Physics 2B

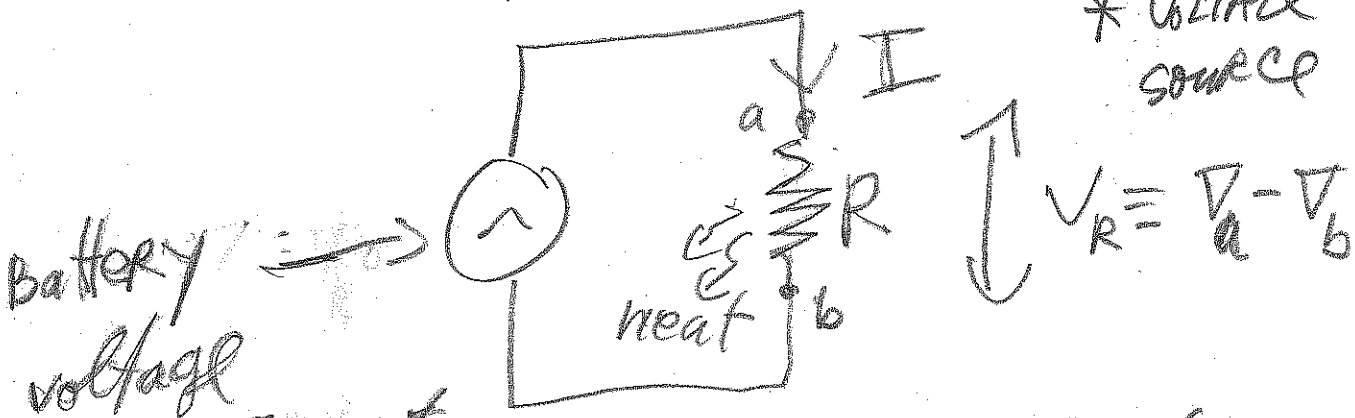
Ch 22

3-25-13

AC circuits

Alternating current

R and source only *

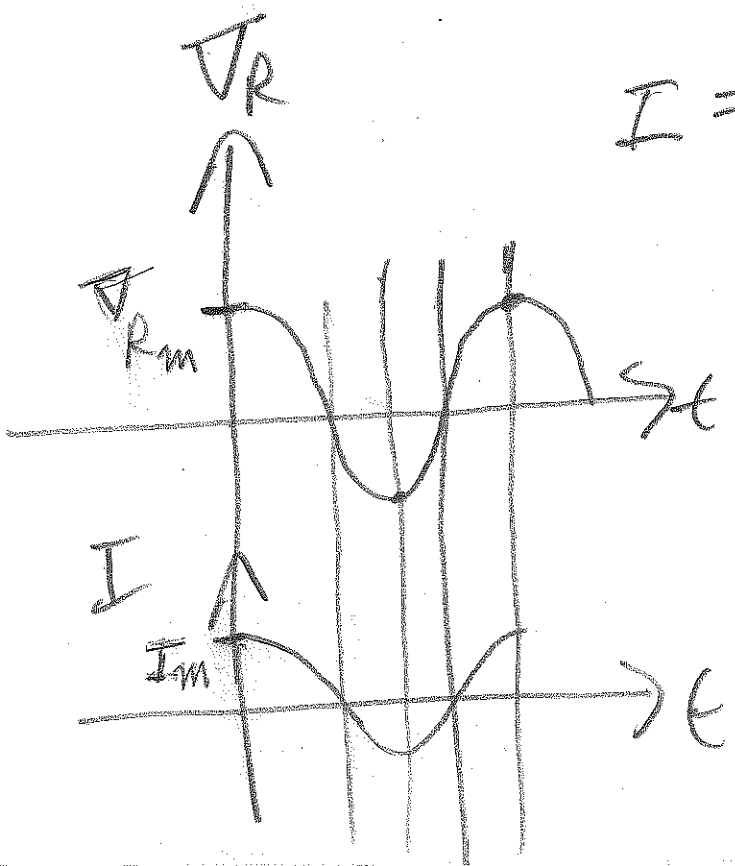


