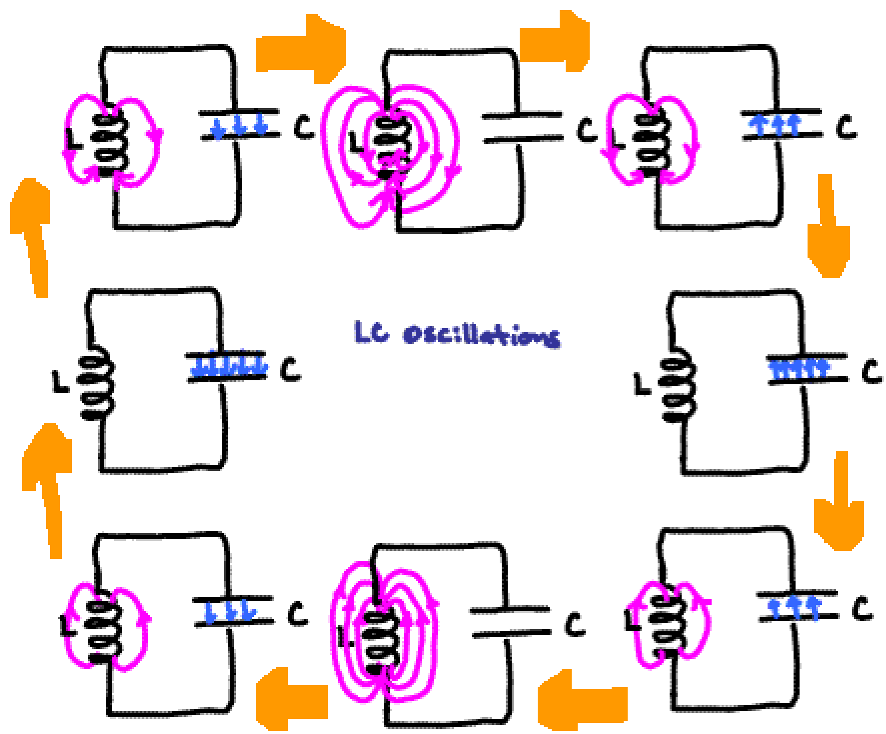
Physics 142 - November 1, 2005

AC circuits, Magnetic fields in Materials

Last time — u_B = Energy density in B field

$$u_B = \frac{B^2}{2\mu_0}$$

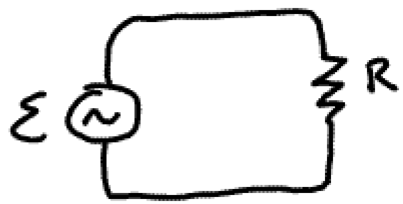
LC circuit



LC oscillations

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

AC Circuits



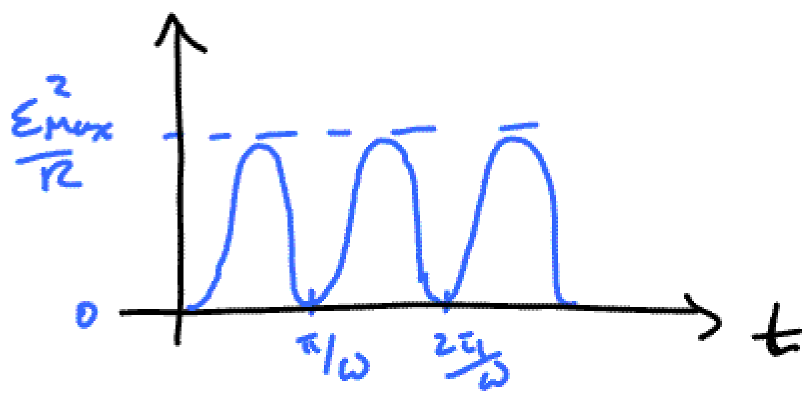
$$\mathcal{E} = \mathcal{E}_{max} \sin \omega t$$

