Physics 142 - November 2, 2010

Note Title 11/2/2010

- Presentation Group updates
- Spokesperson
- Meeting

Remember to Vote

Induction

$$\Phi_M = \int_{loop} \vec{B} \cdot d\vec{A}$$

$$\mathcal{E} = \int_{loop} \vec{E} \cdot d\vec{l} = -\frac{d\Phi_M}{dt}$$

induced EMF

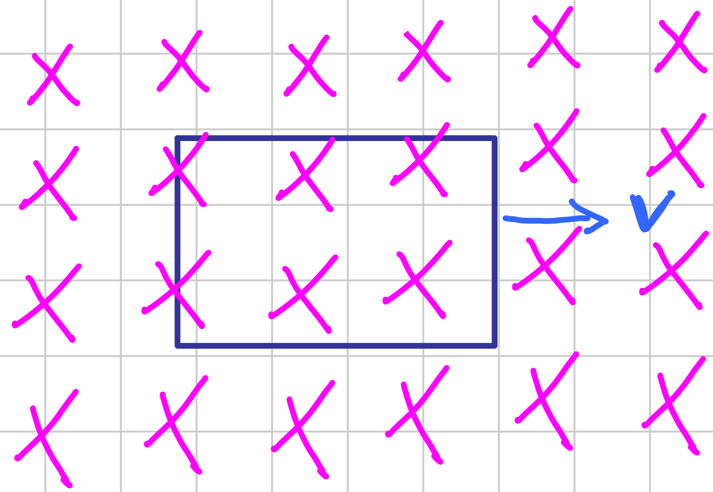
All very Important

Lenz's Law - An induced current in a closed conducting loop will appear in such a way as to oppose the change that created it

Gives the direction of induced effect

Superconductors + induction

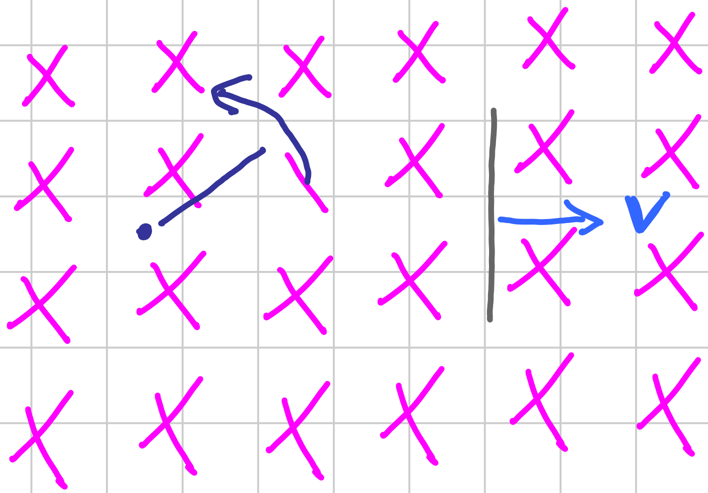
loop moving in B field



check out
the induction

java applet

on class
website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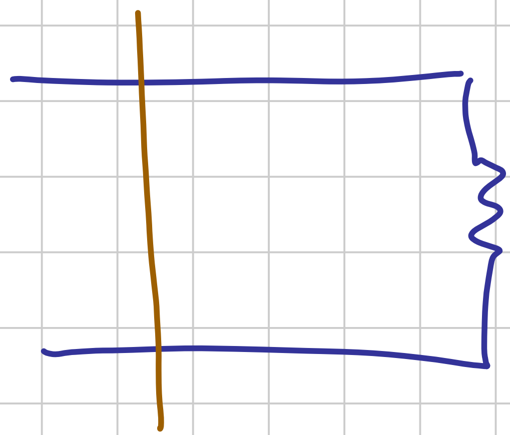
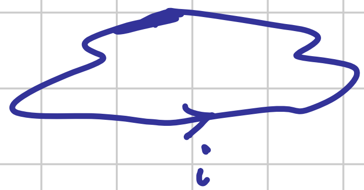
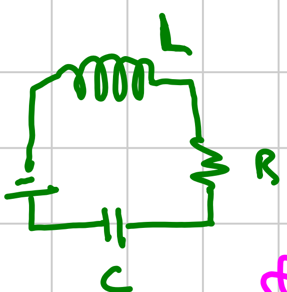


