Lecture 11:

Steady State magnetic field, and Biot Sarvart Law

- Related YouTube Video Link:

1) https://www.youtube.com/watch?v=fK-FapfL_bk
2) https://www.youtube.com/watch?v=Q9J_2UU5bOk
3) https://www.youtube.com/watch?v=1kydon2HxQA
4) https://www.youtube.com/watch?v=Vaqmdrp6k68

- **Read 8.1 of the Given Book**

- **Lecture Notes on Next Page**

⇒ Steady state magnetic field
& Biot Savart law:-

1) Charge moving with constant velocity i.e. Constant current (or direct Current) in current carrying wires
2) Permanent magnets

} Produce steady magnetic field (i.e. constant with time)

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steady magnetic field

Biot-savart's Law
General ≃ for any current distribution
as
(colomb's Law in Electrostatic)

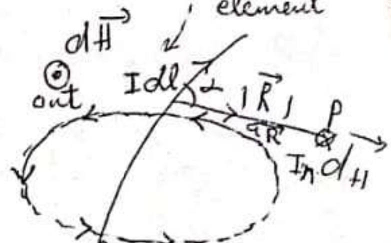
Ampere's circuit law
For only symmetrical current distribution as
(Gauss's Law in Electrostatic)

Applications: - Magnetostatic fields are used in
1) Development of motors
2) Microphones
3) Telephone ringers.
4) Transformers.
5) High speed velocity devices.
6) Electromagnetic pump & so on - - - -

Magnetic field Intensity $\vec{H} \approx \vec{E}$ Electric field intensity
(wb/m²) Magnetic flux density $\vec{B} \approx \vec{D}$ Electric flux density (c/m²)

⇒ BIOT SAVAR'T LAW:-

states that "The differential magnetic field intensity dH produced at a point P by the differential current Element $|\vec{Idl}|$ is proportional to the product Idl and sine of the angle b/w the element and the line joining P to the element and is inversely to the square of the distance R, between P & the element Idl.



Current Element $= Idl$ ---(magnitude)

So, $dH \propto \dfrac{Idl \sin\alpha}{R^2}$ --- magnitude

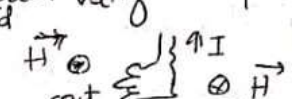
where $dH = \dfrac{k\, Idl \sin\alpha}{R^2}$

where K = constant of Proportionality

$K = \frac{1}{4\pi}$ in SI unit

$dH = \dfrac{Idl \sin\alpha}{4\pi R^2}$ --- Magnitude

Direction Using Right hand Rule:-

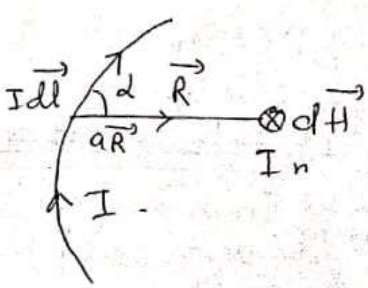


$\vec{H}$ (or $\vec{I}$) is out $\quad$ H (or I) is In

{ Conventional Representation }

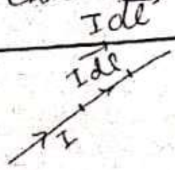
$$\vec{dH} = \frac{I\vec{dl} \times \vec{a_R}}{4\pi R^2}$$

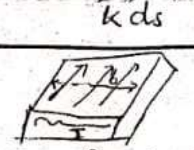
$$\vec{dH} = \frac{I\vec{dl} \times \vec{R}}{4\pi R^3} \quad ; \quad \vec{a_R} = \frac{\vec{R}}{|\vec{R}|}$$



Current distribution in Magnetostatics

Line Current	Surface Current	Volume Current
$I\vec{dl}$	$\vec{K}ds$	$\vec{J}dv$



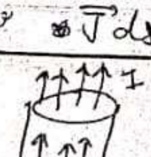


$\vec{K} \approx$ surface current density

$K = \frac{I}{b}$ $\quad$ $b = \perp$ to direction of current

$I = Kb$ → uniform surface

$I = \int K\, dN$ → non-uniform surface current density



$\vec{J} \approx$ volume current density

$$\vec{H} = \int_L \frac{I\,d\vec{l} \times a_R}{4\pi R^2} = \int_L \frac{I\,d\vec{l} \times \vec{R}}{4\pi R^3}$$ — line Current

or

$$\vec{H} = \int_S \frac{K\,ds \times \vec{a_R}}{4\pi R^2} = \int_S \frac{\vec{k}\,ds \times \vec{R}}{4\pi R^3}$$ — Surface Current

$$\vec{H} = \int_V \frac{\vec{J}\,dv \times \vec{a_R}}{4\pi R^2} = \int_V \frac{\vec{J}\,dv \times \vec{R}}{4\pi R^3}$$ — volume Current

Biot - Savart's Law

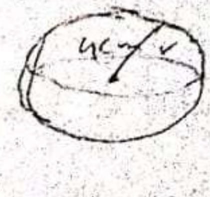
Q:- A Coper sphere of radius 4cm carries a uniformly distributes total charge of 5 μC on its surface in free space.

a) use Gauss's law to find $\vec{D}$ external to the sphere

b) Calculate the total energy stored in the electrostatic field.

c) Use $W_e = \frac{Q^2}{2C}$ to Calculate the capacitance of the isolated sphere.

a) $\vec{D} = \frac{Q}{4\pi r^2}\,\vec{a_r}$ (c/m²) → external to sphere.



$\vec{D} = \frac{5 \times 10^{-6}}{}$