Physics 142 – November 15, 2007

- Exam 2 graded
- $\langle 80 \rangle$ = Ave grade   Nice job

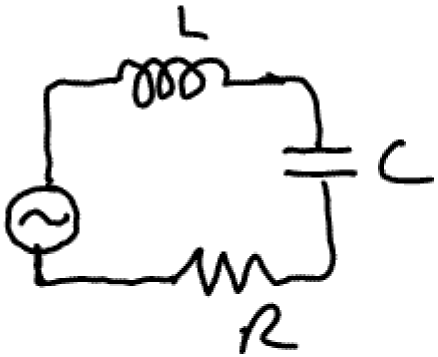
  → Remember that this gets renormalized to 70 ...

Waves ? $\rightsquigarrow e^{i(kx-\omega t)}$

geometric optics ?

physical optics ?

Last Time -



$$\mathcal{E} = \mathcal{E}_{max} \sin \omega t$$

general Expression $I = I_{max} \sin(\omega t + \phi)$

Unknown

$$\mathcal{E} = \Delta V_R + \Delta V_C + \Delta V_L$$

$$\mathcal{E}_{max} \sin \omega t = R I_{max} \sin(\omega t + \phi) - X_C I_{max} \cos(\omega t + \phi) + X_L I_{max} \cos(\omega t + \phi)$$

Acts as "Resistance" of capacitor

Acts as "Resistance" of Inductor

$$\tan \phi = \frac{X_L - X_C}{R}$$

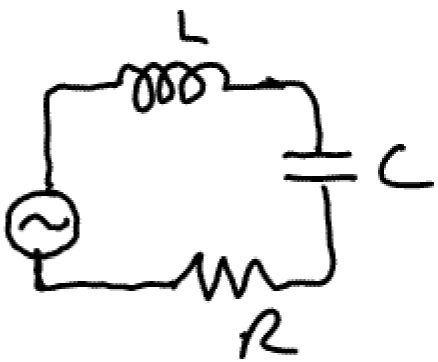
$$I_{max} = \frac{\mathcal{E}_{max}}{\sqrt{R^2 + (X_L + X_C)^2}}$$

$$\boxed{Z \equiv \sqrt{R^2 + (X_L + X_C)^2}}$$

Impedance

Acts as TOTAL Resistance of LRC circuit

Last Time -



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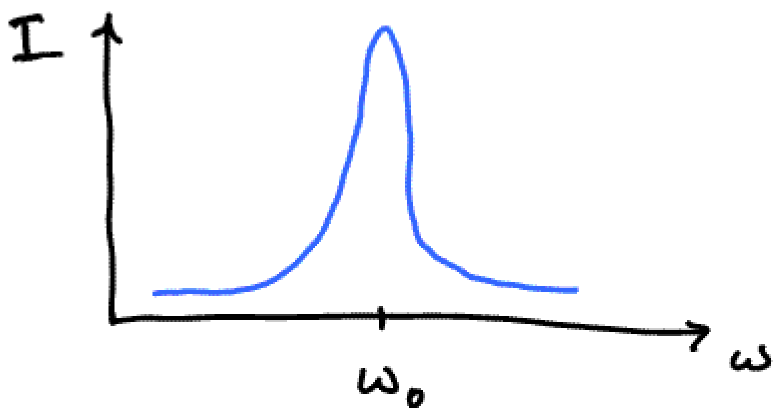
Impedance

Acts as total Resistance of LRC circuit

when $\omega \to \omega_0 = \frac{1}{\sqrt{LC}}$ (Natural frequency of the LC circuit)

