Physics 142 - November 4, 2010

Note Title 11/4/2010

- Exam 2 looms
  - Nov 16, 2010 0800 Location TBA
  - Same drill as last time
  - Info concerning material coverage soon

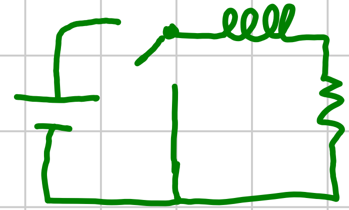
  - Material coverage begins after Exam 1 Material

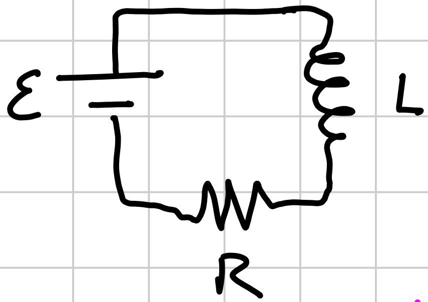
- Presentation groups - Meet
  - Do a bit of work
  - Elect contact
  - Meet with me

Note Title 11/13/2007

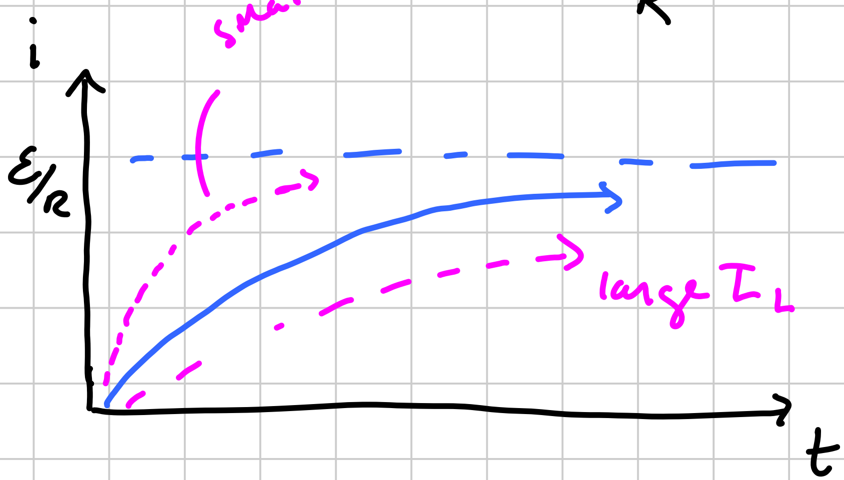
Last Time –

LR circuit



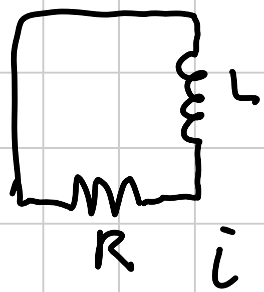


$$i = \frac{\mathcal{E}}{R}\left(1 - e^{-tR/L}\right) = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau_L}\right)$$