$V_R = I \cdot R$ ohms Law

$$I = \frac{V_R}{R} = \frac{V_{Rm} \cdot \cos\omega t}{R}$$

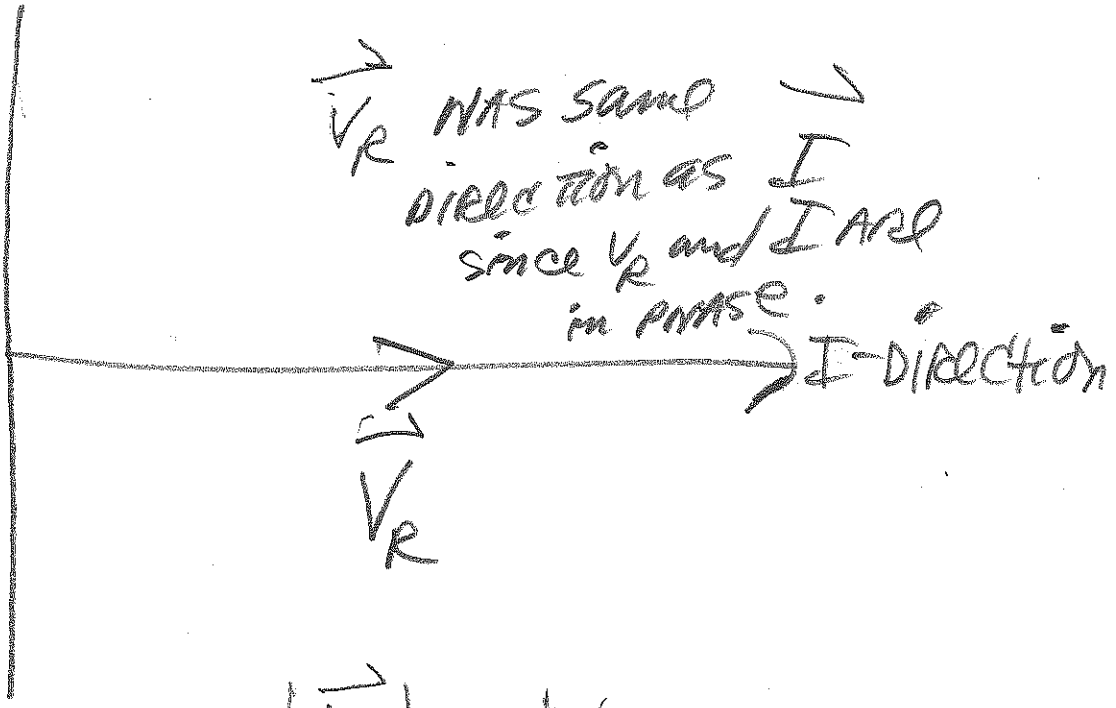
$$I = \frac{V_{Rm}}{R} \cdot \cos\omega t$$

