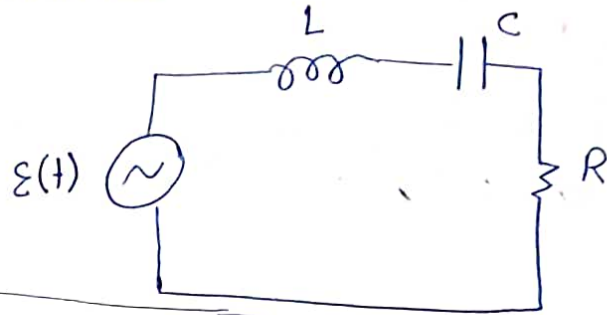


## Exp 8:- Impedance & Reactance

$$\varepsilon(t) = \varepsilon_0 \cos \omega t$$



Impedance = Resistance +  $j$  Reactance  $\rightarrow$  Complex number

$$Z_R = R$$

$$Z_C = -\frac{j}{\omega C} \Rightarrow \text{Reactance } (X_C) = -\frac{1}{\omega C}$$

$$Z_L = j\omega L \Rightarrow \text{Reactance } (X_L) = \omega L$$

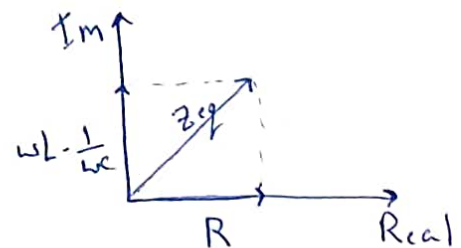
$$I(t) = \frac{\varepsilon(t)}{Z_{eq}}$$

$Z_{eq}$ : equivalent Impedance

$$\begin{aligned} Z_{eq} &= Z_R + Z_C + Z_L \\ &= R + j\left(\omega L - \frac{1}{\omega C}\right) \end{aligned}$$

$$I(t) = I_0 \cos(\omega t + \phi)$$

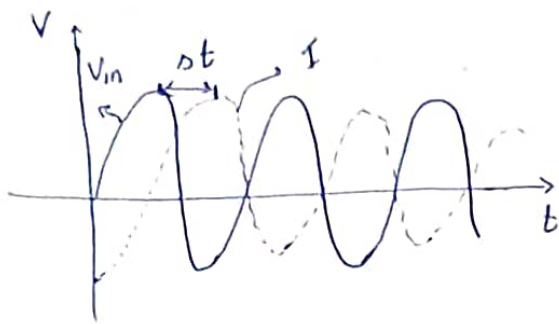
$$I_0 = \frac{\varepsilon_0}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$



$$\phi = \tan^{-1} \left( \frac{-\omega L + \frac{1}{\omega C}}{R} \right) : \text{phase shift bt. } \varepsilon(t) \text{ \& } I(t).$$

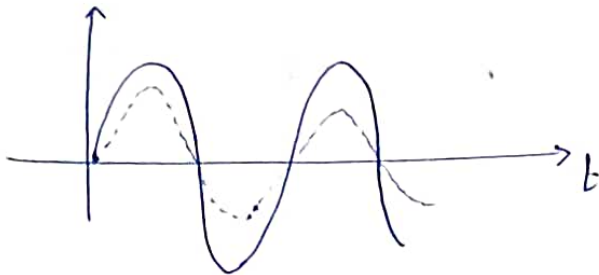
When  $\phi = 0$ ??

$$-\omega L + \frac{1}{\omega C} = 0 \Rightarrow \omega L = \frac{1}{\omega C} \Rightarrow \boxed{\omega = \frac{1}{\sqrt{LC}}}$$



$$\phi = \omega \Delta t$$

$$\phi = 2\pi f \Delta t$$



$$\phi = 0, \Delta t = 0$$

$$V_L = L \frac{dI}{dt} = L \frac{d}{dt} (I_0 \cos(\omega t + \phi))$$

$$= -\omega L I_0 \sin(\omega t + \phi)$$

$$V_R = R I(t) = R I_0 \cos(\omega t + \phi) = R I \sin(\omega t + \phi + \frac{\pi}{2})$$