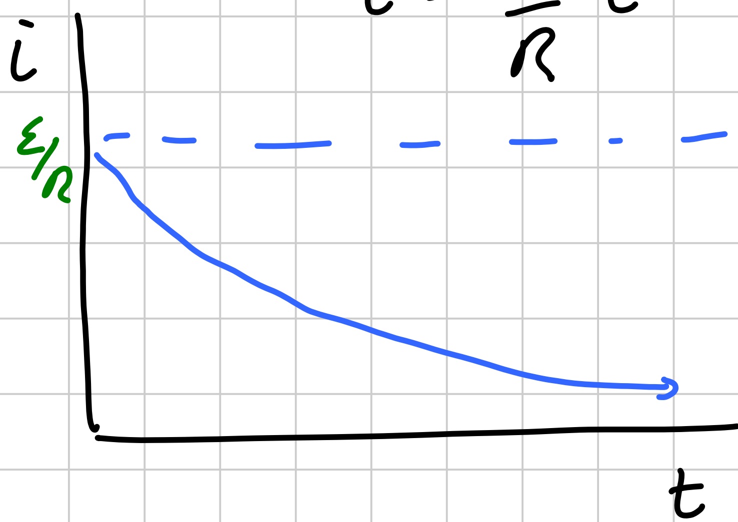


Inductive time constant

$$\frac{L}{R} = \tau_L$$

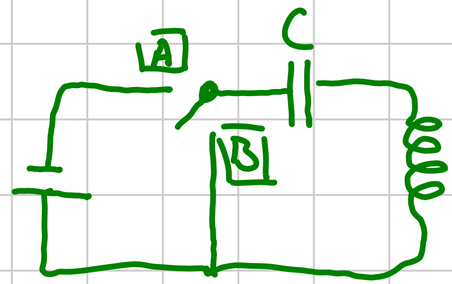


$$i = \frac{\mathcal{E}}{R} e^{-t/\tau_L} = i_0 e^{-t/\tau_L}$$



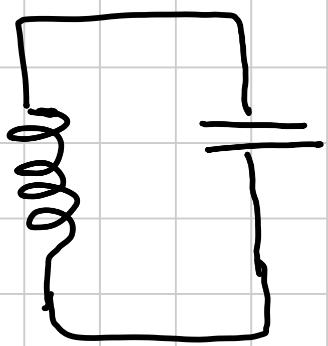
LC Circuit

Charge capacitor fully with switch in position $\boxed{A}$



Switch to position $\boxed{B}$ Then Analyze Energy

$$U = U_B + U_E = \frac{1}{2} L i^2 + \frac{q^2}{2C}$$



Look at $\frac{dU}{dt}$

