VISUAL PHYSICS

SHORT NOTES

CHAPTER

Alternating Current

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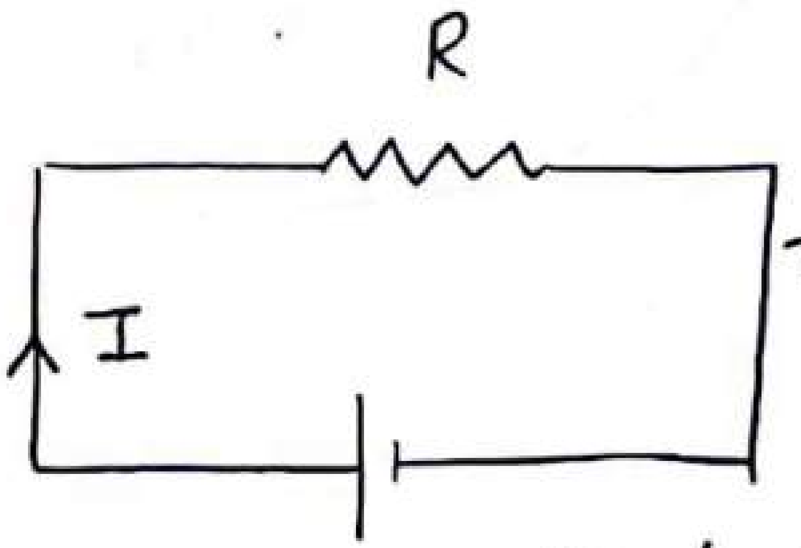
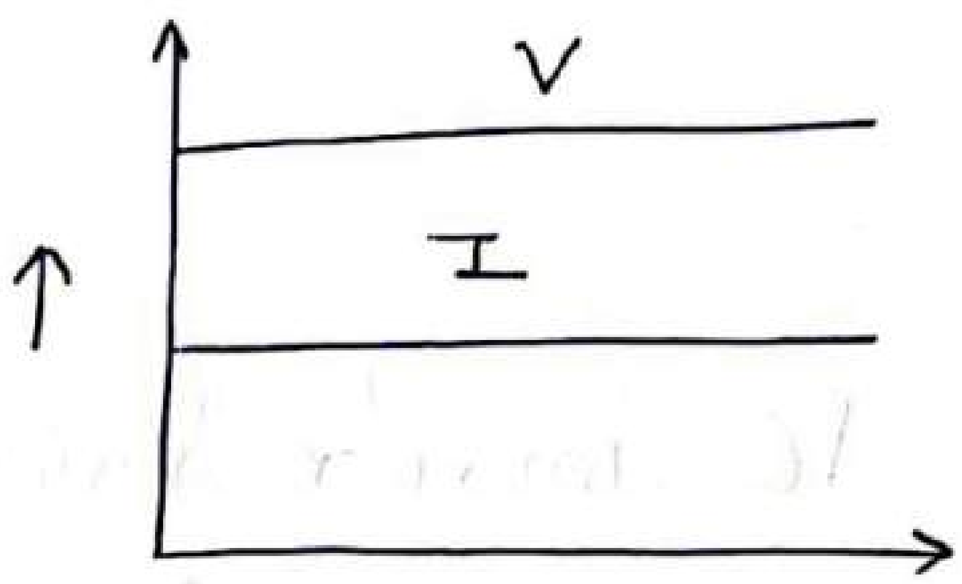
Alternating Current