$$I = I_m \cdot \cos\omega t$$



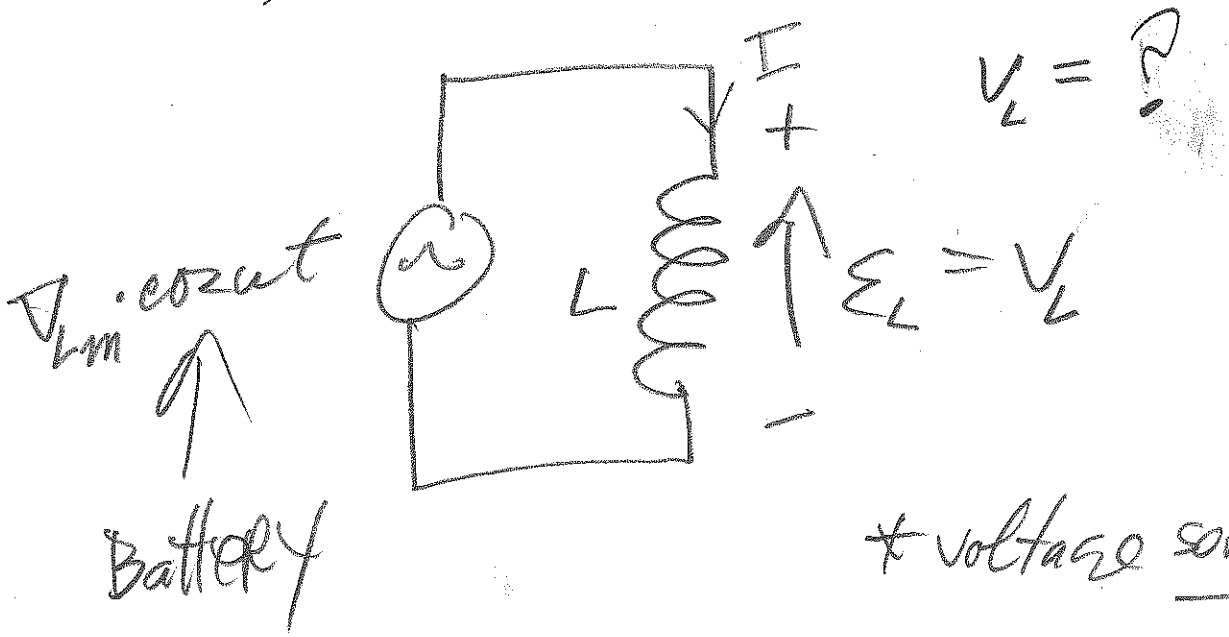
I and V_R are in phase

Phasors = vectors



$$|\vec{V}_R| = V_{Rm}$$

Inductor and source* only



* voltage source

Background to Inductor and source:

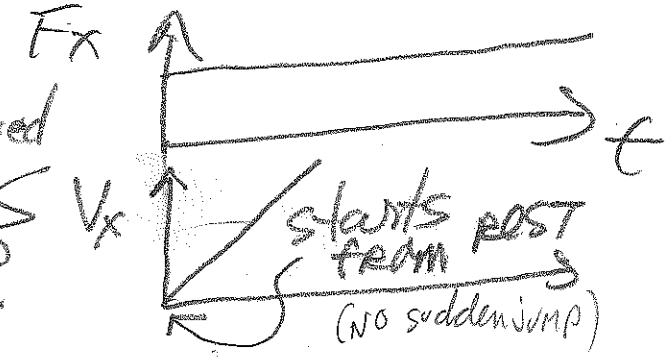
2A

$$F_x = ma_x$$

$$F_x = m\frac{\Delta v}{\Delta t}$$

Since mass has "inertia", the velocity does not change immediately with applied force: inertial time lag.

Example: $F_x = 2(N)$



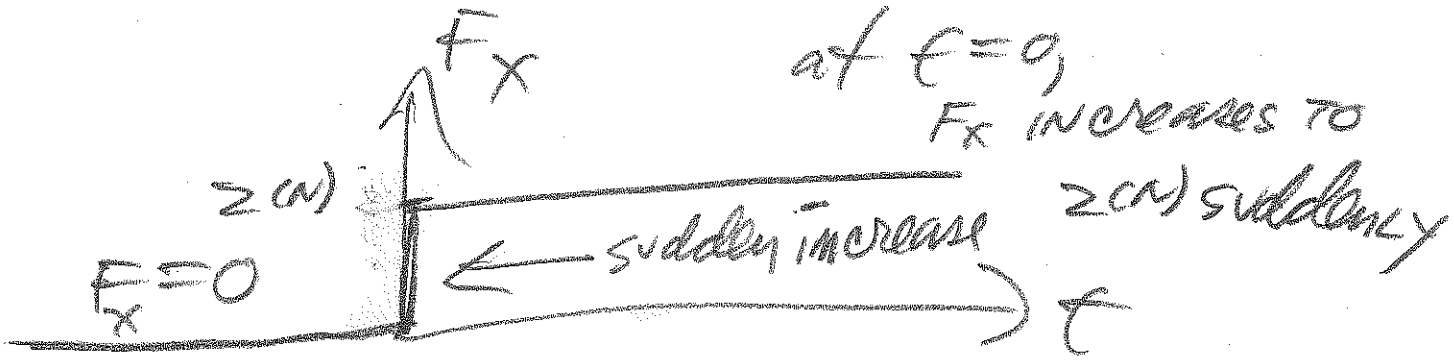
IT takes delayed time for v_x TO BUILD up