$$\underbrace{0 = L\frac{d^2 q}{dt^2} + \frac{q}{C}}_{\text{diff eqn}}$$

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

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

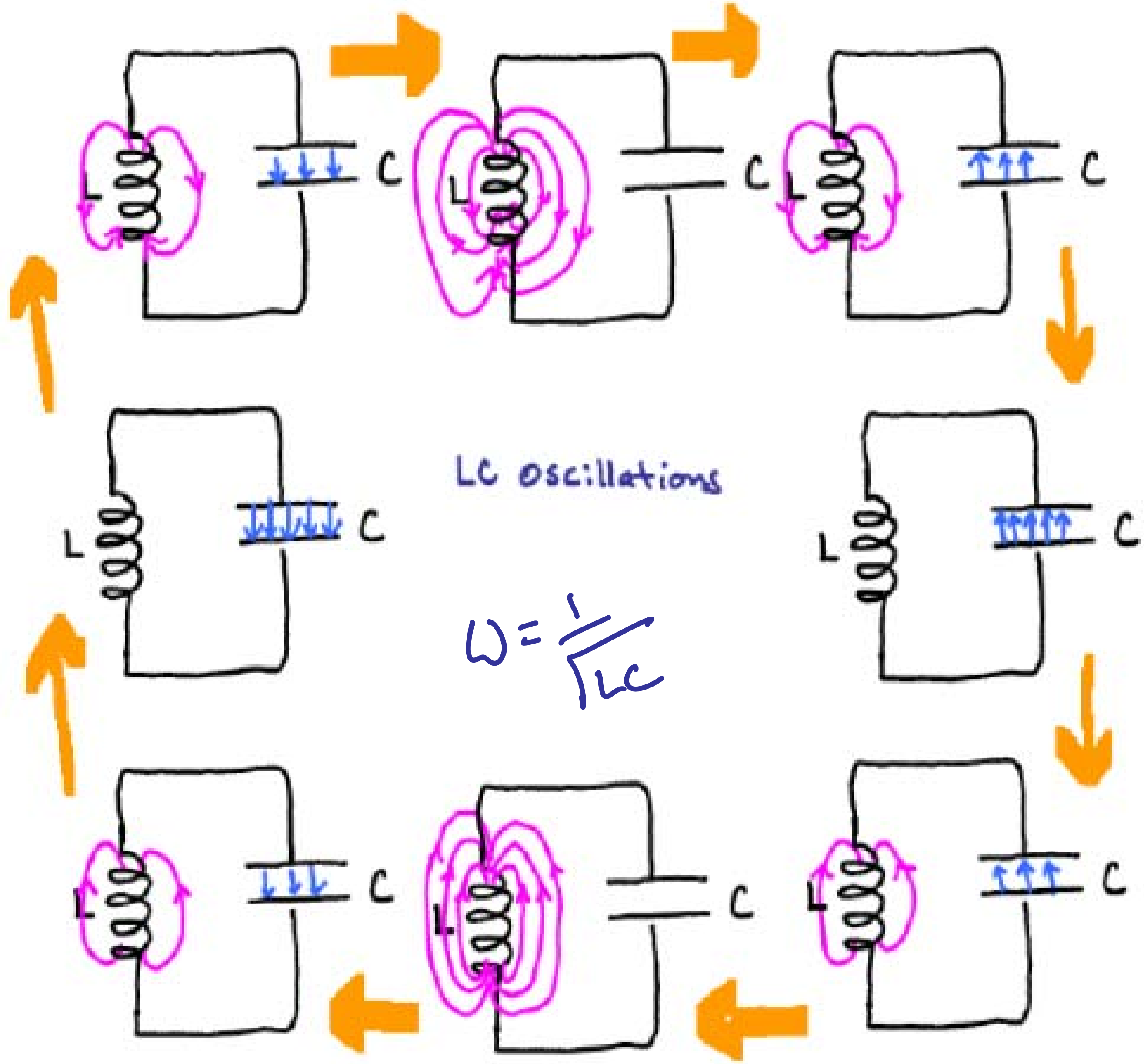
HARMONIC

Energy Flow

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

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

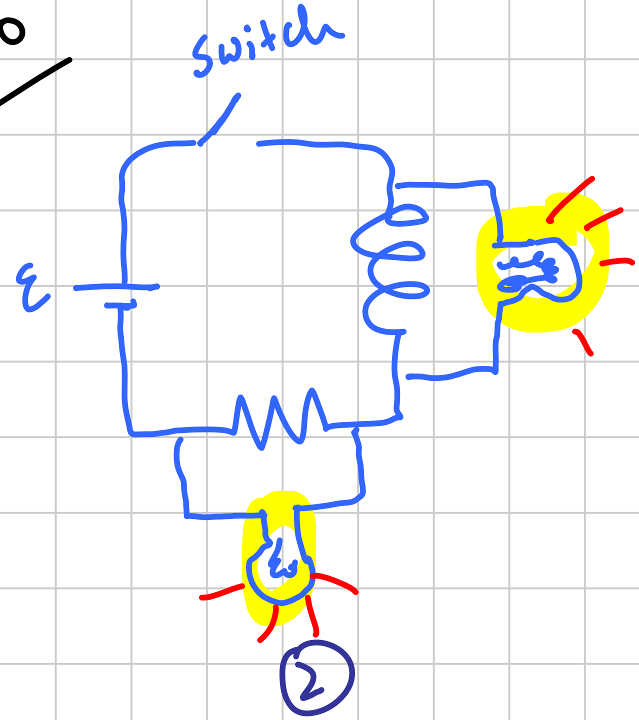
Energy flows from capacitor to inductor + back
(E field) (B field)