$$V_C = \frac{Q}{C}, \quad Q = \int I dt$$

$$= \frac{\int I dt}{C} = \frac{\int I_0 \cos(\omega t + \phi) dt}{C}$$

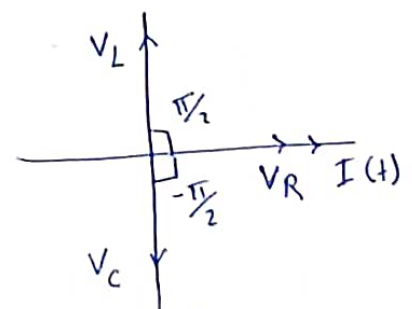
$$V_C = \frac{I_0}{\omega C} \sin(\omega t + \phi)$$

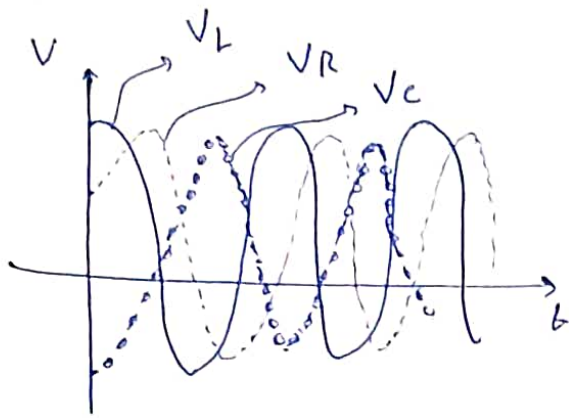
phase shift b.t.  $V_L$  &  $V_R = \frac{\pi}{2}$

" " "  $V_R$  &  $V_C = -\frac{\pi}{2}$

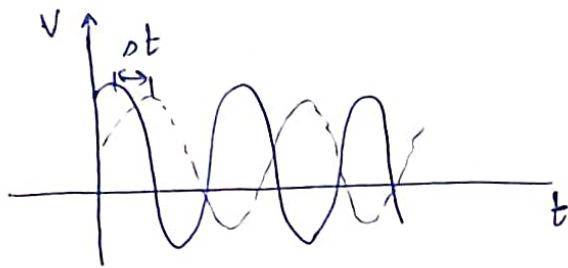
$V_R$  is in phase with  $I(t)$

phase shift b.t.  $V_L$  &  $V_C = \pi$  (out of phase)



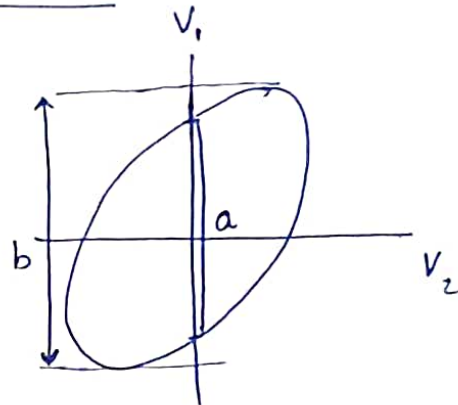


\* phase shift by external mod



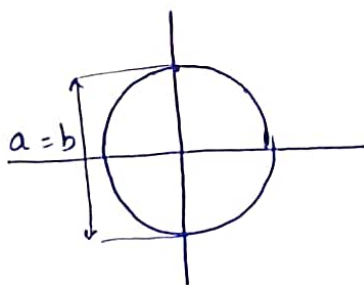
$$\phi = \omega \Delta t$$

Internal mod.



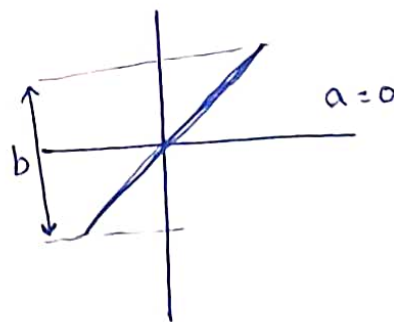
$$\phi = \sin^{-1}\left(\frac{a}{b}\right)$$

Special cases :-



$$\phi = \sin^{-1}(1)$$

$$\phi = \frac{\pi}{2}$$



$$\phi = \sin^{-1}(0)$$

$$= 0$$