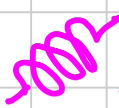


$$\phi_m = L\,i$$

$L \equiv$ constant of self-inductance

$$\mathcal{E} = -\frac{d\phi_m}{dt} = -L\frac{di}{dt}$$



 $\equiv L$

units Henrys

$$\boxed{\mathcal{E} = -L\frac{di}{dt}}$$

unless problem is specifically about Mutual inductance ... usually treat inductance in a circuit as self-inductance

$$\phi_{m_{2}} = M\,i_{1}$$

$$\phi_{m_{1}} = M\,i_{2}$$

same "M" cross-talk dictated by geometry

$M \equiv$ constant of mutual inductance

$$\mathcal{E}_{2\text{ by }1} = -M\frac{di_1}{dt}$$

$$\mathcal{E}_{1\text{ by }2} = -M\frac{di_2}{dt}$$

Energy density in the fields:

$$\boxed{u_E = \frac{\epsilon_0 E^2}{2} \qquad u_B = \frac{B^2}{2\mu_0}}$$

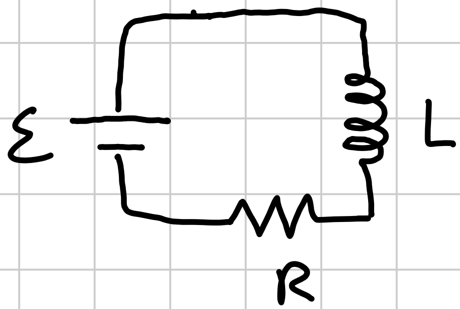
general — Says nothing about circuits or sources or boundary conditions!

Energy in Inductor

$$U = \frac{1}{2} L I^2$$

similar to $U_{capacitor} = \frac{1}{2} C V^2$

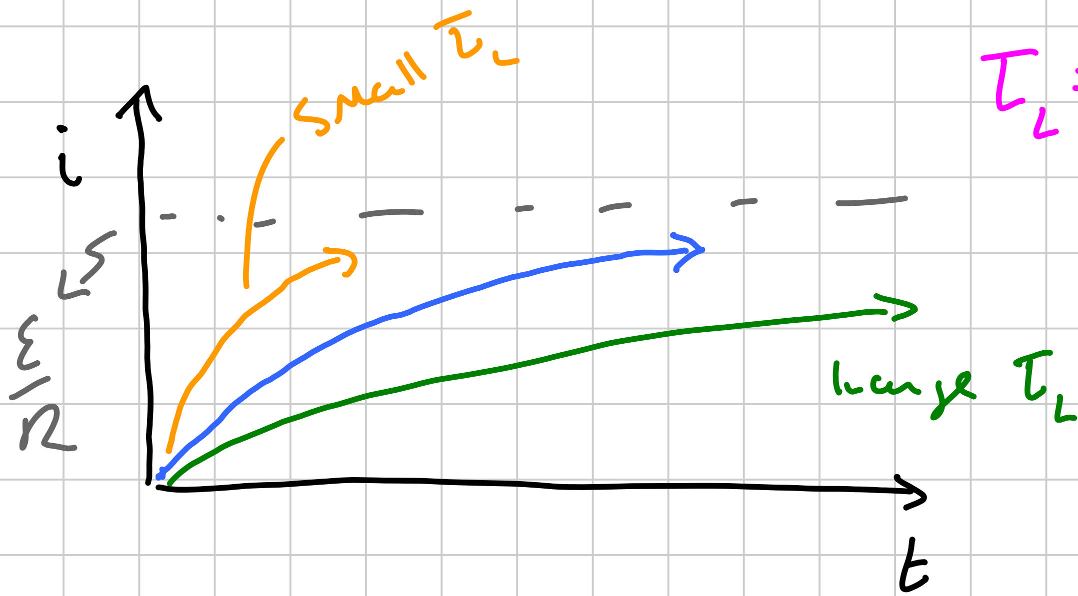
LR circuit



$\sum V = 0$ around circuit

$$\varepsilon - L\frac{di}{dt} - iR = 0$$

$$i = \frac{\varepsilon}{R}\left(1 - e^{-tR/L}\right) = \frac{\varepsilon}{R}\left(1 - e^{-t/\tau_L}\right)$$