→ Constant current

→ Constant Voltage Source



→ Direct Current (DC) source

→ Constant Values

Generaly,

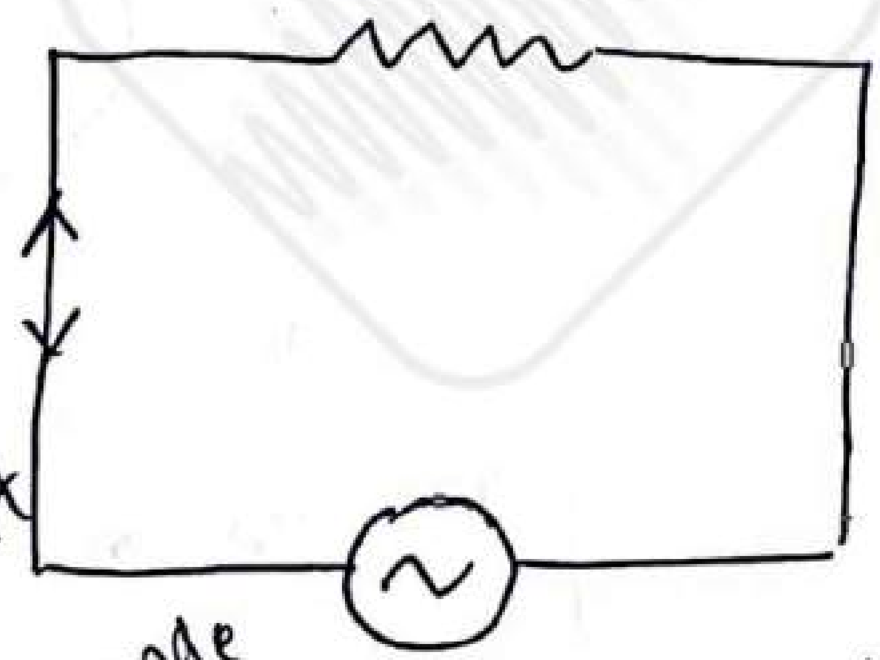
Current sources, are not having constant Voltage & current.

In Constant (DC) source → electrons moves from one point to other.

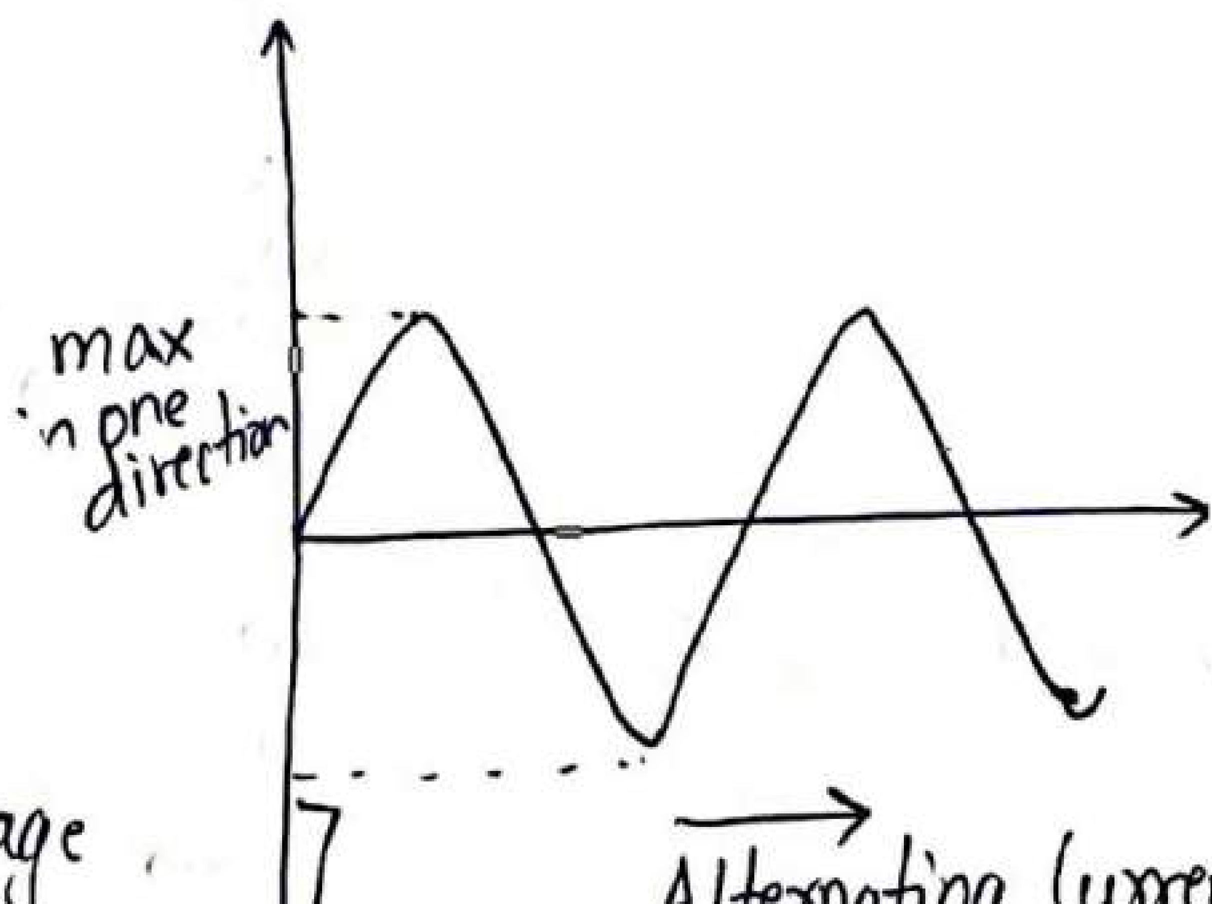
In Alternating Source (AC) → electrons oscillates, they don't move around much.