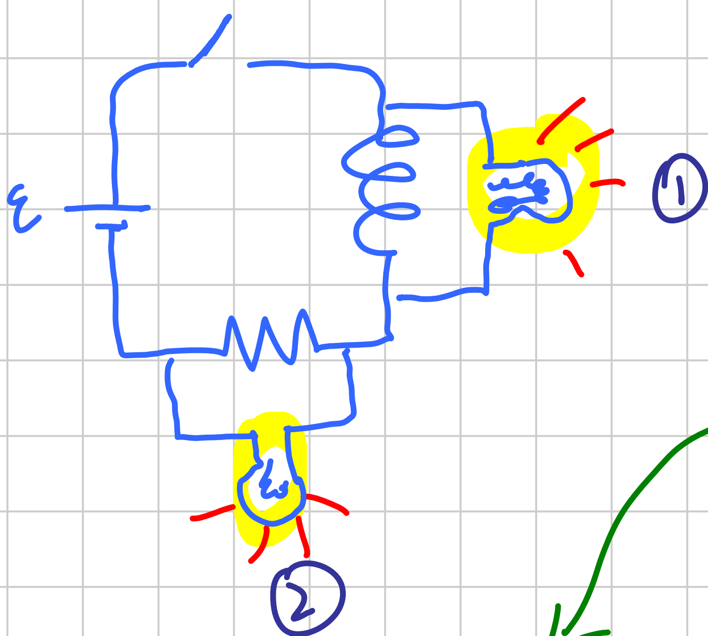


LC oscillations

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

Demo





did demo -

Turn switch on
what happens to
light bulbs ?

Turn switch off
What happens
to light bulbs ?

early time

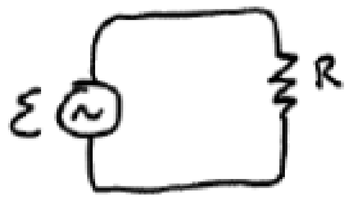
Switch on $\quad i=0, \ \frac{di}{dt}$ big $\rightarrow$ ② off ① bright

Some time later i increases ② gets brighter

$\frac{di}{dt}$ less ① dims

~ follows Ohanian's Treatment

AC Circuits



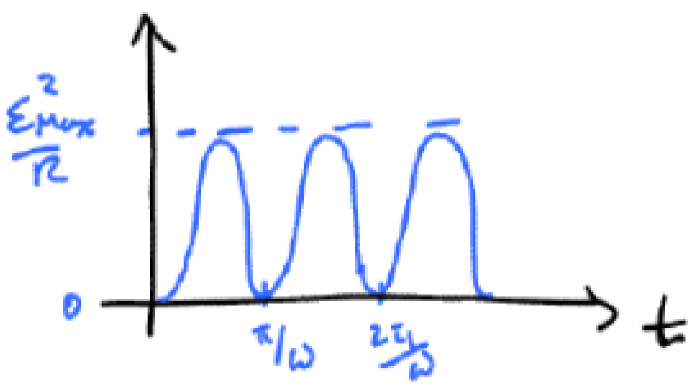
$$\mathcal{E} = \mathcal{E}_{Max} \sin \omega t$$

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

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

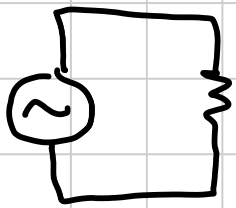
Instantaneous Power Dissipation

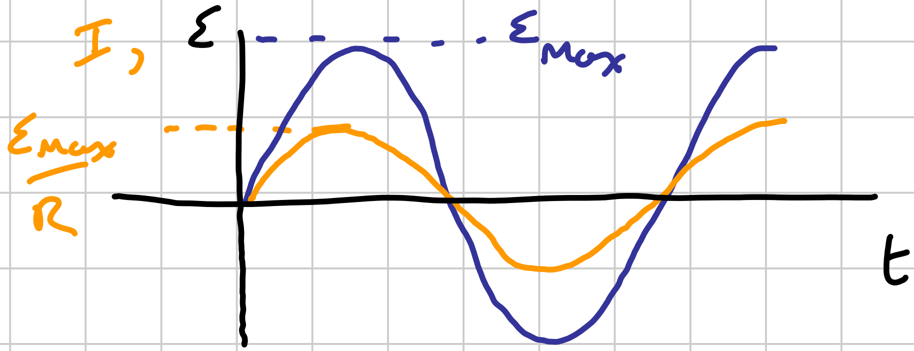
$$P = IV = I\mathcal{E} = \frac{\mathcal{E}_{max}^2}{R} \sin^2 \omega t$$