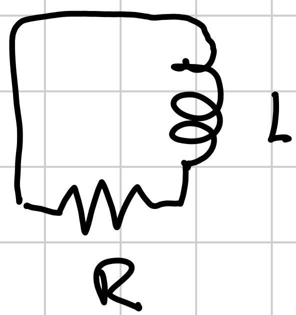
τ_L = inductive time constant

$\tau_L = L/R$

$$V = iR$$

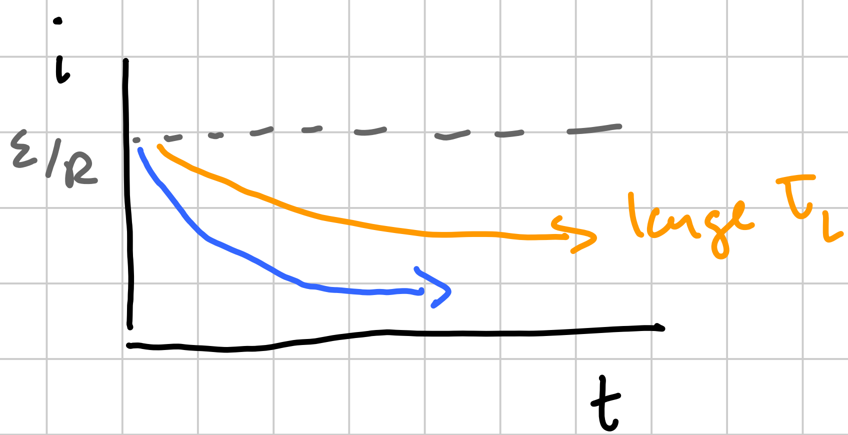
$$V = \mathcal{E}\left(1 - e^{-t/\tau_L}\right)$$

At some time t later, short L across R

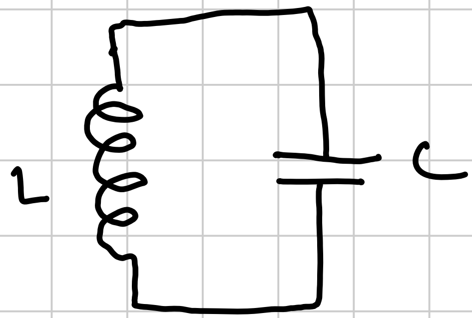


$$0 = iR + L\frac{di}{dt}$$

$$i = \frac{\mathcal{E}}{R} e^{-t/\tau_L}$$



LC circuit



No resistor

Fully charged capacitor at $t=0$

$R \to 0$

$$U = U_E + U_B = \frac{q^2}{2C} + \frac{Li^2}{2}$$

$$\frac{1}{2}CV^2 = \frac{1}{2}\frac{q^2}{C}$$

$$\frac{dU}{dt} = 0 = \frac{dU_E}{dt} + \frac{dU_B}{dt} = \frac{2q}{2C}\underbrace{\frac{dq}{dt}}_{i} + \frac{L}{2}2i\frac{di}{dt}$$

