PH1213

PHYSICS PRESENTATION

BATCH 3

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The **Biot Savart Law** is an equation describing the magnetic field generated by a constant electric current. It relates the magnetic field to the magnitude, direction, length, and proximity of the electric current. Biot–Savart law is consistent with both Ampere's circuital law and Gauss's theorem. The Biot Savart law is fundamental to magnetostatics, playing a role similar to that of Coulomb's law in electrostatics.

The **Biot-Savart law** can be stated as:

$$Hence,\ dB \propto \frac{Idl\sin\theta}{r^2} \quad or \quad dB = k\frac{Idl\sin\theta}{r^2}$$

Where, k is a constant, depending upon the magnetic properties of the medium of the units employed. In the SI system of unit,

$$k = \frac{\mu_o \mu_r}{4\pi}$$

Q. A current i flows in an infinitely long wire with a cross section in the form of a semi circular ring of radius R. The current is directed from the reader in front of the plane of drawing. Find the magnetic induction B on the axis.

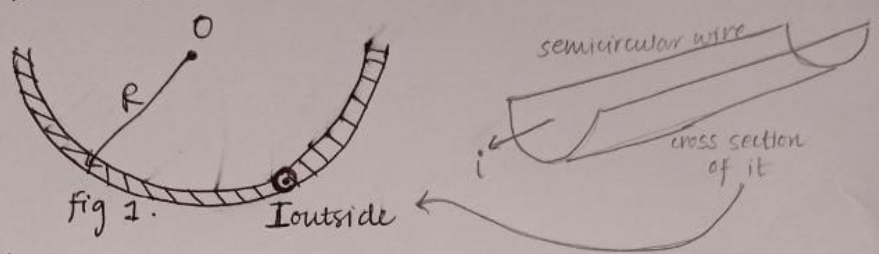


fig 1.

Total current flowing outside the plane of the paper $= I$

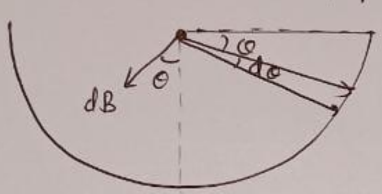


fig 2.

now for π rad, I flows

$\therefore$ for 1 rad, $\frac{I}{\pi}$ current flows.

$\therefore$ for $d\theta$ rad, $\frac{I}{\pi}d\theta$ current flows

let $\boxed{di = \frac{I}{\pi} d\theta}$ — ①

using right hand palm rule, we find the direction of dB due to small angle $d\theta$. Current is flowing outside the plane of paper. Let us take an element from angle theta and a very small angle $d\theta$. $\vec{dl} \times \vec{r}$ is shown in the figure. let dB be the magnetic field by $d\theta$.

now we know that $|B|$ for an infinite ring at a distance r is given by

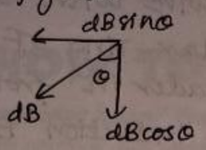
$$\boxed{|B| = \frac{\mu_0 i}{2\pi r}} \quad — ②$$

$$\therefore \text{for } |dB| = \frac{\mu_0 \, di}{2\pi r}$$

$$\therefore \boxed{|dB| = \frac{\mu_0 I \, d\theta}{2\pi^2 r}} \quad — ③$$

now we got the expression for dB. To find total magnetic field B, we will have to integrate dB from 0 to π.

from fig. 2a. the dB will have 2 components. Due to various different dθ elements, we will have different dB in different directions. we will have to integrate them separately and the add them.



$$dB\cos\theta = \frac{\mu_0 i}{2\pi^2 R}\cos\theta \cdot d\theta \qquad dB\sin\theta = \frac{\mu_0 i}{2\pi^2 R}\sin\theta \cdot d\theta$$

let $\boxed{B_y = dB\cos\theta}$ let $\boxed{B_x = dB\sin\theta}$

$$B_y = \int_0^{\pi} dB\cos\theta$$

$$= \frac{\mu_0 i}{2\pi^2 R}\int_0^{\pi}\cos\theta \cdot d\theta$$

$$= \frac{\mu_0 i}{2\pi^2 R}[\sin\theta]_0^{\pi}$$

$$= \frac{\mu_0 i}{2\pi^2 R} \times 0$$

$$\boxed{B_y = 0}$$

$$B_x = \int_0^{\pi} dB\sin\theta$$

$$= \frac{\mu_0 i}{2\pi^2 R}\int_0^{\pi}\sin\theta \cdot d\theta$$

$$= \frac{\mu_0 i}{2\pi^2 R}[-\cos\theta]_0^{\pi}$$

$$= \frac{\mu_0 i}{2\pi^2 R} - [\cos\pi - \cos 0]$$

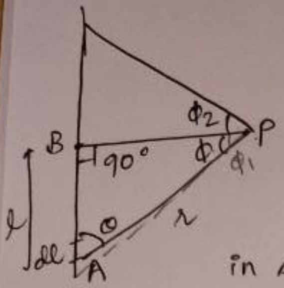
$$= \frac{\mu_0 i}{2\pi^2 R} \times 2$$

$$\boxed{\therefore B_x = \frac{\mu_0 i}{\pi^2 R}}$$

$$\boxed{\therefore B_{net} = \frac{\mu_0 i}{\pi^2 R}}$$ → The magnetic induction along the axis.

We used B for infinite wire at point p as $B = \frac{\mu_0 I}{2\pi R}$.

The derivation of the formula is,



$$|\vec{B}| = \frac{\mu_0 I}{2\pi R}$$

proof:

Biot savart's law.

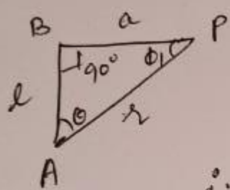
$$\boxed{dB = \frac{\mu_0}{4\pi} \frac{idl \sin\theta}{r^2}} \quad \text{—①}$$

in ΔABP $\quad 90° + \phi + \theta = 180°$

$$\theta = 90 - \phi$$

$$\therefore \sin\theta = \sin(90-\phi)$$

$$\therefore \boxed{\sin\theta = \cos\phi} \quad \text{—②}$$



$$\tan\phi = \frac{l}{a}$$

$$\cos\phi = \frac{a}{r}$$

$$\therefore \boxed{r = \frac{a}{\cos\phi}} \quad \text{—④}$$

$$\therefore l = a\tan\phi$$

$$\therefore \boxed{dl = a\sec^2\phi\, d\phi} \quad \text{—⑤}$$

Here $\sec\phi = \frac{1}{\cos\phi}$

$$\therefore dB = \frac{\mu_0}{4\pi} \frac{I a \sec^2\phi\, d\phi \cos\phi}{\frac{a^2}{\cos^2\phi}}$$

integrating both sides

$$\therefore \int dB = \int \frac{\mu_0}{4\pi} \frac{I}{a} \cos\phi\, d\phi$$

$$\therefore B = \int_{-\phi_1}^{\phi_2} \frac{\mu_0}{4\pi} \frac{I}{a} \cos\phi\, d\phi$$

$$= \frac{\mu_0}{4\pi} \frac{I}{a} [\sin\phi]_{-\phi_1}^{\phi_2}$$

$$\therefore \boxed{B = \frac{\mu_0}{4\pi} \frac{I}{a} [\sin\phi_2 + \sin\phi_1]}$$

for infinitely long wire, $\phi_1 = \phi_2 = 90°$

$$\boxed{\therefore B = \frac{\mu_0}{4\pi} \frac{2I}{a}} \Rightarrow \boxed{\therefore B = \frac{\mu_0 I}{2\pi a}}$$

Hence proved.

THANK YOU