current varies

→ direction of current will also change



→ Symbol of AC Voltage source



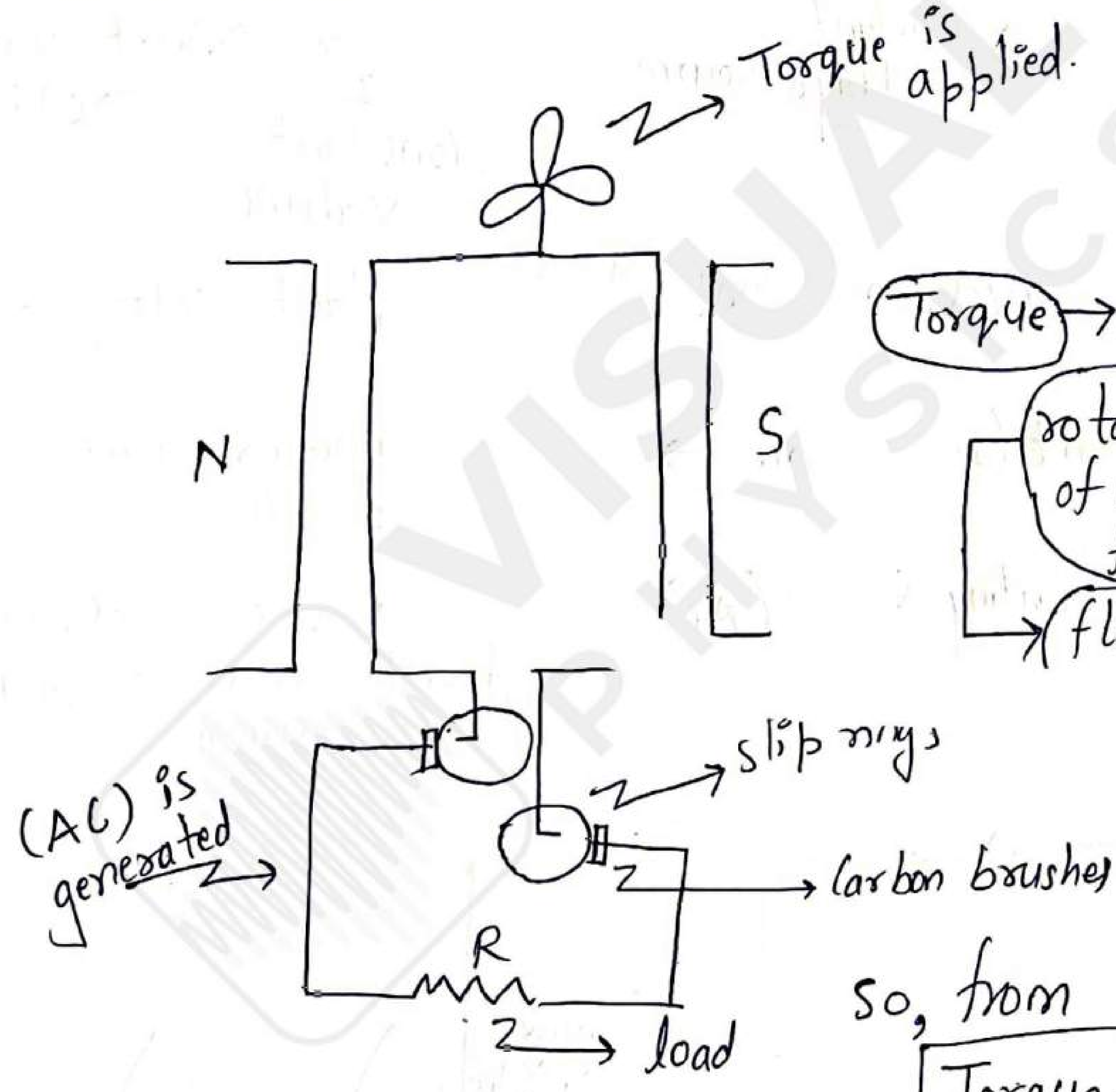
→ Alternating Current (AC) Source

max in other direction

AC → easy and economical to generate, hence in homes we get AC.

