II PUC – CHAPTER 05
MAGNETISM AND MATTER

Bar magnet:

1) Magnetic moment of a bar magnet or a dipole is $m = 2\ell \times q_m$ (Am^2) (From S to N pole) where q_m is the pole strength (in Am) and 2ℓ is the magnetic length (distance between the poles) of the magnet.

2) **Magnetic field due to a bar magnet**

(a) at point on the axial line $B_a = \frac{\mu_o}{4\pi}\frac{2mr}{(r^2-\ell^2)^2}$ along dipole moment

(b) at point on the equatorial line $B_e = \frac{\mu_o}{4\pi}\frac{m}{(r^2+\ell^2)^{3/2}}$

This field is parallel to the axial line and opposite to the direction of magnetic moment.

m = magnetic dipole moment, r = distance of the point from the centre of the magnet, ℓ = semi magnetic length.

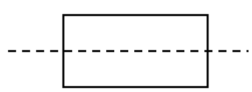
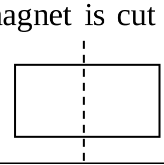
3) **Magnetic field due to a short bar magnet** ($r >> \ell$)

(a) at point on the axial line $B_a = \frac{\mu_o}{4\pi}\frac{2m}{r^3}$

(b) at point on the equatorial line $B_e = \frac{\mu_o}{4\pi}\frac{m}{r^3}$

(c) $B_a : B_e = 2 : 1$

4)

Initial pole strength = q_m Initial magnetic length = 2ℓ Initial magnetic moment = m	Pole strength	Magnetic Length	Magnetic moment
When the magnet is cut along its length 	$q_m/2$	2ℓ	m/2
When the magnet is cut perpendicular to its length 	q_m	ℓ	m/2

5) When a bar magnet of magnetic moment m is bent to form an arc which subtends an angle θ, then new magnetic moment is $m' = \frac{m}{\theta}\sin\left(\frac{\theta}{2}\right)$ (θ is in radian)

6) Period of oscillation of a bar magnet in a magnetic field, $T = 2\pi\sqrt{\frac{I}{mB}}$ where I is the moment of inertia, m is the magnetic moment and B is the magnetic induction.

7) Two magnets are placed one above the other with like poles facing each other (time period T_1)
Two magnets are placed one above the other with unlike poles facing each other (time period $T_2 > T_1$)

(i) $\frac{m_1}{m_2} = \frac{T_2^2+T_1^2}{T_2^2-T_1^2}$ (if $m_1 > m_2$) (ii) $\frac{m_1}{m_2} = \frac{T_2^2-T_1^2}{T_2^2+T_1^2}$ (if $m_2 > m_1$)

8) Moment of inertia of a bar magnet of mass M is $I = M\left[\frac{L^2+B^2}{12}\right]$

9) If length L >> breadth, then I = $\frac{ML^2}{12}$

10) Work done in rotating a suspended magnet in a uniform magnetic field B from one position to another is $W = mB(\cos\theta_1 - \cos\theta_2)$
m – magnetic moment, θ_1 and θ_2 – angle made by the needle with B in two positions.

11) Work done in rotating a suspended magnet from equilibrium position to an angle θ w.r.to the magnetic field B is $W = mB(1 - \cos\theta)$ where m is the magnetic moment.

12) Torque experienced by a suspended magnet in a uniform magnetic field B is
$\tau = mB\sin\theta$, where θ is the angle between the needle or m and B.

13) Magnetic potential energy of a magnet in a magnetic field is $U = - mB\cos\theta$
a) When $\theta = 0^o$, $U = -mB$ i.e. when dipole is aligned in the direction of magnetic field, energy stored in it is minimum.
b) When $\theta = 90^o$, $U = 0$ i.e. when dipole is aligned perpendicular to the magnetic field, energy stored in it is zero.
c) When $\theta = 180^o$, $U = mB$ i.e. when dipole is aligned opposite to the direction of magnetic field, energy stored in it is maximum.

14) **Gauss law in magnetism:** i.e. $\oint \vec{B}.\vec{ds} = 0$

Terrestrial magnetism

1) Components of the earth's magnetic field, B at a place along the horizontal drawn in the magnetic meridian is called the horizontal component B_H of the earth's field.
The component of B along the vertical is called the vertical component B_V of the earth's field.
$B_H = B\cos\theta$, $B_V = B\sin\theta$, $B = \sqrt{B_H^2 + B_V^2}$ and $\theta = \tan^{-1}\left(\frac{B_V}{B_H}\right)$
where θ is the angle made by B with B_H or magnetic dip

2) If θ_R and θ_A are real dip and apparent dip respectively, then $\tan\theta_R = \tan\theta_A \cos\delta$; δ is declination

3) If θ_{A1} and θ_{A2} are apparent dips in two mutually perpendicular planes then $\tan\delta = \frac{\tan\theta_{A1}}{\tan\theta_{A2}}$
or $\cot^2\theta_R = \cot^2\theta_{A1} + \cot^2\theta_{A2}$

4) When the plane of circular coil is along the magnetic meridian resultant magnetic field at the centre of the coil, $B_R = \sqrt{B_H^2 + B^2}$ where B is field due to the coil

5) When the plane of circular coil is perpendicular to the magnetic meridian resultant magnetic field at the centre of the coil, $B_R = B \pm B_H$

6) A neutral point is obtained at the centre of the coil if $B - B_H = 0$

Magnetic materials:

1) Magnetic intensity due to a solenoid $H = nI$
n = number of turns per unit length; I = current

2) If m_{net} is the net magnetic moment acquired by a material of volume V then, its magnetisation $M = \frac{m_{net}}{V}$

3) Magnetic susceptibility $\chi = \frac{M}{H}$

4) Absolute magnetic permeability $\mu = \frac{B}{H} = \mu_o(1 + \chi)$

5) $\mu_r = \frac{B}{B_o} = \frac{\mu}{\mu_o} = 1 + \chi$ where $B_o = \mu_o H$ and $B = \mu H$

6) Net magnetic field $B = B_o + B_m = \mu_o(H + M)$
where $B_m = \mu_o M$, is the magnetic flux density due to magnetisation M.

7) Susceptibility (χ) is inversely proportional to absolute temperature (T).

i.e. $\chi \propto \frac{1}{T}$ This is called Curie law.

Or χ T = Constant = C, This constant is called Curie constant

8) The susceptibility in paramagnetic phase is inversely proportional to excess temperature above critical temperature.

i.e. $\chi \propto \frac{1}{T - T_C}$ This is called Curie-Weiss law.

$\chi = \frac{C}{T - T_C}$ where C is a constant.