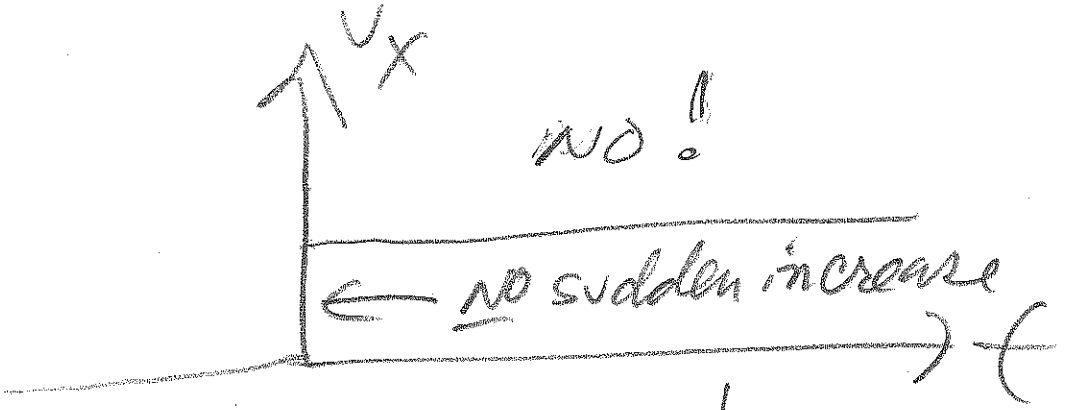
$$2(N) = m\frac{\Delta v_x}{\Delta t}$$

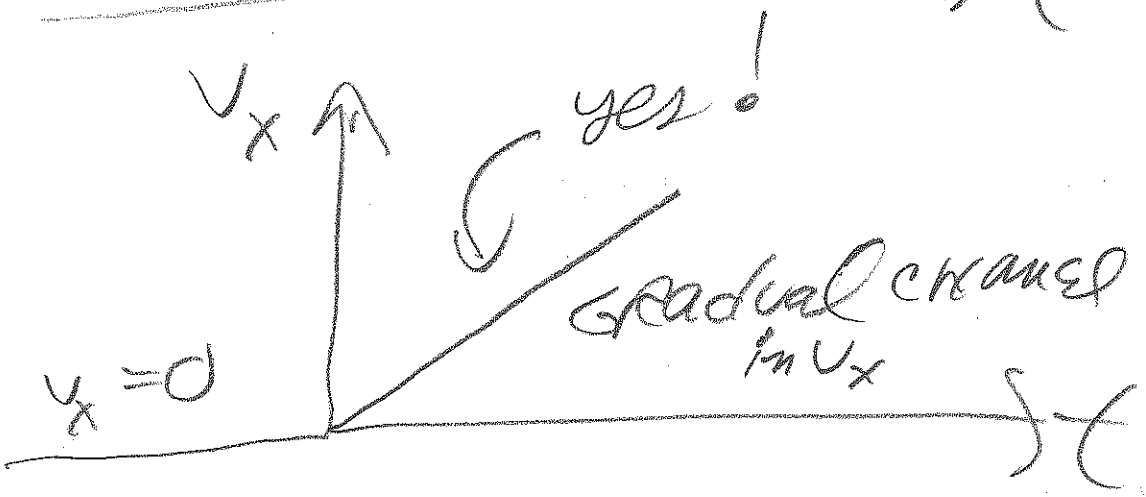
$$v_x = \frac{2(N)}{m} \cdot t$$

2B

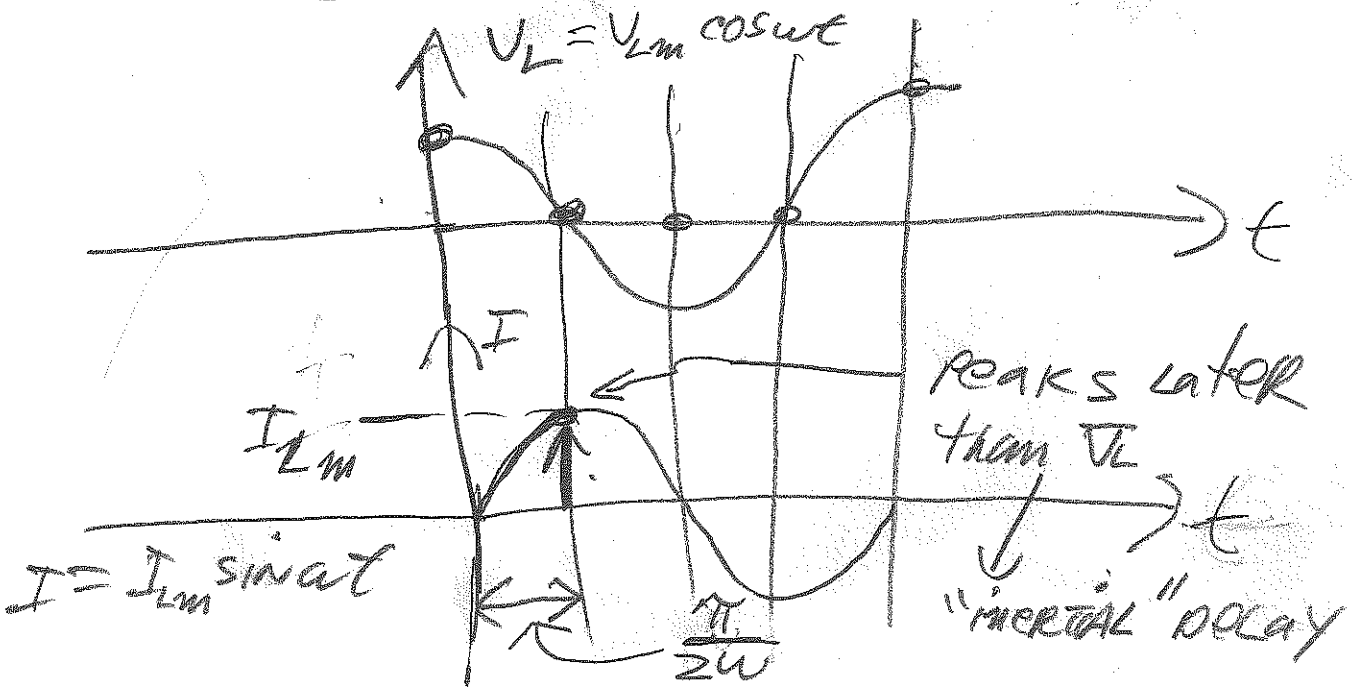
$$V_L = L \cdot \frac{\Delta I}{\Delta t}$$

