Properties of Magnetism
Lecture – 2

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Potential at a point due to Magnetic Shell:

Let XY be a magnetic shell.

Let RSH is the S-polarity

Let LSH is the R-polarity

P is a point on LHS of the shell

Let shell may be considered as made up of a large number of dipoles placed side by side of length (t) which is equal to thickness of the shell.

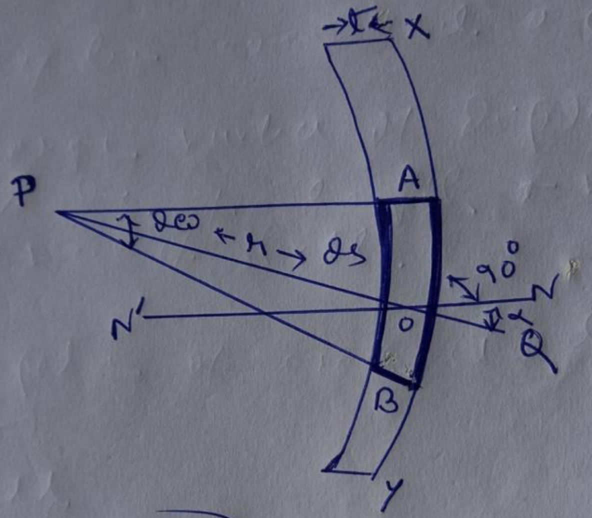

Fig ①

Let AB is dipole of cross-sectional area *ds*

So strength of the shell

$$\Omega = \sigma . t$$

Where σ is the surface density of magnetism or intensity of magnetization.

The magnetic moment of the elementary dipole is equal to ($\Omega . ds$) directed along the normal $NON^{/}$ of the surface.

Now the potential at P due to elementary magnet is

$$d\varphi = \frac{\mu_0}{4\pi} \frac{\Omega ds cos\Theta}{r^2}$$

$$= \frac{\mu_0}{4\pi} \Omega.\mathrm{d}\omega$$

Where dω is the solid angle subtended at point P

Therefore potential at point P due to whole shell is

$$\varphi = \frac{\mu_0}{4\pi} \int \Omega.\mathrm{d}\omega$$

ω is solid angle & φ is positive if P lies on positive pole side, it is negative if P lies on negative pole side. It depends on the periphery of the shell.

Relation between Permeability & Susceptibility:

What do you mean by Permeability & Susceptibility?

Permeability (μ) = B/H

Susceptibility (χ) = I_m/H

Now let us take magnetic substance in the form of a bar having its length in the direction of magnetization. Consider a cylindrical cavity inside the substance whose length *dl* is extremely small. The magnetic field is normal to the plan face of the cavity. Here we consider one face is inside the cavity & other face is outside the cavity.

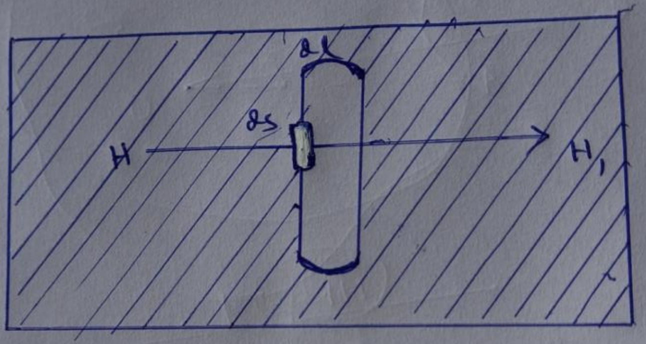

Fig (1)

Applying Gauss's Theorem on extremely small area *ds*, we get

$$\mu_0 H ds + H_1 ds = \mu_0 I_m ds$$

Where H_1 is field inside the cavity & is supposed to be uniform.

$$H_1 . ds = \mu_0 [H ds + I_m ds]$$

The lines of force per unit area inside a magnetic substance is known as magnetic induction (*B*). Hence H_1 can be identified as *B*. Here contribution from the side of the cavity is zero, because magnetic field *H* along the length of the cavity.

Therefore

$$B = \mu_0[H + I_m]$$

Again

$B = \mu H$

$I_m = \chi H$

$$\mu H = \mu_0[H + \chi H]$$
$$\mu H = \mu_0 H[1 + \chi]$$
$$\mu = \mu_0[1 + \chi]$$

This is relation between permeability & susceptibility

Gauss's Theorem in magnetism:

This theorem states,

The total normal magnetic induction over a closed surface is equal to μ_0 times the total magnetism inside the surface.

Let S is a closed surface of a medium of permeability μ

AB is an elementary area *ds* on the surface at a distance *r* from the point O, where an N-pole of strength *m* is placed. Let *H* be the intensity of the magnetic field at P making an angle Θ with the normal of the surface *ds* at P.

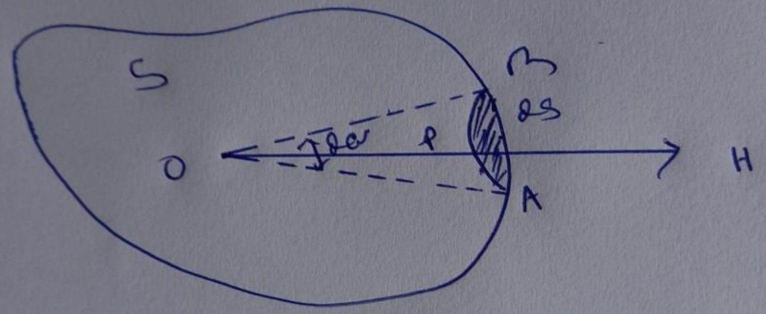

Fig (111)

Therefore normal induction over ds

$$= Hcos\theta ds$$

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

$$= \frac{\mu_0}{4\pi}md\omega$$

Where dω is the solid angle subtended at O by ds, m is the pole strength of N-pole $H = \frac{\mu_0}{4\pi}\frac{m}{r^2}$

Therefore The total normal induction over the surface S

$$= \int \frac{\mu_0}{4\pi} m d\omega$$

$$= \frac{\mu_0}{4\pi} m \int d\omega$$

$$= \frac{\mu_0}{4\pi} m \, 4\pi$$

$$= \mu_0 \, m$$

If the pole lies outside the closed surface, the total normal induction over the surface is zero, because the flux entering the closed surface & the outgoing flux are zero.