Fields and Waves

Lesson 3.5

INDUCTANCE

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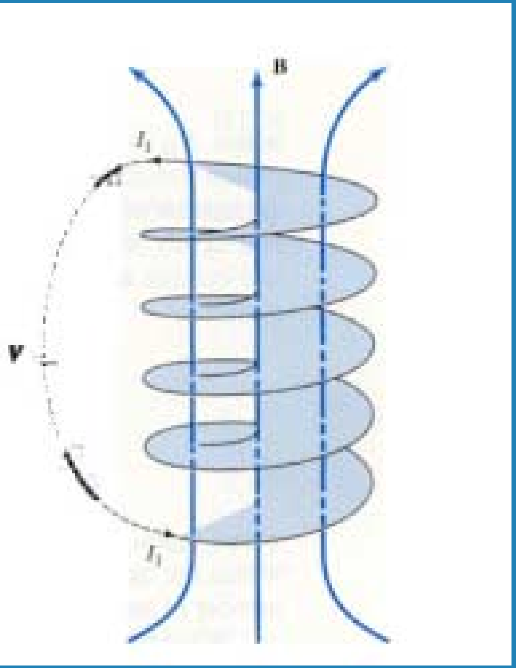
Inductances

Two types of Inductances:

- self inductance - e.g. inductors
- mutual inductance - e.g. transformers

Self Inductance:

- coil of wire with I_1 , creates $\vec{B}$
- wire loop intersects $\int \vec{B} \bullet d\vec{s}$
- this creates $e.m.f. = -\frac{d}{dt}\int \vec{B} \bullet d\vec{s}$



Self Inductance

Do Problem 1

$$\oint \vec{E} \bullet d\vec{l} = e.m.f. = -\frac{d}{dt}\int \vec{B} \bullet d\vec{s} = -\frac{d\Psi}{dt}$$

For 1 turn: $= -\frac{d}{dt}\left(\frac{\Psi}{I}\right) \cdot I = -\frac{d}{dt}(L \cdot I)$

For N turns: $= \frac{d\sum\Psi}{dt} = \frac{d\Lambda}{dt}$, and $L = \frac{\Lambda}{I}$

Since $\vec{B} \propto I$ $\therefore \Psi, \Lambda \propto I$ → $L = \frac{\Lambda}{I}$ is independent of I

L depends on materials (through μ) and geometry (like *C*)

Self Inductance

In general:

$L \propto N^2$, because

- x N, because $\vec{B} \propto N$
- x N, because $\Lambda = \sum \Psi = N \cdot \Psi$

Note: To calculate L, don't need Faraday's Law just need: $L = \frac{\Lambda}{I}$

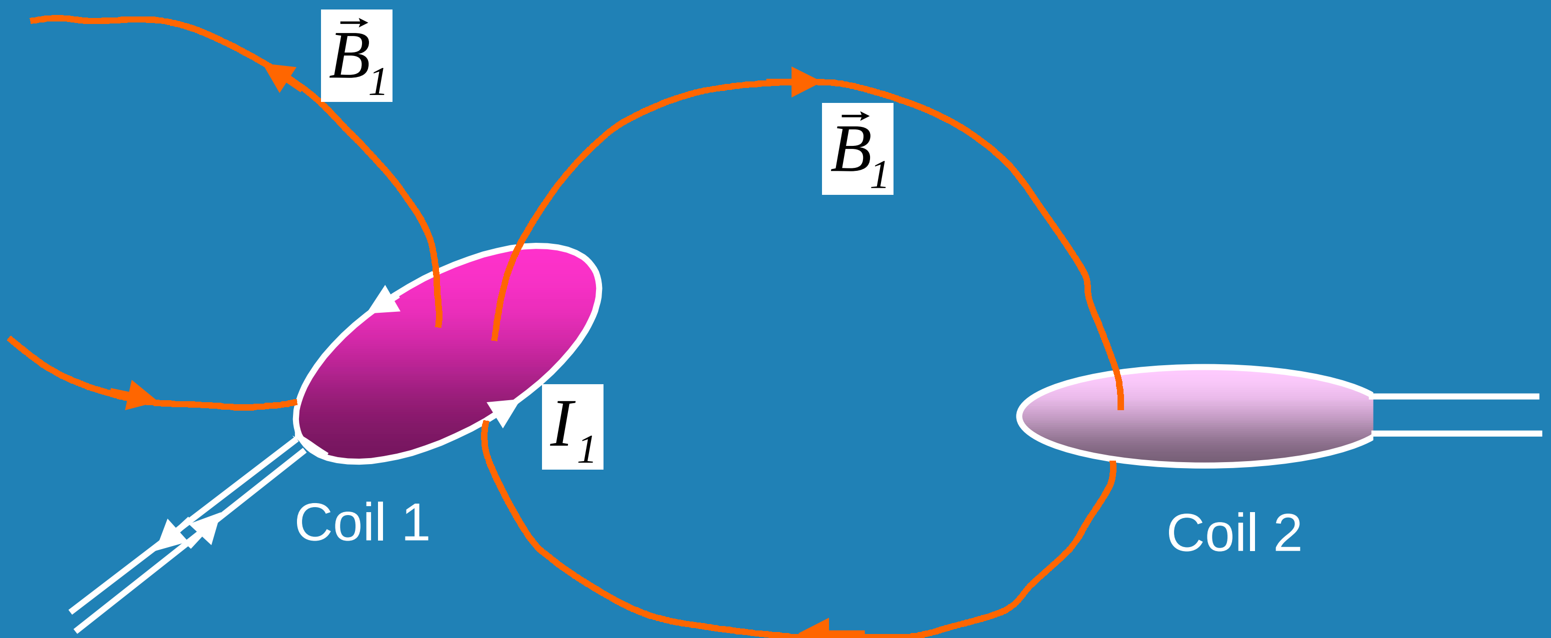
The flux linkage, $\Lambda = N \cdot \Psi$, only if all loops intersect same flux

- not true for finite solenoid and will need: $\Lambda = \sum \Psi$

Computation of $\Psi = \int \vec{B} \bullet d\vec{s} = \oint \vec{A} \bullet d\vec{l}$ ⇨ Can use either method

Do problem 2

Mutual Inductance



Mutual Inductance:

Current through Coil 1
induces e.m.f. in Coil 2

Mutual Inductance

$$L_{21} = \frac{\Lambda_{21}}{I_1}$$ where, $$\Lambda_{21} = \int \vec{B}_1 \bullet d\vec{s}_2$$

L_{21} → Mutual Inductance

Also, $$emf_2 = L_{21} \cdot \frac{dI_1}{dt}$$

And, $$L_{12} = L_{21}$$

Do Problem 3b