CHAPTER

5

Magnetism and Matter

Important terms

(*a*) Magnetic field – Total no. of lines of Magnetic force per unit area

(*b*) Magnetizing field

$$\vec{H} = \frac{\vec{B}}{\mu} A/m$$

$\vec{H}$ is independent of medium

(*c*) Intensity of magnetization

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

$$\Rightarrow I = \frac{M}{V}$$

(*d*) Magnetic susceptibility,

$$\chi = \frac{I}{H}$$

(*e*) Magnetic permeability: The measure of the degree to which the lines of force can penetrate or permeate the medium

μ = permeability of medium

μ_0 = permeability of free space.

$$\boxed{|\vec{B}| = \mu_0 H + \mu_0 I = \mu H}$$

Relative Permeability.

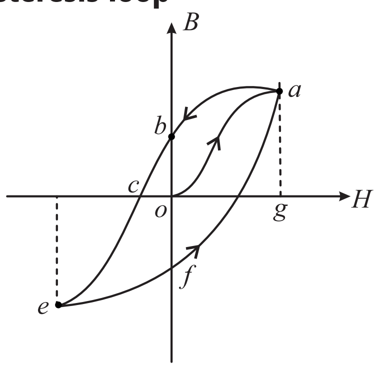
$$\mu_r = \frac{\mu}{\mu_0} = 1 + \chi$$

Magnetic Materials

Paramagnetic	Diamagnetic	Ferromagnetic
Feeble Magnetisation along $\vec{H}$	Feeble Magnetisation opposite of $\vec{H}$	Strong Magnetisation along $\vec{H}$
$0 < \chi < 1$	$-1 \le \chi < 0$	χ is of the order 10^3
$\mu_r > 1$	$0 < \mu_r < 1$	$\mu_r >> 1$
$\chi \propto \frac{1}{T}$	χ is Independent of T	$\chi = \frac{C}{T - T_C} (T > T_C)$

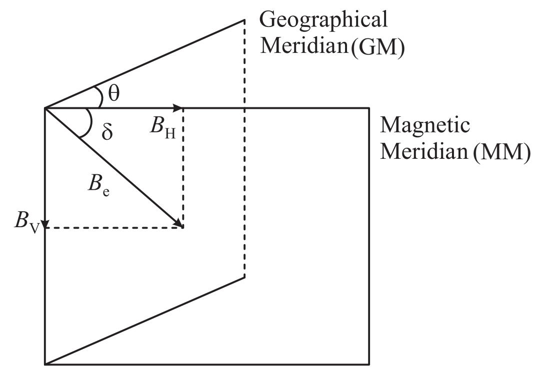
Here $T_C \rightarrow$ Curie temperature (above which a ferromagnetic material becomes paramagnetic.)

Hysteresis loop



- Retentivity = *ob*
- Coercivity = *oc*
- Area of loop = energy loss per unit volume per cycle.

Components of Earth's magnetic field



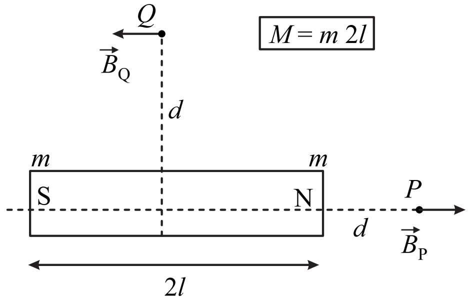
θ = Angle of declination (Angle between G.M and M.M)

δ = Angle of dip.

- $\tan\delta = \frac{B_V}{B_H}$
- $B_e = \frac{B_H}{\cos\delta}$
- $B_e = \sqrt{B_V^2 + B_H^2}$

Bar Magnet

(*a*) Magnetic field due to bar magnet.



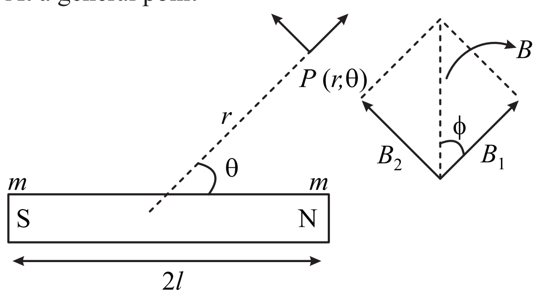
(i) $B_P = \left(\frac{\mu_0}{4\pi}\right)\frac{(4md)l}{(d^2-l^2)^2} = \frac{\mu_0}{4\pi}\frac{2Md}{(d^2-l^2)^2}$

If $l^2 << d^2 \Rightarrow$; $B_P = \frac{\mu_0}{4\pi}\frac{2M}{d^3}$

(ii) $B_Q = \frac{\mu_0}{4\pi}\frac{2ml}{(d^2+l^2)^{3/2}} = \frac{\mu_0}{4\pi}\frac{M}{(d^2+l^2)^{3/2}}$

If $l^2 << d^2$; $B_Q = \frac{\mu_0}{4\pi}\frac{M}{d^3}$

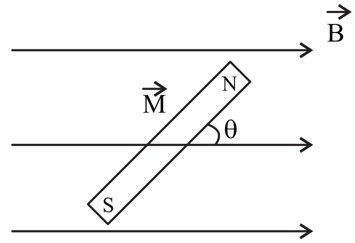
(iii) At a general point



$B = \frac{\mu_0}{4\pi}\cdot\frac{M}{r^3}\sqrt{1+3\cos^2\theta}$

$\tan\phi = \frac{\tan\theta}{2}$.

(*b*) Bar magnet in uniform magnetic field.



(i) Torque on bar magnet $\vec{\tau} = \vec{M} \times \vec{B}$

(ii) Potential energy $U = -\vec{M}.\vec{B}$

(iii) Work done in rotating the bar magnet

$W_{ext} = MB(\cos\theta_i - \cos\theta_f)$

(iv) Time period of small oscillations

$T = 2\pi\sqrt{\frac{I}{MB}}$

$I \rightarrow$ Moment of inertia of bar magnet