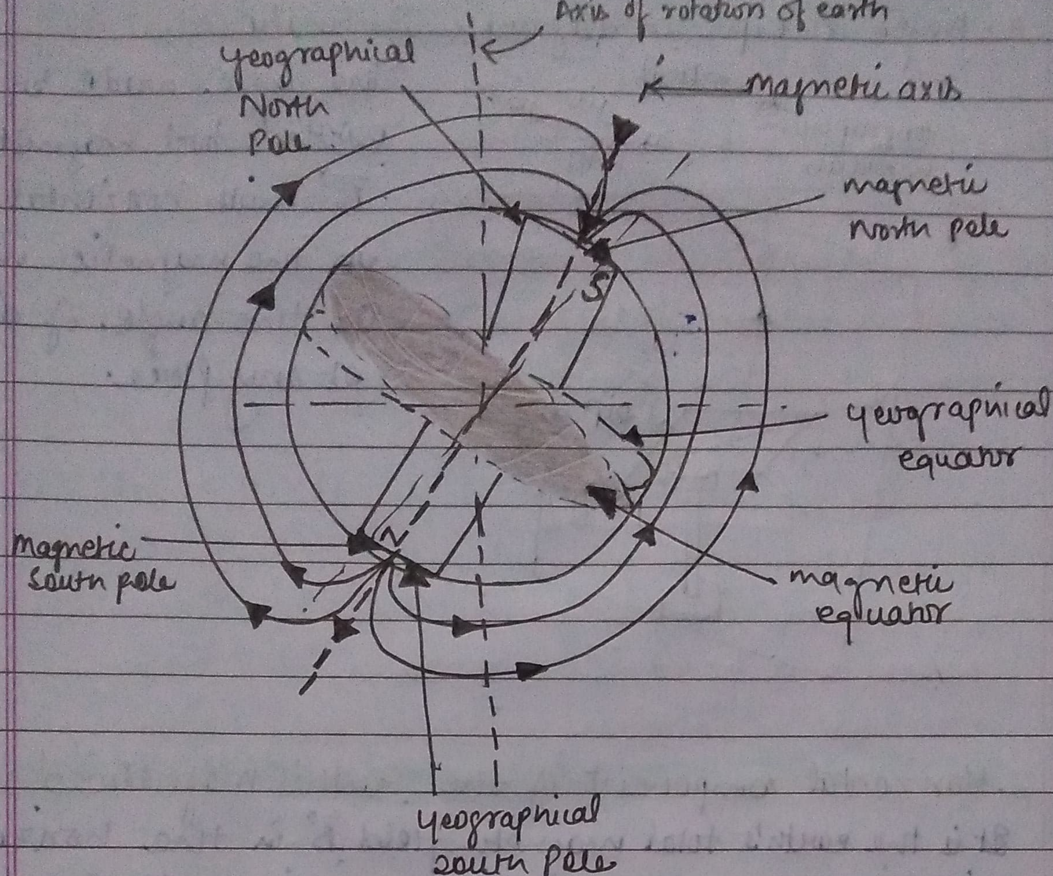
1. Geographic axis : The straight line passing through the geographical north and south pole of the earth. It is axis of rotation of earth.

2. magnetic axis : ~~The~~ The straight line passing through the magnetic north and south poles of the earth.

3. magnetic equator : It is the great circle on the earth perpendicular to the magnetic axis

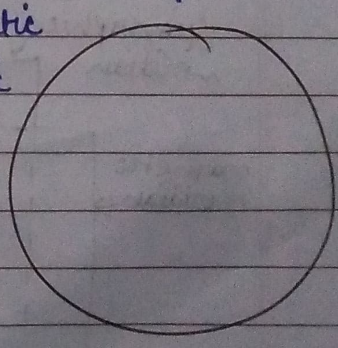
4. magnetic ~~p~~ meridian : The vertical plane passing through the magnetic axis of a freely suspended small magnet. The earth's magnetic field acts in the direction of the magnetic meridian.

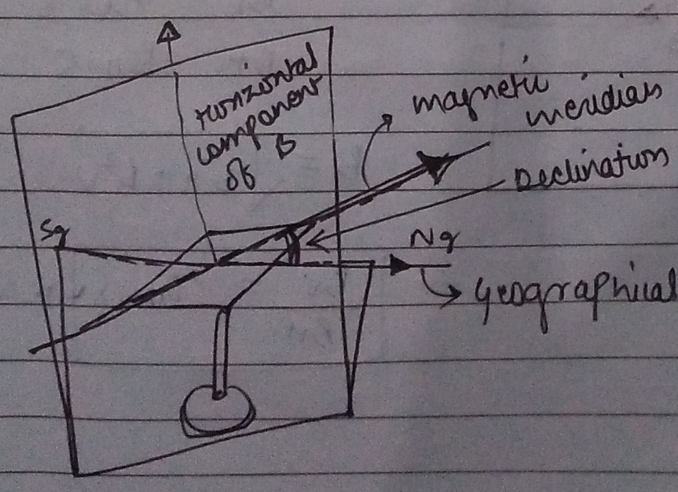
5. Geographic meridian : The vertical plane passing through the geographic north and south pole.