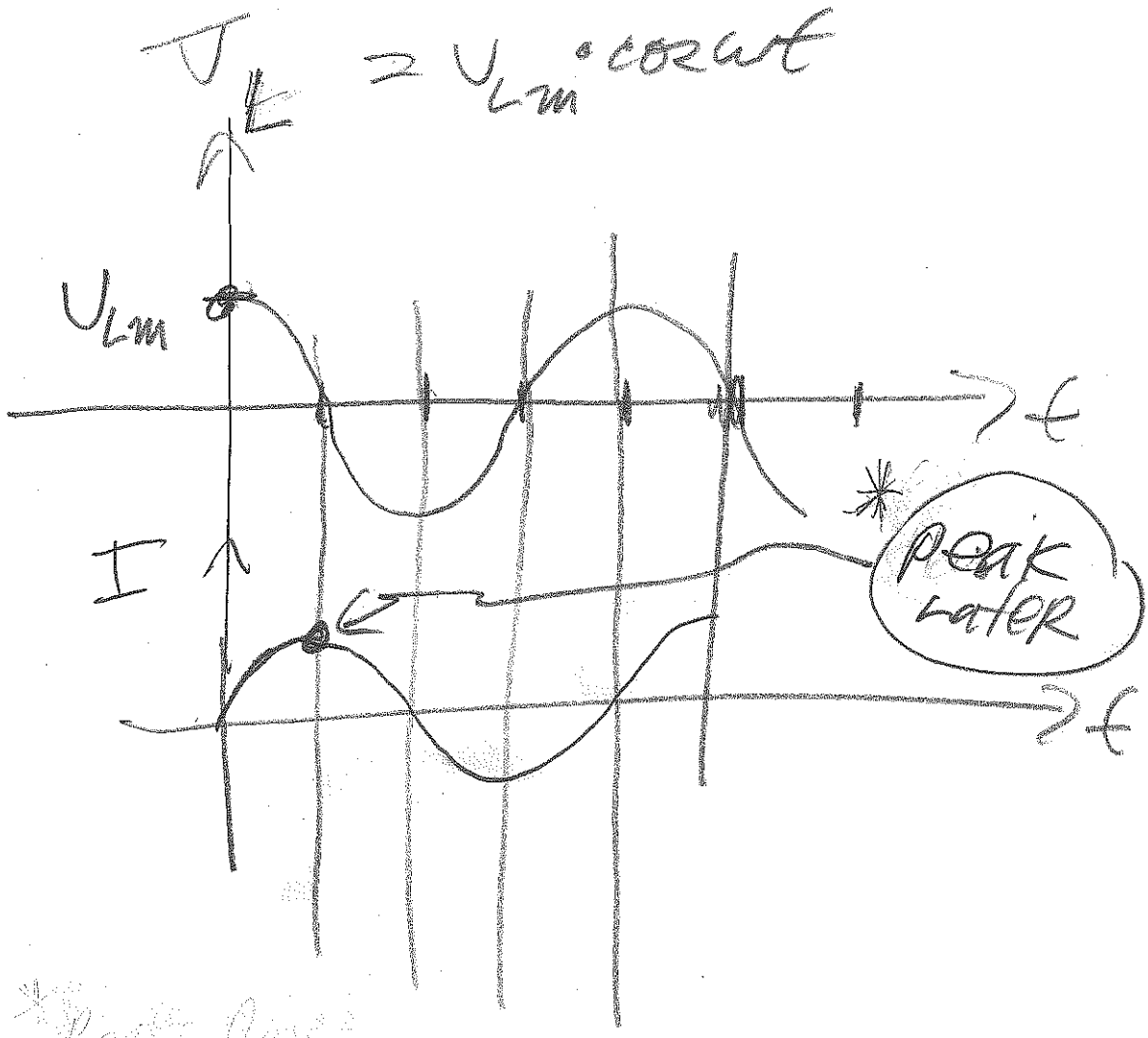






GO BACK TO L CIRCUIT.





Because of the "inertia" of L, the current I lags V_L.

Table of correspondence

ΣA	ΣB
mass (m)	$\rightarrow$ L (inductance)
position x	$\rightarrow$ Q (charge)