dq/dt

$$0 = L\frac{di}{dt} + q/C$$

$$0 = \frac{d^2 q}{dt^2} + \frac{1}{LC} q \succ \text{SHM}$$

$F = -kx$

$$m\frac{d^2 x}{dt^2} + kx = 0$$

$\sin \omega t$

$$\omega = \pm\sqrt{\frac{k}{m}}$$

SHM $\Rightarrow$ $\omega^2 = \frac{1}{LC}$

$q(t)$

phase angle

$$q(t) = Q\cos(\omega t + \phi)$$

$\omega^2 = 1/LC$

$$i(t) = \frac{dq(t)}{dt} = -\omega Q \sin(\omega t + \phi)$$

Look at energy flow

$$U_E = \frac{q^2}{2C} = \frac{Q^2}{2C}\cos^2(\omega t+\varphi)$$

E stored in C or elect. field as fn of time

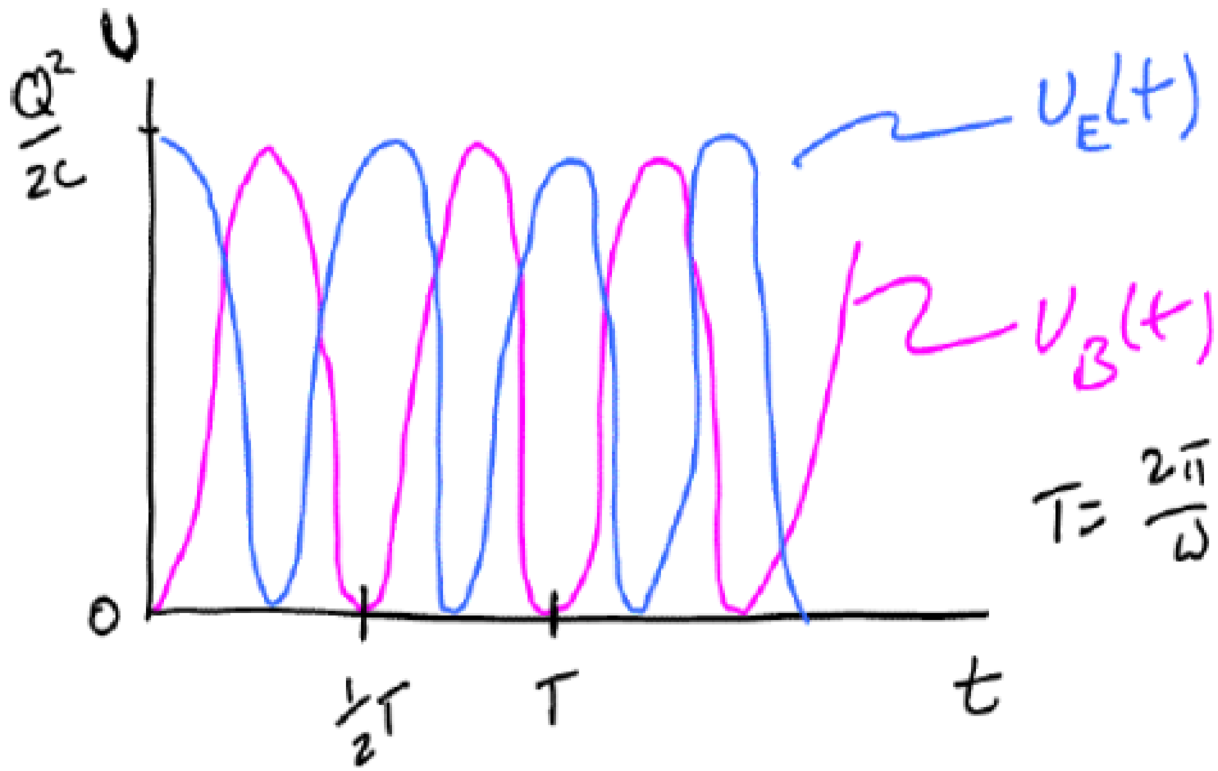
$$U_B = \frac{1}{2}Li^2 = \frac{L}{2}Q^2\omega^2\sin^2(\omega t+\varphi)$$