↳ And can be effectively transmitted over distance

AC Generator basics.



Torque → Applied → rotating of coil in magnetic field → flux linked continue → Current generated

So, from

$\boxed{\text{Torque} \rightarrow \text{Current generation}}$

* As flux varies → Sinusodialy

↳ So emf and current generated sinusodial.

and current

So voltage & can be represented by:

$$\boxed{\begin{aligned} V &= V_0 \sin(\omega t + \phi_1) \\ i &= i_0 \sin(\omega t + \phi_2) \end{aligned}}$$

ϕ_1, ϕ_2 initial phase

$V_0, i_0 \rightarrow$ amplitudes.

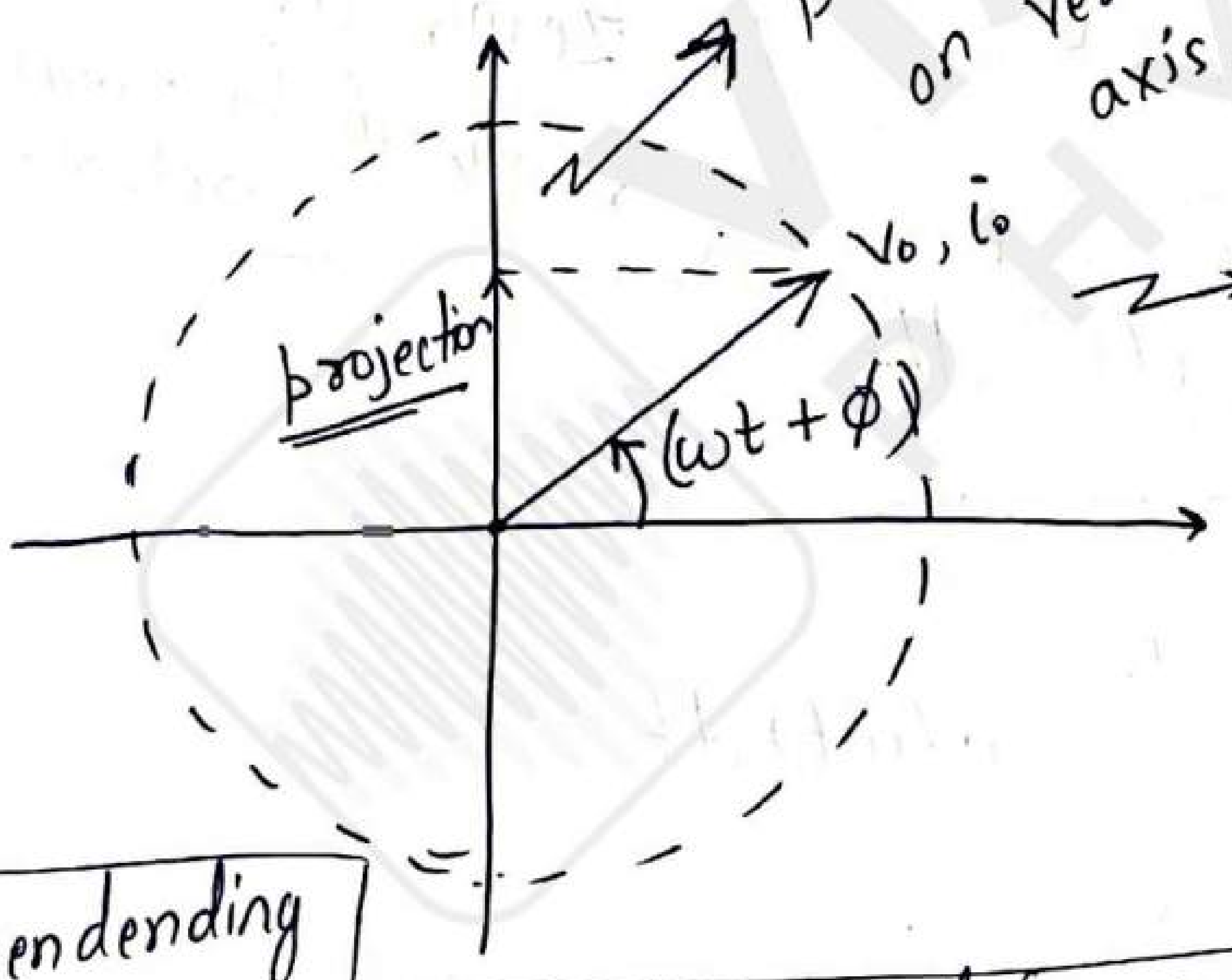
$\omega \rightarrow$ angular frequency

$\boxed{\omega = 2\pi f}$ $\rightarrow$ frequecy

similar as of SHM.

means, it can be represented
As projection of uniform circular motion

So, we can similarly represent voltage and current as the projection of vector, with angular frequency ω.