velocity v_x	$\rightarrow$ I (current)
FORCE F	$\rightarrow$ VOLTAGE
spring constant k	$\rightarrow$ $1/C = \frac{1}{\text{capacitance}}$

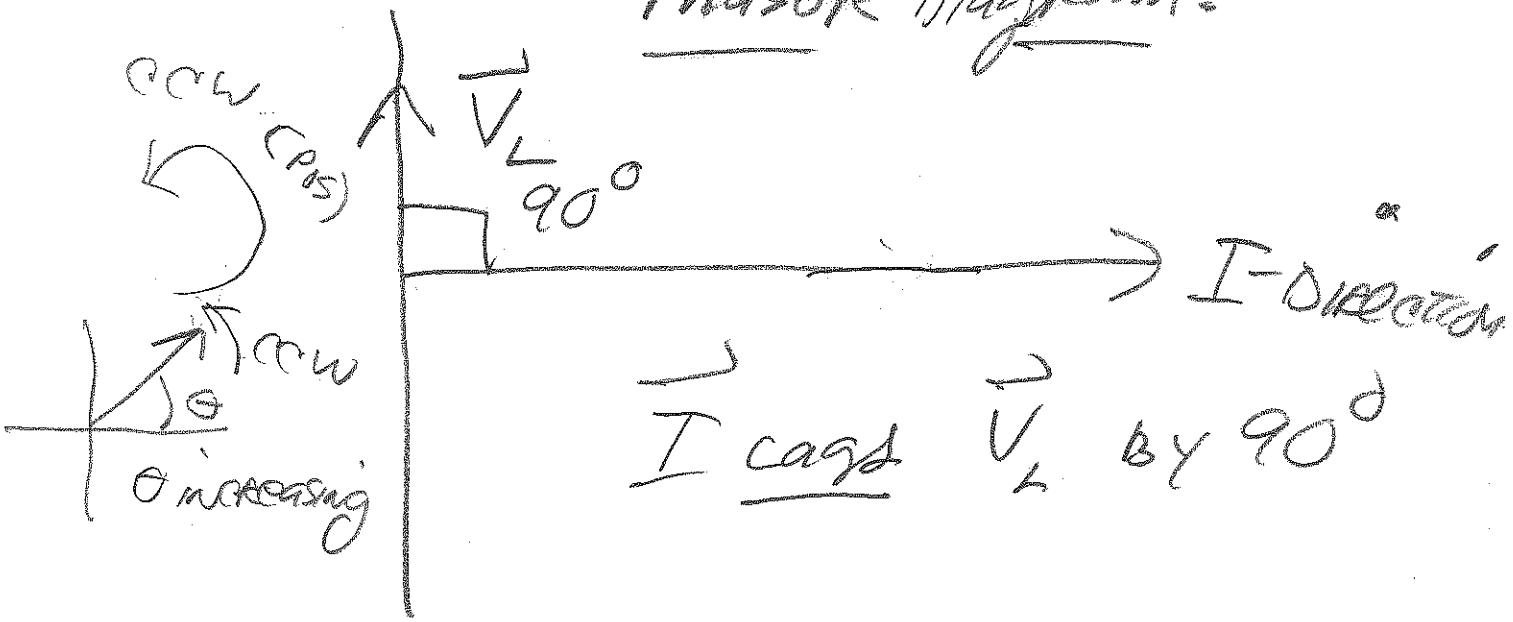
$$I_{Lm} = \frac{V_{Lm}}{X_L}, \quad X_L = \omega \cdot L$$