Kirchoff $\quad \mathcal{E} - IR = 0$

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

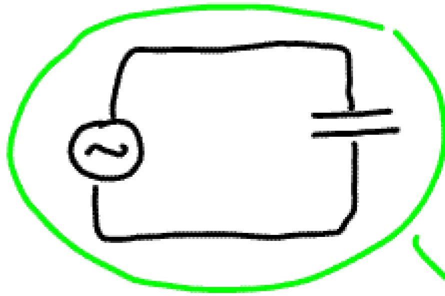
Instantaneous Power Dissipation

$$P = IV = I\mathcal{E} = \frac{\mathcal{E}_{max}^2}{R} \sin^2 \omega t$$



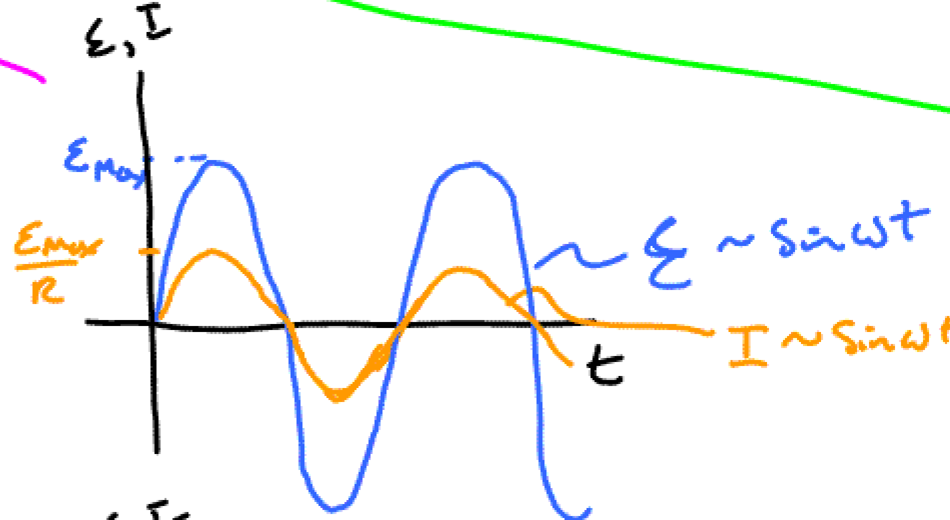
$$\overline{\sin^2 \theta} \rightarrow \frac{1}{2}$$

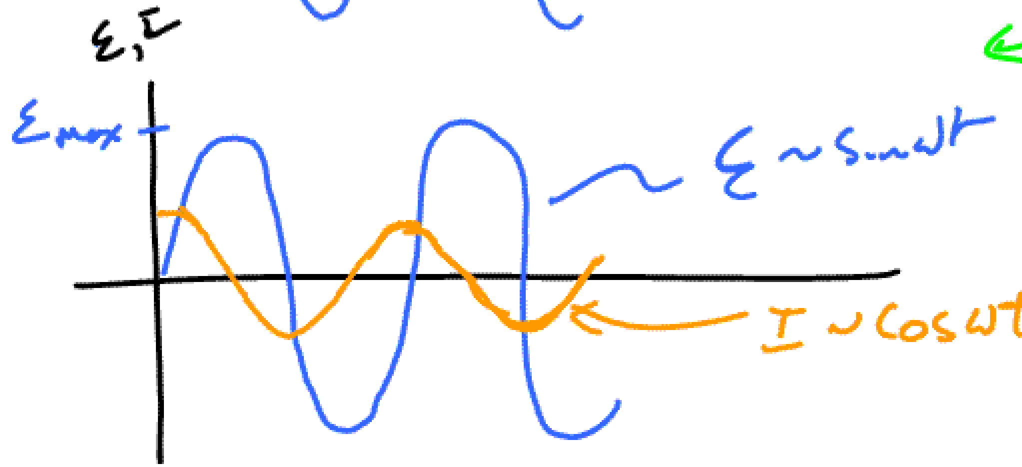
Ave power $\quad \boxed{\bar{P} = \frac{\mathcal{E}_{max}^2}{2R}}$



