Answer on Question #38152, Physics, Other

Question:

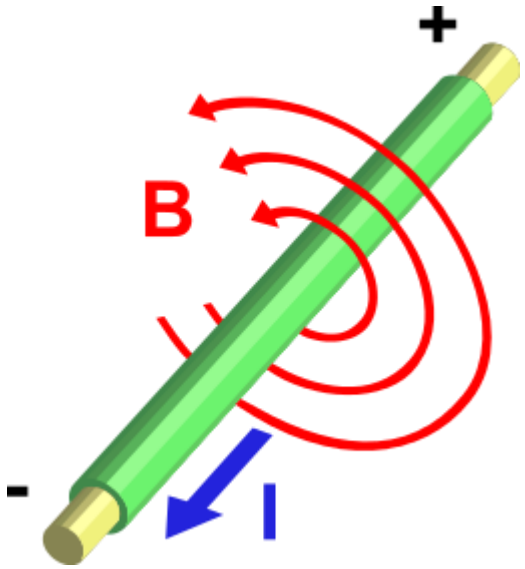
A wire of finite length l carrying current I produces magnetic field of B Tesla at a distance of 10 cm on the perpendicular bisector of its length. If this wire is converted into a circular loop of single turn, find the expression for the magnetic field at its center.

Answer:

Ampere's Law:

The integral of B around any closed mathematical path equals μ_0 times the current intercepted by the area spanning the path

For wire of finite length l carrying current I magnetic field at distance $r = 10\ cm$ equals:



$$2\pi r B_1 = \mu_0 I$$

$$B_1 = \frac{\mu_0 I}{2\pi r} \qquad (\mu_0 I = 2\pi r B_1)$$

Biot–Savart law:

$$B = \frac{\mu_0}{4\pi} \int \frac{d\vec{I} \times \vec{r}}{|r|^2}$$

For circular loop with radius $R = \frac{l}{2\pi}$ carrying current I magnetic field at its center equals:

$$B_2 = \frac{\mu_0}{4\pi} I \frac{2\pi R}{R^2} = \frac{\mu_0 I}{2R} = \frac{\pi \mu_0 I}{l}$$

$$B_2 = \frac{\pi \mu_0 I}{l} = \frac{2\pi^2 r}{l} B_1$$

Answer: $B_2 = \frac{2\pi^2 r}{l} B_1$