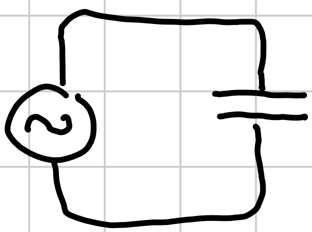


$$\overline{\sin^2 \theta} \rightarrow \frac{1}{2}$$

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

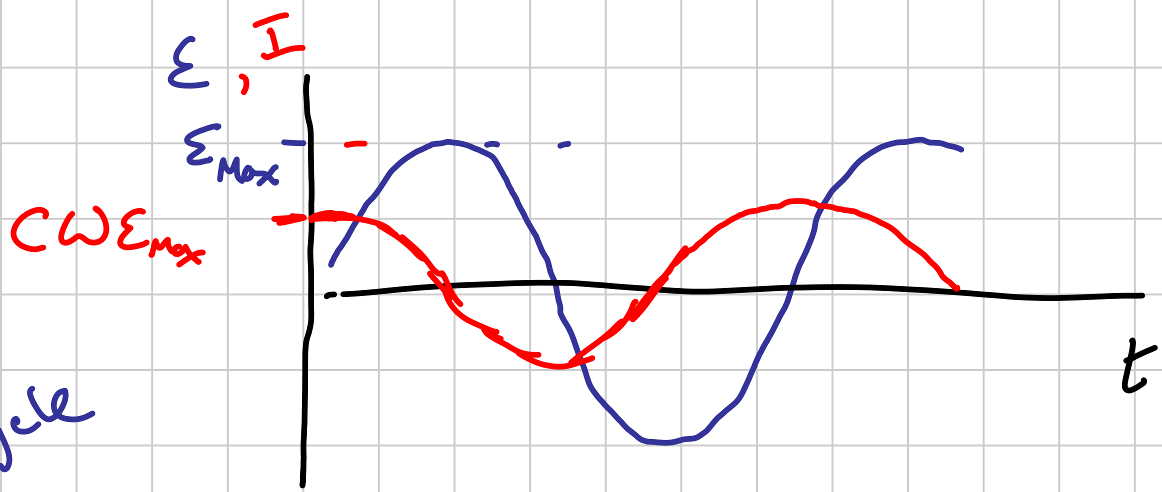






$$Q = C\varepsilon = C\,\varepsilon_{Max} \sin \omega t$$

$$I = \frac{dQ}{dt} = C\omega\,\varepsilon_{max} \cos \omega t$$



I "Leads" ε by 1/4 cycle

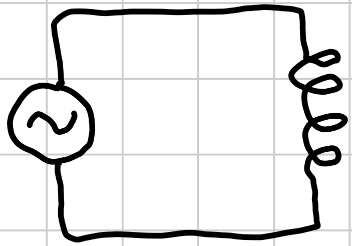
$V = IR$

$I = \frac{\mathcal{E}}{R}$

$\boxed{\frac{1}{\omega C}} I = \mathcal{E}_{max} \cos \omega t$

plays role of resistance in Capacitive Ac Circuit

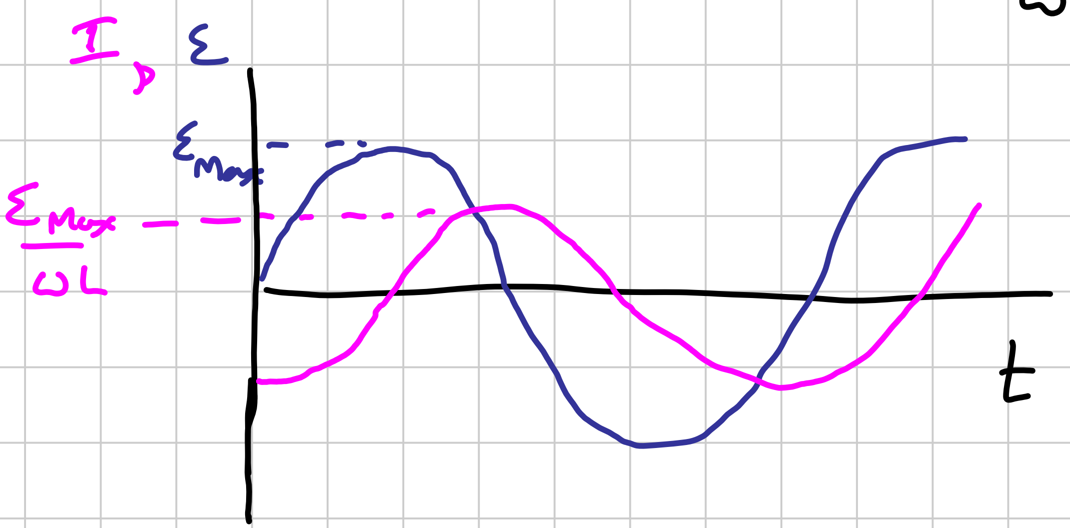
$\equiv$ Capacitive Reactance $\equiv X_c$