note: when ω is large I_{Lm} is small.

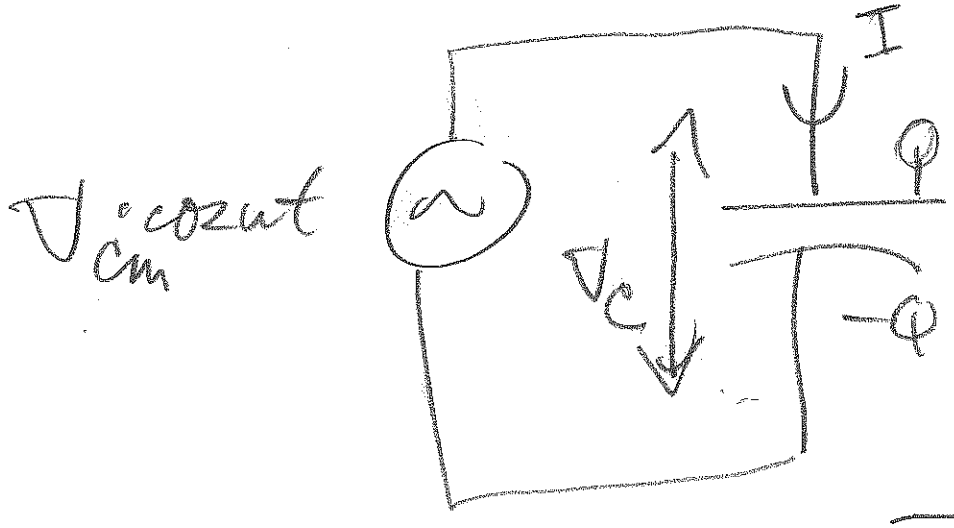
X_L = reactance

$$I = \frac{V_{Lm}}{X_L} \sin \omega t = I_m \sin \omega t$$

Phasor diagram:

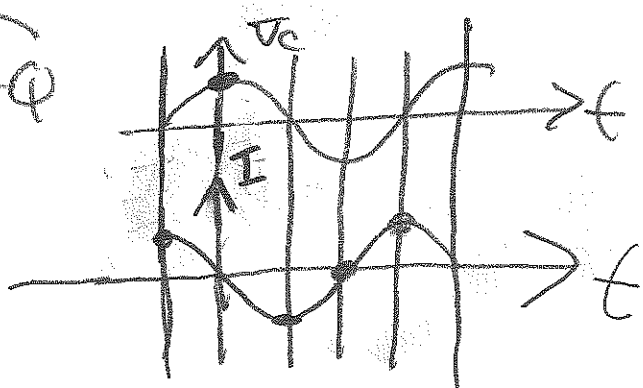


$\vec{I}$ lags $\vec{V}_L$ by 90°



C and source only:

I leads V_C by 90°.



