REMF

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Background

Faraday's law of EM induction

$$\epsilon = \frac{-d\varphi}{dt}$$

where ϵ - emf
φ - mag flux

$$\varphi = \oint_S B \cdot dA$$

$$\nabla \times E = \frac{-dB}{dt}$$

$$\text{or } \varphi = \oint_{\partial S} E \cdot dl = \frac{-d}{dt} \oint_S A \cdot dA$$

we know emf can be induced by changing $\vec{B}$ field

if $\frac{d\vec{B}}{dt} \neq 0 \rightarrow \epsilon$

Questions

5. Using:

$$\epsilon = \int_0^r (\underline{v} \times B) \cdot d\vec{s}$$

where $V = r \times \omega$

$$\rightarrow \epsilon = \frac{r^2 \omega B}{2}$$

$$I = \frac{|\epsilon|}{R} = \frac{r^2 \omega B}{2R}$$

resistance

6. Using Biot-Savart

$$B = \frac{\mu_0 I r^2}{2(r^2+x^2)^{3/2}} \longrightarrow \frac{\mu_0 I n r^2}{2(r^2+x^2)^{3/2}}$$ for n turns in coil

For halfway point in HC $x = r/2$

$$\rightarrow B = \frac{\mu_0 I n r^2}{2\left[r^2 + \left(\frac{r}{2}\right)^2\right]^{3/2}}$$

$$B_T = 2B = \frac{\cancel{2}\mu_0 I n r^2}{\cancel{2}\left[r^2+\left(\frac{r}{2}\right)^2\right]^{3/2}} = \frac{\mu_0 I n r^2}{\left[r^2 + \frac{r^2}{4}\right]^{3/2}}$$

$$\rightarrow B_T = \frac{\mu_0 I n r^2}{\left(\frac{5r^2}{4}\right)^{3/2}} = \frac{\mu_0 I n}{r}\left(\frac{4}{5}\right)^{3/2}$$

$$\therefore B_T = \left(\frac{8}{5\sqrt{5}}\right)\frac{\mu_0 I n}{r}$$

7. We know ϵ is induced from change in flux of B field, which is indirectly dependent on time.

8. The direction of $\vec{B}$ will rotate with the coils