I gets Maximized $\rightarrow$ Resonance

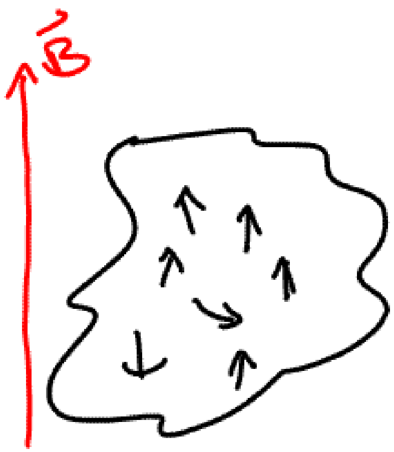


circuits have natural frequency + Bandwidth

Magnetism in Materials

Paramagnetic

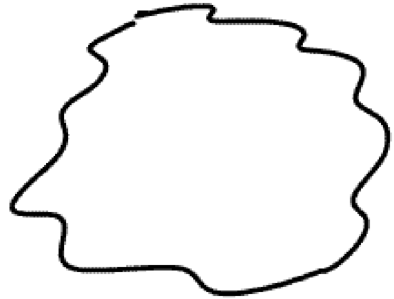
Natural Dipoles



Torque from $\vec{B}$
Aligns more Dipoles along $\vec{B}$

$\Rightarrow \vec{B}$ increased

Diamagnetic



No Dipole

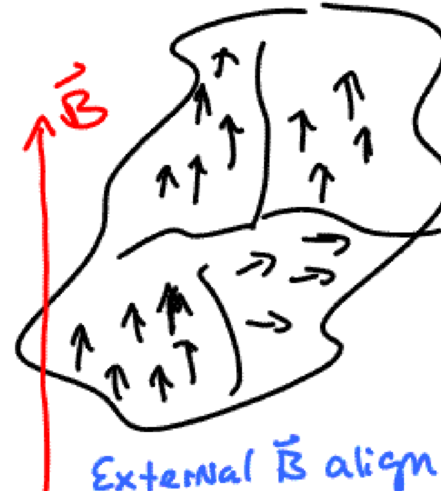
Induced Dipoles

Oppose External $\vec{B}$

$\Rightarrow \vec{B}$ weakened

Ferromagnetic

Strong Dipoles in Domains of local Alignment



External $\vec{B}$ aligns more Domains along $\vec{B}$

$\Rightarrow \vec{B}$ increased

$$B = \mu_0 (1+\chi_m) B_{free}$$

External $\vec{B}$

Magnetic Susceptibility

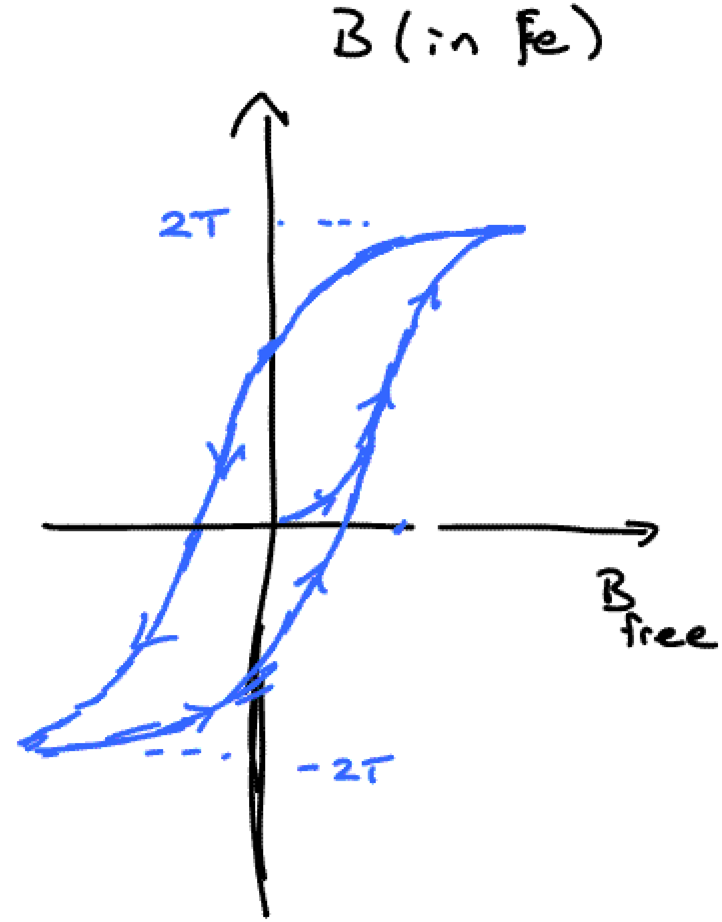
relative permeability $= K_m$

$K_m \gtrsim 1$ Paramagnetism

$\gg 1$ Ferromagnetism

< 1 Diamagnetism

$\mu_0 K_m \sim$ permeability $\to \mu$



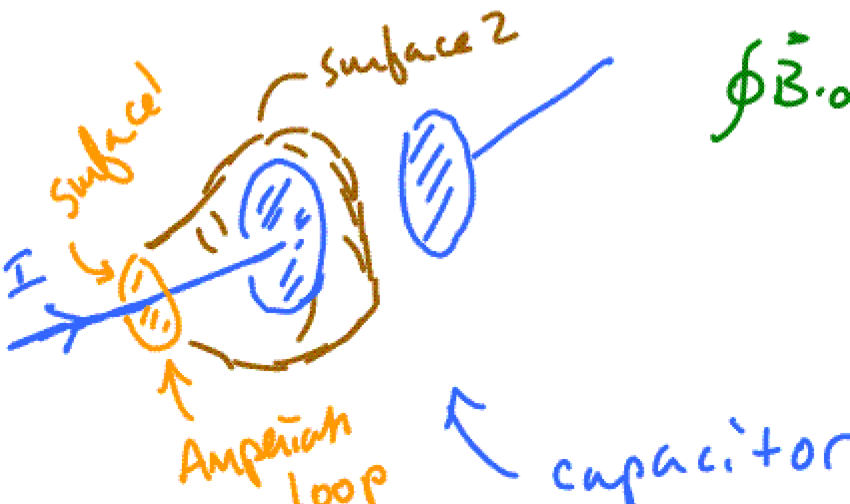
Hysteresis Loop

$$\oint_S \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$ Gauss' law

$$\oint_S \vec{B}\cdot d\vec{A} = 0$$ nature has No Magnetic Monopole

$$\oint_C \vec{B}\cdot d\vec{\ell} = \mu_0 I_{encl}$$ Ampere's law

$$\oint_C \vec{E}\cdot d\vec{\ell} = -\frac{d\Phi_M}{dt} = -\frac{d}{dt}\int_S \vec{B}\cdot d\vec{A}$$ Faraday's law



$$\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I + \underbrace{\mu_0 \epsilon_0 \frac{d}{dt}\int_S \vec{E}\cdot d\vec{A}}_{\mu_0 I}$$

