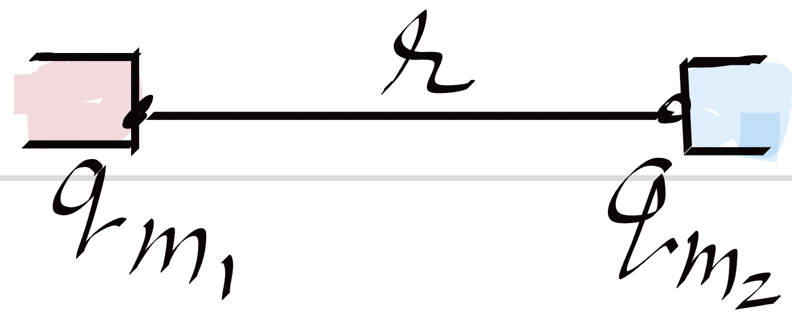
Ch. 5

Formula Sheet
Magnetism And Matter

1. Coulomb's Law In Magnetism

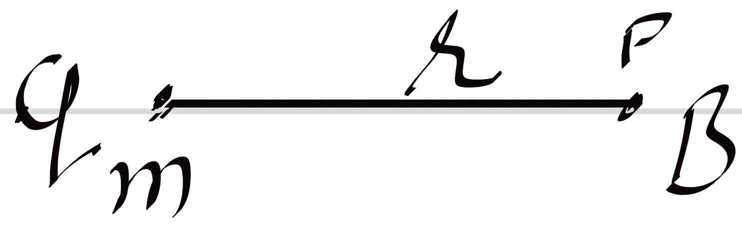
$$\boxed{F = \frac{\mu_0}{4\pi}\frac{q_{m_1} \times q_{m_2}}{r^2}}$$