$$\varepsilon - L\frac{dI}{dt} = 0$$

$$\frac{dI}{dt} = \frac{\varepsilon_{max}}{L}\sin\omega t$$

$$I = -\frac{\varepsilon_{max}}{\omega L}\cos\omega t$$

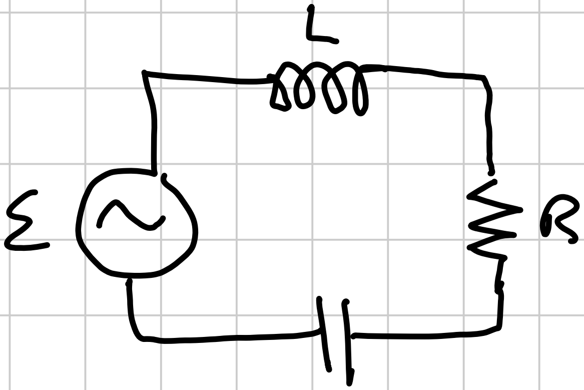


I "lags" EMF

ωL acts like resistance in inductive AC circuit

$$\omega L \equiv X_L$$

Inductive Reactance



LRC circuit

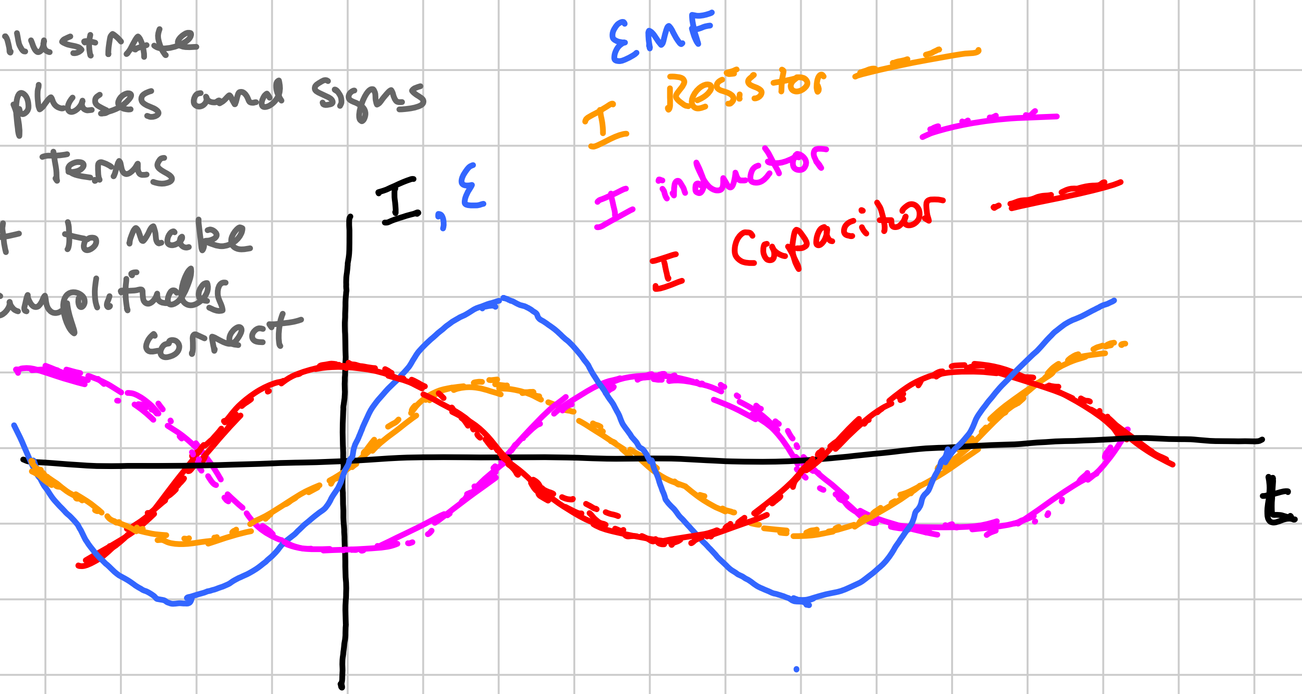
$$\varepsilon = \varepsilon_{Max} \sin \omega t$$

Assume $I = I_{Max} \sin(\omega t + \phi)$

What are these?

Graph to illustrate relative phases and signs of EMF Terms

No attempt to make relative amplitudes correct



$$\mathcal{E} = \underbrace{\Delta V_R}_{R I_{Max} \sin(\omega t + \phi)} + \underbrace{\Delta V_C}_{X_C I_{Max} \cos(\omega t + \phi)} + \underbrace{\Delta V_L}_{-X_L I_{Max} \cos(\omega t + \phi)}$$