$\rightarrow$ phasor diagram.

rotation is consider in anticlockwise direction

depending on components, voltage and current are not necessary in phase.

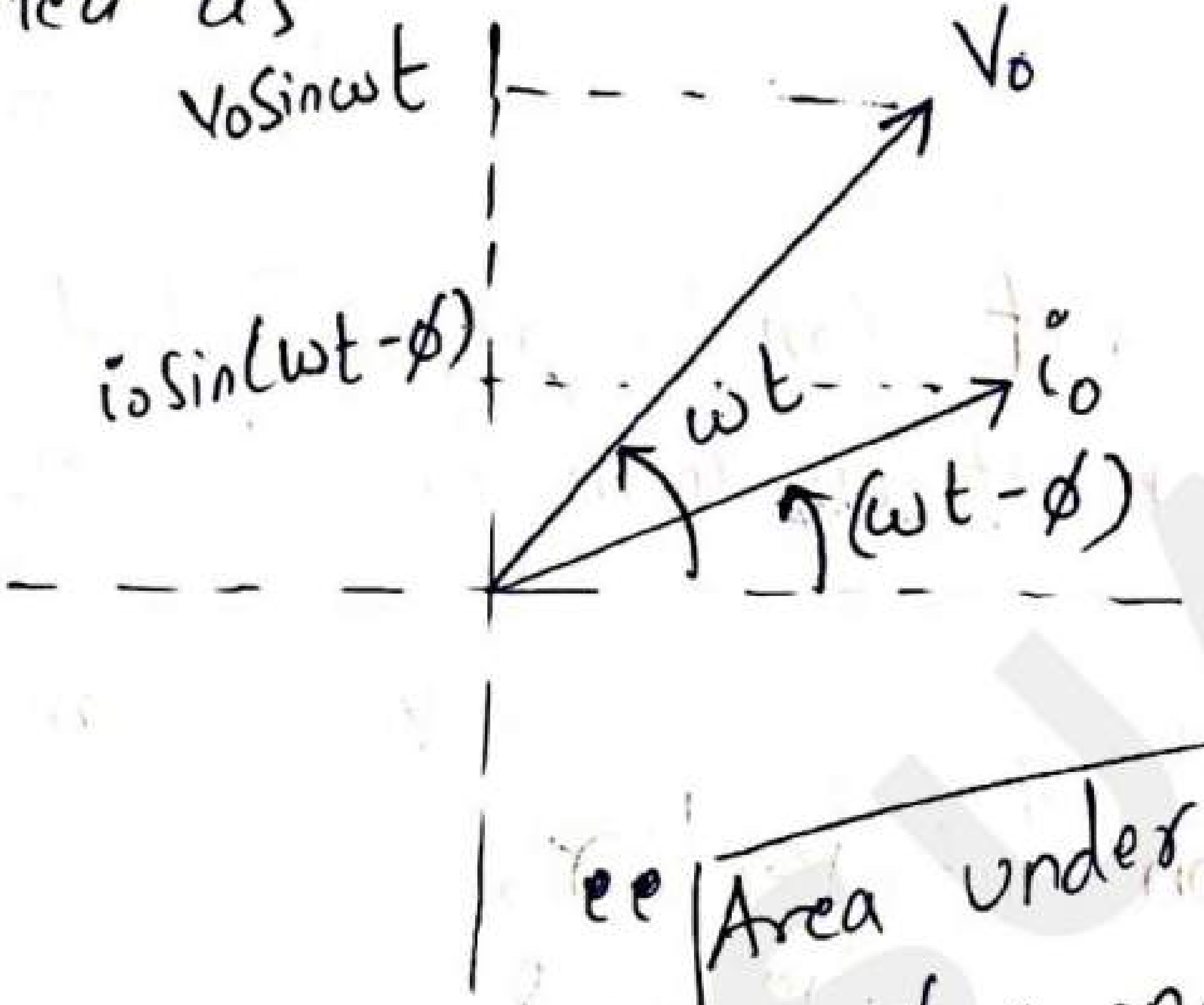
$\rightarrow$ reaching max, min at ~~s~~ same time.

