quasi static currents

7.12 ; 7.15 ; 7.34

Law of solenoids    gaps in conductors

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Phys 330

# Homework 6 Chapter 7

7.12). solenoid radius $a$

field inside $B(t) = B_0 \cos(\omega t)\hat{z}$

radius $a/2$ Resistance $R$

magnetic flux $= \phi = B \cdot A$

induced emf $= \mathcal{E} = -\frac{d\phi}{dt}$

$A = \pi\left(\frac{a}{2}\right)^2 \hat{z}$    $B_0 \cos(\omega t)\hat{z}$ for $\bar{B}$ and $\pi\left(\frac{a}{2}\right)^2 \hat{z}$

$= B_0 \frac{\pi a^2}{4} \cos(\omega t)$

as a function of time

$B_0 \frac{\pi a^2}{4} \cos(\omega t)$ for $\phi$   $\mathcal{E} = -\frac{d\phi}{dt}$

$\mathcal{E} = -\frac{d}{dt}\left[B_0 \frac{\pi a^2}{4} \cos(\omega t)\right] = \frac{\pi B_0 \omega a^2}{4} \sin(\omega t)$ emf as a function of time

$I(t) = \frac{\mathcal{E}}{R}$   $\frac{\pi B_0 \omega a^2}{4} \sin \omega t$   $I(t) = \frac{\mathcal{E}}{R}$

$$\boxed{= \frac{\pi B_0 \omega a^2}{4R} \sin \omega t}$$

7.15). radius $a$   $n$ turns per unit length

current $I$

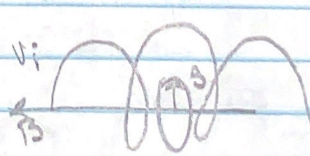
Efield, magnitude & direction

$s < a$

$B(s) = \mu_0 n I$   $\mu_0$ = magnetic permeability

$\phi = B \cdot A$

$\phi$ = magnetic flux   area $= A = \pi r^2$




$$\phi = \begin{cases} \mu_0 n I (\pi s^2) & s < a \\ \mu_0 n I (\pi a^2) & s > a \end{cases}$$

inside solenoid $s<a$ $-\frac{\partial \Phi}{\partial t} = E \oint dl$

$$-\frac{\partial}{\partial t}(B\,A) = E \oint dl$$

$$B = \mu_0 n I$$
$$A = \pi s^2$$

$$-(\pi s^2)\left(\mu_0 n \frac{dI}{dt}\right) = E(2\pi s)$$

$$\frac{-s}{2}\mu_0 n \frac{dI}{dt}\hat{\phi} = E_{inside}$$

$s>a$ $\frac{\partial \Phi}{\partial t}$

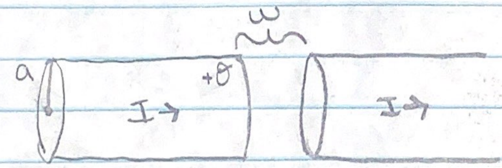
$$-\frac{\partial \Phi}{\partial t} = E \oint dl \qquad B \cdot A \frac{\partial \Phi}{\partial t}$$

Stokes theorem: $-\frac{\partial}{\partial t}(B\,A) = E \oint dl$ $\mu_0 n I$ for B and $\pi a^2$ for A

$$-(\pi a^2)\left(\mu_0 n \frac{dI}{dt}\hat{\phi}\right) = E(2\pi s)$$

$$\boxed{E = \frac{-\pi a^2 \mu_0 n}{2\pi s}\frac{dI}{d\phi}}$$

7.34).




$$J_d = \varepsilon_0 \frac{dE}{dt} = \frac{I}{A} \qquad A = \pi a^2$$

$$J_d = \frac{I}{\pi a^2}\hat{z}$$

$$\oint B \cdot dl = B(2\pi s) = \mu_0 I_{dенc}$$

$$J_d(\pi s^2) = I_{denc}$$

$$B(2\pi s) = \mu_0 J_d(\pi s^2)$$
$$= \mu_0 \frac{I}{\pi a^2}\pi s^2$$
$$= \mu_0 I \frac{s^2}{a^2}$$

$$\boxed{B = \frac{\mu_0 I s}{2\pi a^2}}$$