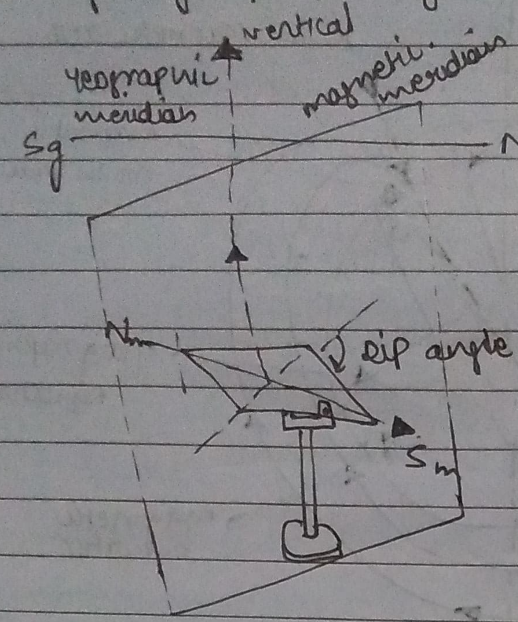
Elements of earth's magnetic field

Magnetic declination – ~~the axi~~ The angle between the geographical ~~axis~~ meridian and the magnetic meridian at a place is called magnetic declination (α)





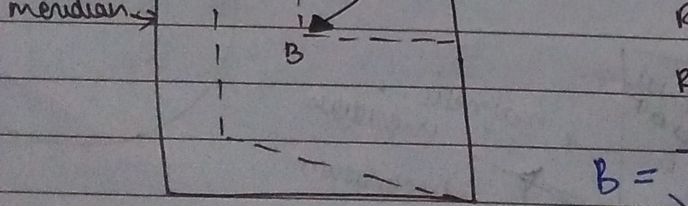
2. **Angle of dip or magnetic Inclination:**



The angle made by the earth's total magnetic field $\vec{B}$ with horizontal direction in the magnetic meridian is the angle of dip (δ) at any place.

3. **Horizontal component of the earth's magnetised field:**
It is the earth's total magnetic field $\vec{B}$ in the horizontal direction in the magnetic meridian. If δ is the angle of dip at any place, then the horizontal component of the earth's field $\vec{B}$ at the place is given by

$$B_H = B\cos\delta$$



$$B_H = B\cos\delta$$

$$B_H = B\sin\delta$$

$$B = \sqrt{B^2_H + B^2_V}$$

$$\boxed{\frac{B_V}{B_H} = \tan\delta}$$ → angle of dip

Q. A magnetic needle free to rotate in a verticle plane parallel to the magnetic meridian has its north tip down at 60° with the horizontal. The horizontal component of the earth's magnetic field at the place is known to be 0.4 G. Determine the magnitude of the earth's magnetic field at the place. [CBSE Delhi 2011]

$\delta = 60^\circ$

$B_H = 0.4\,G$ $\quad$ $\cancel{[B = B_H \cos\delta]}$

$B_H = 0.4 \times 10^{-4} T$

$B_H = B_e \cos\delta$

$0.4 \times 10^{-4} = B_e \cos 60^\circ$

$\frac{0.4 \times 10^{-4}}{\cos 60^\circ} = B_e$.

$B_e = \frac{0.4 \times 10^{-4} T}{0.5} = 0.8 \times 10^{-4} T = 0.8 G$.

Q. At a place, the horizontal component of earth's magnetic field is B and angle of dip is 60°. What is the value of horizontal component of the earth's magnetic field at equator? [CBSE Delhi 2017]

$B_H = B$

$\delta = 60^\circ$

$B_H = B_e \cos 60^\circ$

$B = B_e \times \frac{1}{2}$

$\boxed{2B = B_e}$

At equator, $\delta = 0^\circ$

$B_H = 2B \cos 0^\circ = 2B$.

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Magnetic properties of materials -

1. ~~Magnetised field~~ Magnetising field : When a magnetic ~~field~~ material is placed in a magnetic field a magnetism is induced in it.
The magnetic field that exists in vacuum and induces magnetism is called magnetizing field.

$$\boxed{B_0 = \mu_0 n I}$$

2. Magnetic induction - The total magnetic field inside a magnetic material is the sum of the external magnetizing field & the additional magnetic produced due to magnetisation of the material & is called magnetic induction B.

$$\boxed{B = B_0 + B_m}$$

current

$$B_0 = \mu_0 n I$$
$$B_m = \mu_0 n I_m$$

3. Magnetising field intensity : The ability of magnetising field to magnetise a material medium is expressed by a vector $\vec{H}$. Its magnitude ~~...~~ → ampere turns (nI)

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

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4. Intensity of Magnetization - The magnetic moment developed per unit volume of a material when placed in a magnetizing field is called intensity of magnetization.

$$\vec{M} = \frac{\vec{m}}{V}$$

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

5. Magnetic permeability : ~~The magnetic permeability~~ ratio of its magnetic induction B to the magnetic intensity H.

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

6. Relative Permeability : The ratio of the permeability of the medium to the permeability of free space.

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

7. Magnetic susceptibility : It is defined as the ratio of intensity of magnetization M to the magnetizing field intensity.

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

Relatⁿ betⁿ magnetic permeability & magnetic ~~suspec~~ susceptibility

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

$$B = \mu H$$

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

$$\mu = \mu_0 \left(1 + \frac{M}{H}\right) \Rightarrow \boxed{\mu = \mu_0 (1 + \chi_m)}$$

$$\mu_0 \mu_r = \mu_0 (1 + \chi_m)$$

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