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

$$I = \frac{dQ}{dt} = \omega C\,\mathcal{E}_{max}\cos\omega t$$



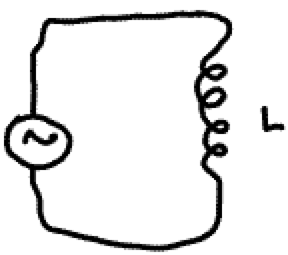


I leads EMF by 1/4 period

$$\frac{I}{\omega C} = \mathcal{E}_{max}\cos\omega t$$

plays role of R in Capacitive AC Circuit

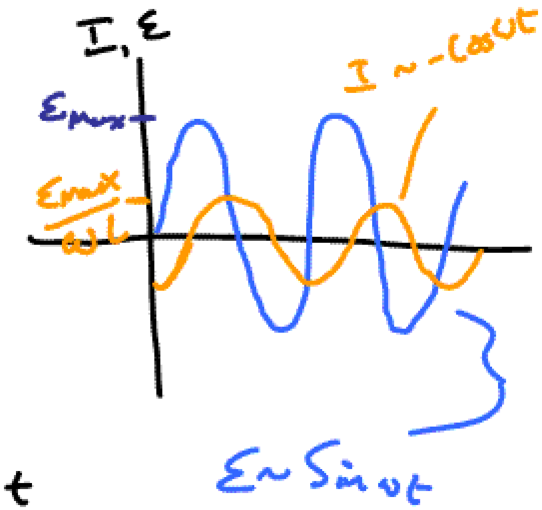
$$\frac{1}{\omega C} \equiv X_C = \text{Capacitive reactance}$$



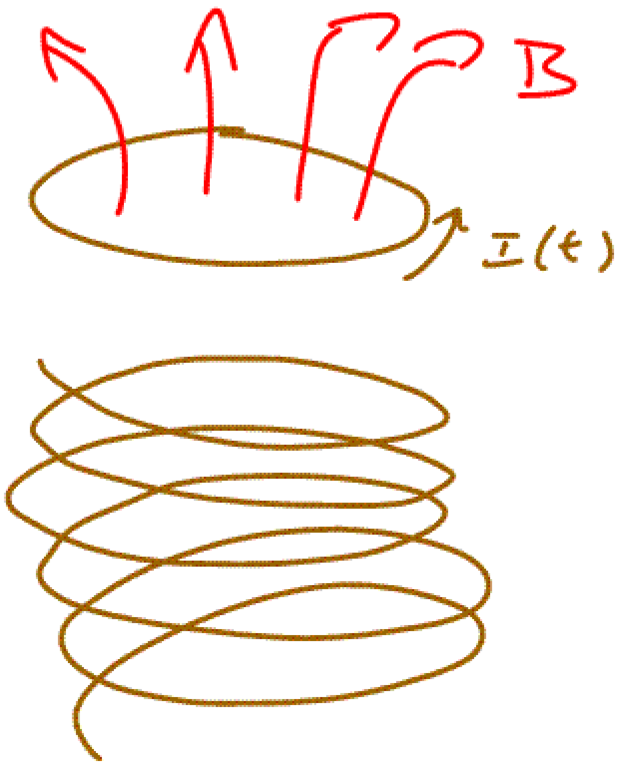
$$\mathcal{E} - L\frac{dI}{dt} = 0$$

$$\frac{dI}{dt} = \frac{\mathcal{E}_{max}\sin\omega t}{L}$$

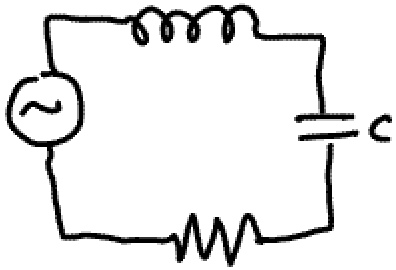
$$I = -\frac{\mathcal{E}_{max}}{\omega L}\cos\omega t$$



$$X_L \equiv \omega L \equiv \text{Inductive reactance}$$



Transformer



LRC circuit

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

?

