Fields and Waves

Lesson 3.8

ENERGY and FORCE

Darryl Michael/GE CRD

ENERGY

Power in inductor:

$$P = I \cdot V = I \cdot L \cdot \frac{dI}{dt} = \frac{d}{dt}\underbrace{\left(\frac{1}{2} \cdot L \cdot I^{2}\right)}_{\text{energy in Inductor}}$$

Obtain energy in terms of <u>B</u> and <u>H</u> fields

Flux linkage: $\Lambda = L \cdot I = B \times Area \times N$

Also, $I = \frac{\oint \vec{H} \bullet d\bar{l}}{N} = \frac{H \cdot length}{N}$

ENERGY

Energy =

$$\frac{1}{2}\cdot L\cdot I^{2}=\frac{1}{2}\cdot(L\cdot I)\cdot I=\frac{1}{2}\cdot(B\times Area\times N)\cdot\left(\frac{H\times Length}{N}\right)$$

$$=\frac{1}{2}\cdot\int\vec{B}\bullet\vec{H}\cdot dv=W_{m}$$

VOLUME

Energy stored in Magnetic field

Energy Density: (per unit volume)

$$w_{m}=\frac{1}{2}\cdot\vec{B}\bullet\vec{H}=\frac{1}{2}\cdot\frac{B^{2}}{\mu}=\frac{1}{2}\cdot\mu\cdot H^{2}$$

Do problem 1a

PROBLEM

For problem 1b:

Difficult to use flux linkage method to compute Inductance

- not all I intersects same flux
- have to add contributions carefully

SIMPLER WAY:

$$\frac{1}{2} \cdot L \cdot I^2 = W_m$$

known quantities

FORCE

First approach - similar to that for individual particles

For one particle: $\vec{F} = q \cdot (\vec{v} \times \vec{B})$

For many particles: $\dfrac{\vec{F}}{volume} = \rho \cdot (\vec{v} \times \vec{B}) = \vec{j} \times \vec{B}$

Second approach - <u>F</u> does work and changes energy

$Work = \int \vec{F} \bullet d\vec{l}$ → Calculate W_m for 2 configurations with small δx difference

$\Delta W_m = F \cdot \delta x$ → $F = \dfrac{\Delta W_m}{\delta x}$

Do Problem 2