$$I = \frac{\Delta Q}{\Delta t} = C\frac{\Delta V_C}{\Delta t}, \quad \Delta V_C = \text{change in voltage}$$

$$I = -I_{cm} \cdot \sin\omega t = -\omega C V_{cm} \cdot \sin\omega t$$

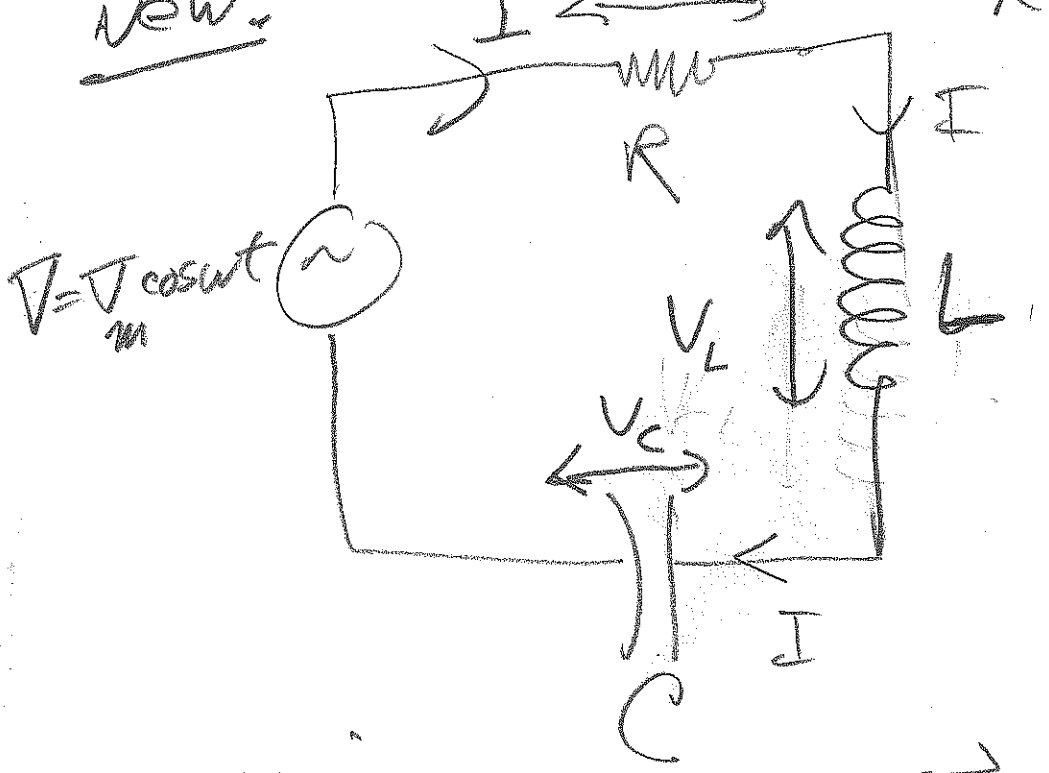
I leads V_C by 90°

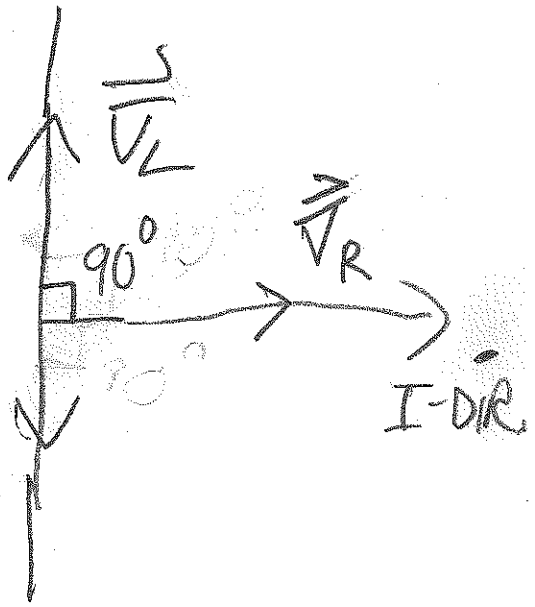
$$I_{cm} = \frac{V_{cm}}{X_C}, \quad X_C = \frac{1}{\omega C}$$

note: as C gets large, I can get large.

↑ Reactance

NEW! R-L-C in series





MAIN RESULT

$$I = I_m \cdot \cos(\omega t - \phi)$$

↑ complicated phase function

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

$$= \frac{V_m}{Z}, \quad Z = \underline{\text{impedance}}$$

I_m = maximum at resonance:

$$\omega L - \frac{1}{\omega C} = 0$$

$$\omega = \frac{1}{\sqrt{LC}} = \text{natural frequency}$$

$$I_{m_{MAX}} = \frac{V_m}{R}$$

as R get small $I_{m_{MAX}}$ is large.

* see Tacoma Falls bridge collapse on U-tube: velocity, like current I