imagine Q on plat

$$\int E\cdot dA = Q/\epsilon_0$$

Maxwell's Displacement Current

$$\oint_S \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

$$\oint_S \vec{B}\cdot d\vec{A} = 0$$

$\int \vec{j}\cdot d\vec{A}$ ($j \equiv$ current density)

$$\oint_C \vec{B}\cdot d\vec{l} = \mu_0 I_{encl} + \mu_0\epsilon_0 \frac{d}{dt}\int \vec{E}\cdot d\vec{A}$$

$$\oint_C \vec{E}\cdot d\vec{l} = -\frac{d}{dt}\int \vec{B}\cdot d\vec{A}$$

Integral form of Maxwell's Equations

Gauss' Law

$$\oint \vec{E}\cdot d\vec{A} = \frac{q_{encl}}{\epsilon_0}$$

Gauss' Theorem
Green's theorem
divergence Theorem

$$\int_{vol} (\vec{\nabla}\cdot\vec{v})\, dv = \int_{surf} \vec{v}\cdot d\vec{A}$$

$$\text{del} \equiv \vec{\nabla} \equiv \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}$$

$\vec{\nabla}\cdot\vec{v}$ $\downarrow$ divergence of $\vec{v}$

$$\vec{\nabla}\cdot\vec{v} = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z}$$

Scalar

Measure of this

$$\oint_S \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$$

$$\int_V \vec{\nabla}\cdot\vec{E}\, dv = \frac{Q_{encl}}{\epsilon_0} \leftarrow \int \rho\, dv$$

$$\boxed{\vec{\nabla}\cdot\vec{E} = \frac{\rho}{\epsilon_0}}$$

differential form of Gauss' Law

$$\boxed{\vec{\nabla}\cdot\vec{B} = 0}$$

same for $\vec{B}$

$\vdots$

will do differential form
of other two Maxwell's eqns
next time