$$I = \underbrace{I_{max}}_{?} \sin(\omega t + \overbrace{\phi}^{?})$$

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

$$I_{max} R \sin(\omega t + \phi)$$

$$-X_C I_{max} \cos(\omega t + \phi)$$

$1/X_C$

$$X_L I_{max} \cos(\omega t + \phi)$$

$1/X_L$

Math — Trig ID's

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

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

$\equiv Z \equiv$ Impedance $\rightsquigarrow$ plays role of R in LRC circuit

$\textcircled{\sim} \longrightarrow \omega$

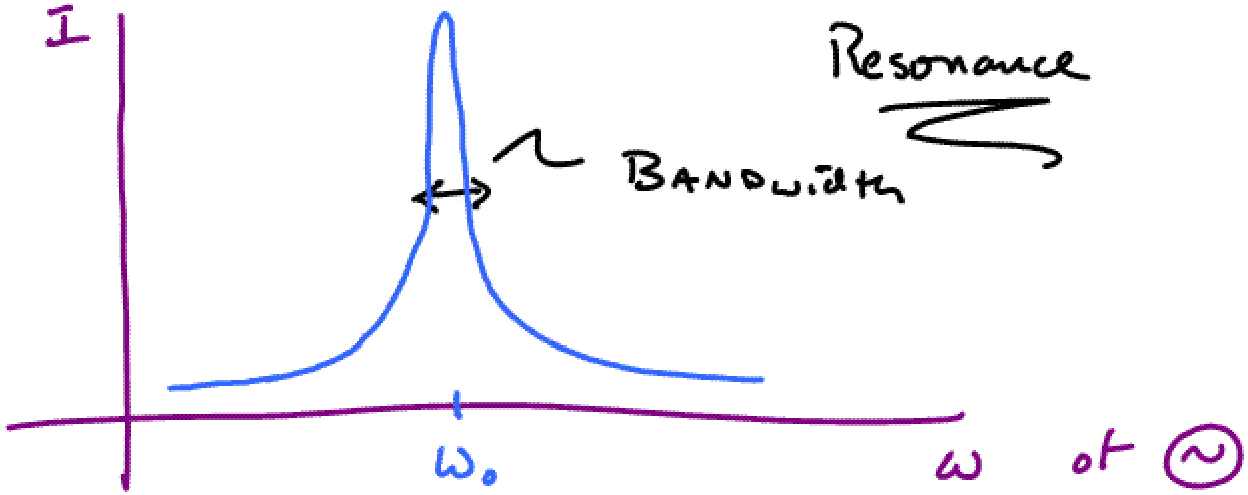
$$\omega_0 = \frac{1}{\sqrt{LC}}$$ Natural frequency

$\omega \to \omega_0$

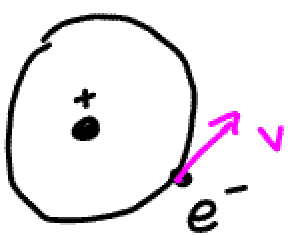
$$Z \to \frac{\mathcal{E}_{max}}{\sqrt{R^2 + \left(\frac{L}{\sqrt{LC}} - \frac{\sqrt{LC}}{c}\right)^2}}$$

$\longrightarrow 0$

Resonance



Magnetic fields in Matter



$$I = \frac{e}{2\pi r/v} = \frac{ev}{2\pi r}$$

Current loop (Area A) $\equiv \mu \equiv$ Magnetic Moment

$$= I A$$

x-sectional Area current subtends

$$\mu_e = \frac{ev}{2\pi r}(\pi r^2) = \frac{evr}{2}$$

L = Angular Momentum = mvr

$$\mu_e = \frac{eL}{2m_e}$$

Bohr $\rightarrow$ $L = 0, \hbar, 2\hbar, \ldots$

$$\mu_e = \# \frac{e\hbar}{2m_e}$$

Bohr Magneton