q_{m_1} and q_{m_2} are pole strength

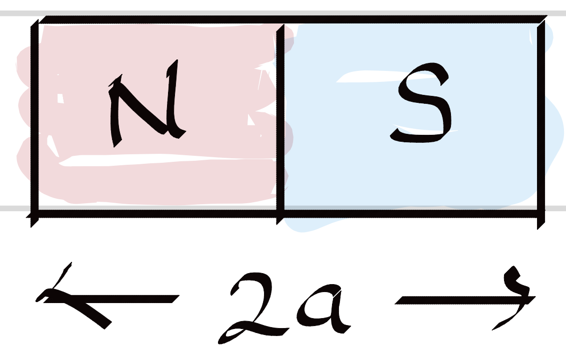
2. Magnetic Field Intensity At A Point

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



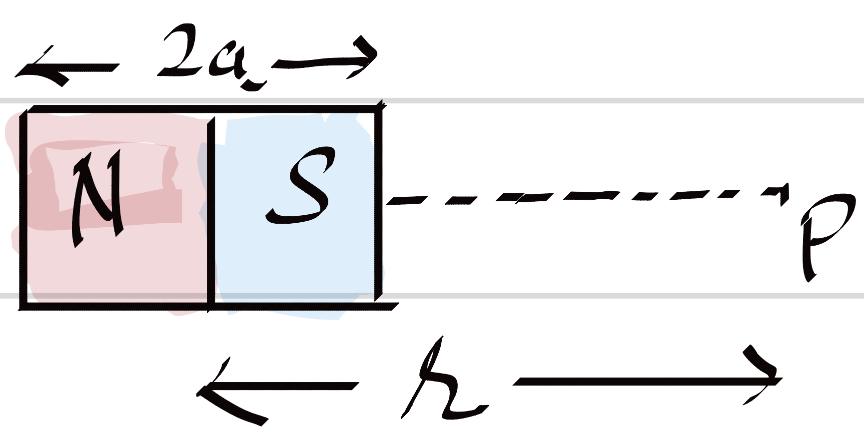
3. Magnetic Dipole Moment

$$\boxed{m = 2a \times q_m}$$



4. Magnetic Field At Axial Line

$$\boxed{B_{ax} = \frac{\mu_0}{4\pi}\frac{2mr}{(r^2-a^2)^2}}$$

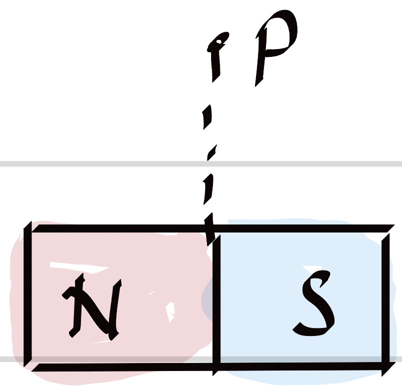


For short dipole

$$\boxed{B_{ax} = \frac{\mu_0}{4\pi}\cdot\frac{2m}{r^3}}$$

5. Magnetic Field on Equatorial Line

$$\boxed{B_{eq} = \frac{\mu_0}{4\pi} \cdot \frac{m}{(r^2 + a^2)^{3/2}}}$$



For short dipole, $\boxed{B_{eq} = \frac{\mu_0}{4\pi} \frac{m}{r^3}}$

6. Magnetic Moment of a Loop

$$\boxed{m = NIA}$$

$N \rightarrow$ no. of turns, $I \rightarrow$ current in loop, $A \rightarrow$ Area of loop

7. Magnetic field at the far axial field of a solenoid
And magnetic field at the axial point of a bar magnet

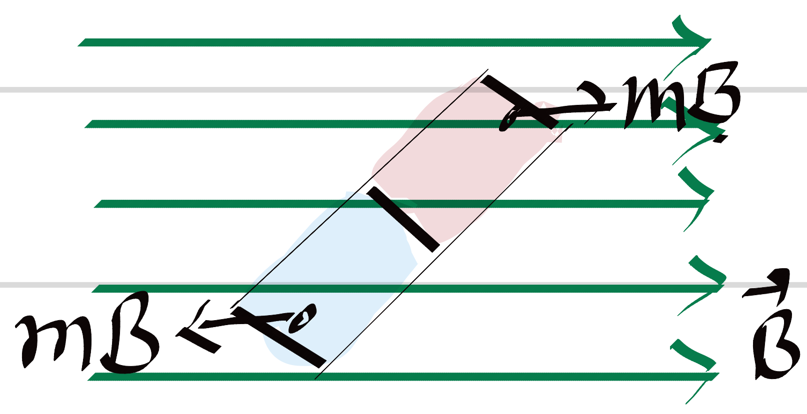
$$\boxed{B = \frac{\mu_0}{4\pi} \frac{2m}{r^3}}$$

$m \rightarrow$ magnetic moment
$r \rightarrow$ distance from the centre of a solenoid or barmagnet

(This formula shows $\rightarrow$ Bar magnet as an equivalent solenoid)

8. Dipole in a uniform magnetic field

(i) Torque on the dipole -



$$\boxed{\begin{aligned}\vec{\tau} &= \vec{m} \times \vec{B} \\ &= mB\sin\theta\end{aligned}}$$

(ii) Time period of the magnetic dipole

$$\boxed{T = 2\pi\sqrt{\frac{I}{mB}}}$$

or $$\boxed{B = \frac{4\pi^2 I}{mT^2}}$$

(iii) Magnetic Potential Energy

$$\boxed{\begin{aligned}U_m &= -mB\cos\theta \\ &= -\vec{m}\cdot\vec{B}\end{aligned}}$$

for $\theta = 0^\circ$, $U_m = -mB$

P.E is min^m (most stable position)

For $\theta = 180^\circ$, $U_m = +mB$

P.E is maximum (most unstable position)

9. Magnetic flux through any close surface

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

$B \rightarrow$ magnetic field

10. Magnetisation (M)

$$\boxed{M = \frac{m_{net}}{V}}$$, $m \rightarrow$ magnetic moment

$V \rightarrow$ volume

11. Magnetic Intensity (H)

$$\boxed{H = \frac{B}{\mu_0} - M}$$

* Unit of M and H $\rightarrow$ A/m

12. Total magnetic field

$$\boxed{B = \mu_0 (H + M)}$$

13. Magnetic Susceptibility (χ)

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

χ is dimensionless

For paramagnetic material χ is small and +ve

For diamagnetic material χ is small and -ve

14. Magnetic Permeability (μ)

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

$$B = \mu H$$

or $$\boxed{B = \mu_0 \mu_r H}$$ $\mu_r \rightarrow$ Relative permeability

here $$\boxed{\mu_r = 1 + \chi = B/B_0}$$

15. Curie Temperature T_c and Susceptibility χ

(The temp. of transition from ferromagnetic to paramagnetic)

$$\boxed{\chi = \frac{C}{T - T_c} \quad (T > T_c)}$$

where $C \rightarrow$ curie constant

$T \rightarrow$ Absolute temp.

By curie's law

$$\boxed{M = C \frac{B}{T}}$$

here $M \rightarrow$ magnetisation

$B \rightarrow$ magnetic field