E stored in B (inductor) as fn of time

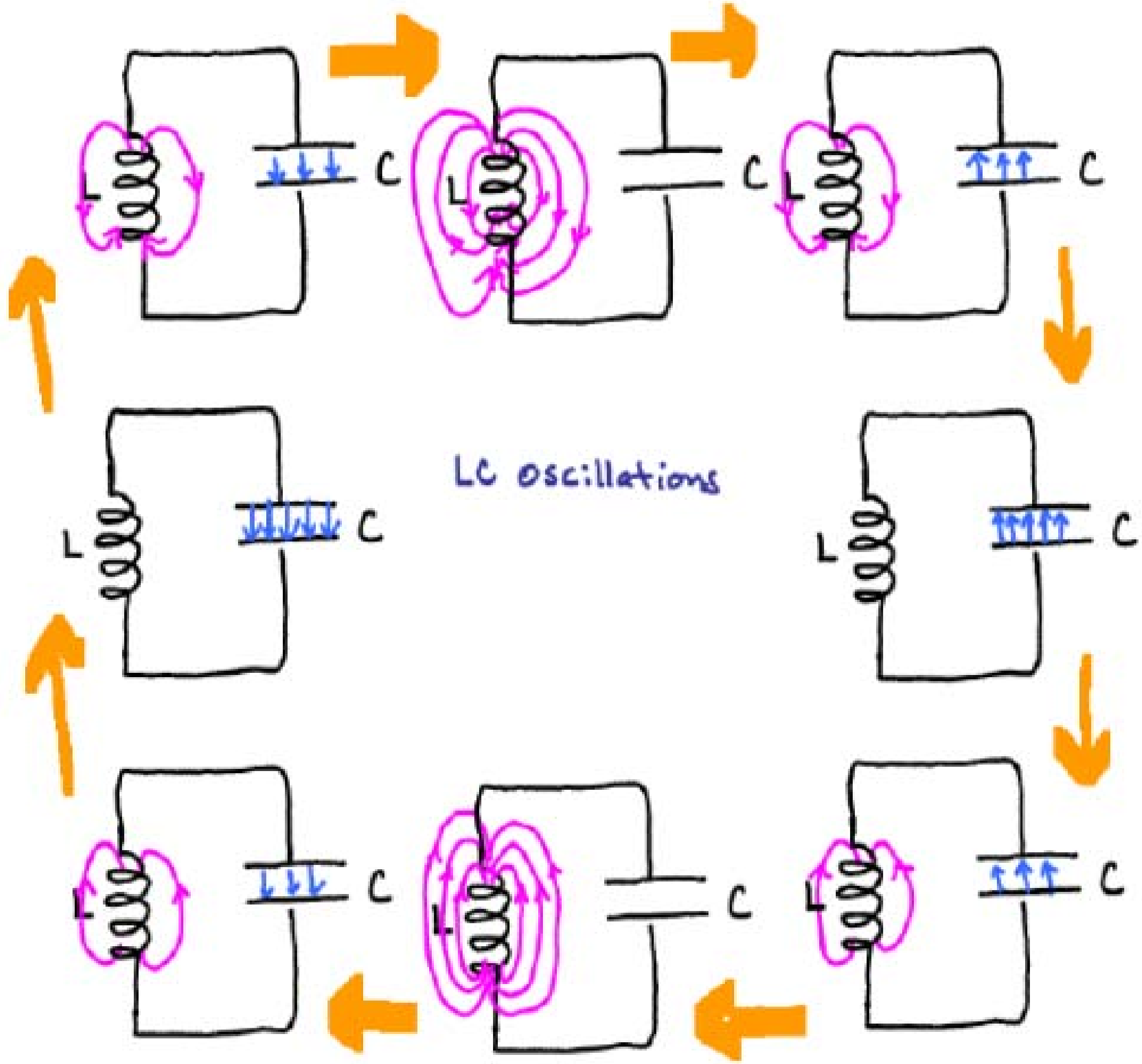
$$\omega^2 = \frac{1}{LC}$$

$$\frac{\cancel{L}Q^2}{2\cancel{L}C}$$

LC Oscillations

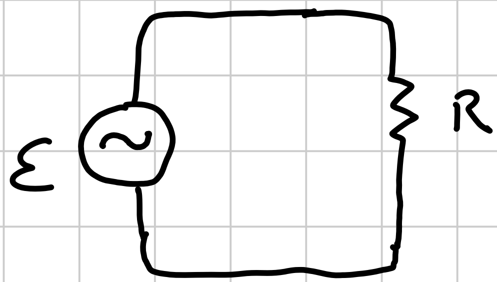


$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{LC}$$


LC oscillations
L
C

AC circuits

Alternating current



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

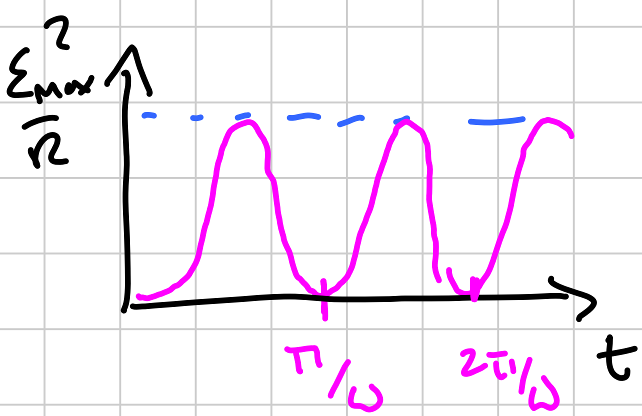
Kirchoff

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

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

Insi- Power dissaption

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



$$\overline{\sin^2 \omega t} = \frac{1}{2}$$

$$\overline{P} = \mathcal{E}_{max}^2 / 2R$$