often people use a graphical analysis with I and ε vectors rotating in a plane → phasors [see Ohanian p. 1047]

I think earlier edition of Ohanian did a nice treatment using Math + Trig ID's → get

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

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

$\equiv$ Impedance $\equiv Z$

Plays Role of Resistance in LRC circuit

(~) $\longrightarrow$ Frequency ω

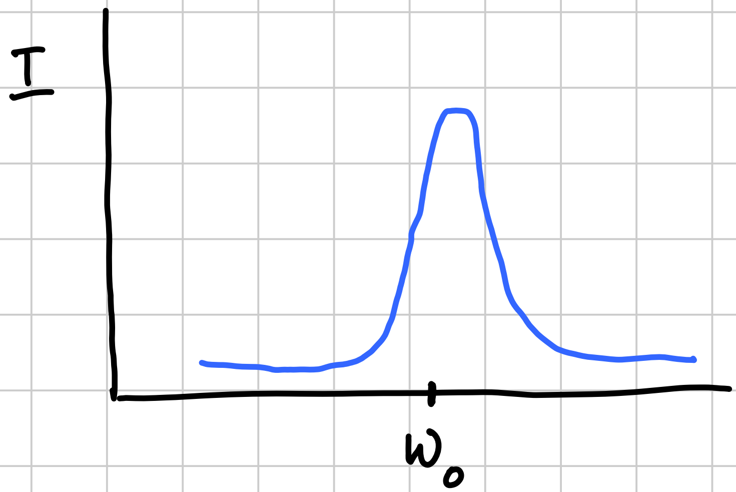
$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

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

$$Z = \sqrt{R^2 + \underbrace{\left(\frac{1}{\sqrt{LC}}L - \frac{\sqrt{LC}}{C}\right)}_{0}^2}$$

Minimize Z

Maximize I



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

Resonance