if for example $V(t) = V_0 \sin(\omega t)$

and $i(t) = i_0 \sin(\omega t - \phi)$

i.e. $\boxed{i \rightarrow \phi \text{ behind} \rightarrow V}$

so represented as



* V & i have same frequency but may or may not same amplitude

Average of i & V

"Area under i, V and t graph for one cycle, that is zero, as area above is equal to area below."

$$\langle i(t) \rangle = \frac{\int_0^T i(t)\,dt}{T}$$

average of $i(t)$

$$= \frac{i_0}{T} \int_0^T \sin(\omega t)\,dt$$

$$= -\frac{I_0}{\omega t} [\cos \omega t - \cos 0] = 0$$

similarly $\langle V(t) \rangle = 0$

average of $V(t)$

"So, in terms of dealing with AC components average values are not helpful."

root means square.

let

$i_{rms} \rightarrow$ Constant current source value. which provides same heat in one cycle emits as the AC current $i(t)$ emits.

as $H = \int_0^T i^2 R dt =$

$$= \int_0^T i_0^2 \sin^2\omega t \, R dt$$

$$H = \int_0^T i_{rms}^2 R dt$$

$$\Rightarrow \quad i_{rms}^2 R T = \int_0^T i_0^2 \sin^2\omega t \, R dt$$

$$= i_0^2 R \int_0^T \left[\frac{1 - \cos(2\omega t)}{2}\right] dt$$

$$i_{rms}^2 R T = \frac{i_0^2 R}{2} T$$

$$\boxed{i_{rms} = \frac{i_0}{\sqrt{2}}}$$

Now as from ohm's law

$$v(t) = i(t)R$$

We will get same result for rms value of voltage. rms value.

$$\boxed{V_{rms} = \frac{V_0}{\sqrt{2}}}$$

★ AC voltmeter and ammeter are calibrated to measure the rms values.

"So if nothing is mentioned than values provided is in rms form unless stated."

so for calculation of peak value,

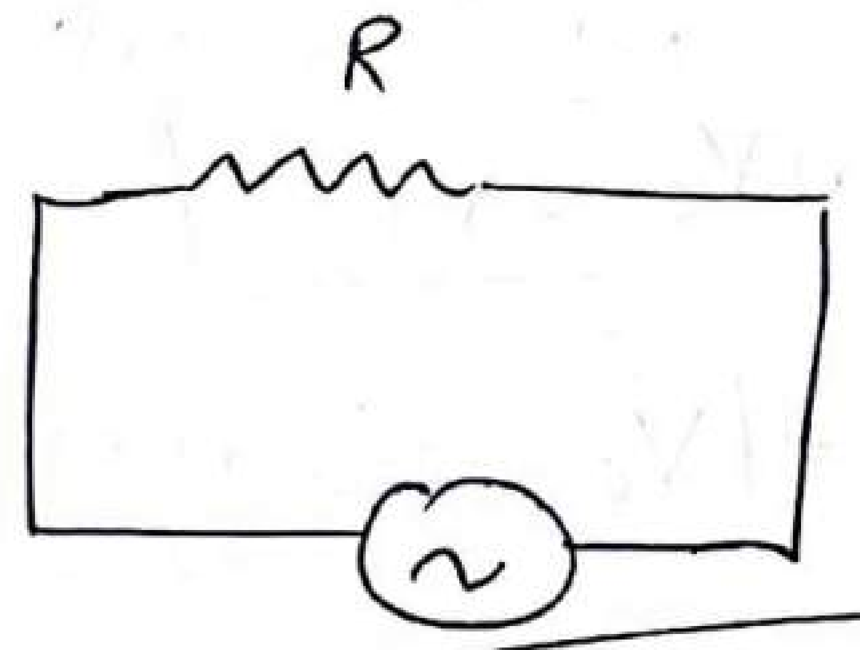
$\boxed{V_0 = \sqrt{2}\, V_{rms}}$ and $\boxed{i_0 = \sqrt{2}\, i_{rms}}$

★ DC voltmeter & Ammeter cannot be used to measure values of AC, voltage & current.

as DC voltmeter and Ammeter measures average values

Zero for AC, current and voltage

Resistive load



$$\boxed{v(t) = V_0 \sin(\omega t)}$$

As, from ohm's law around the resistor

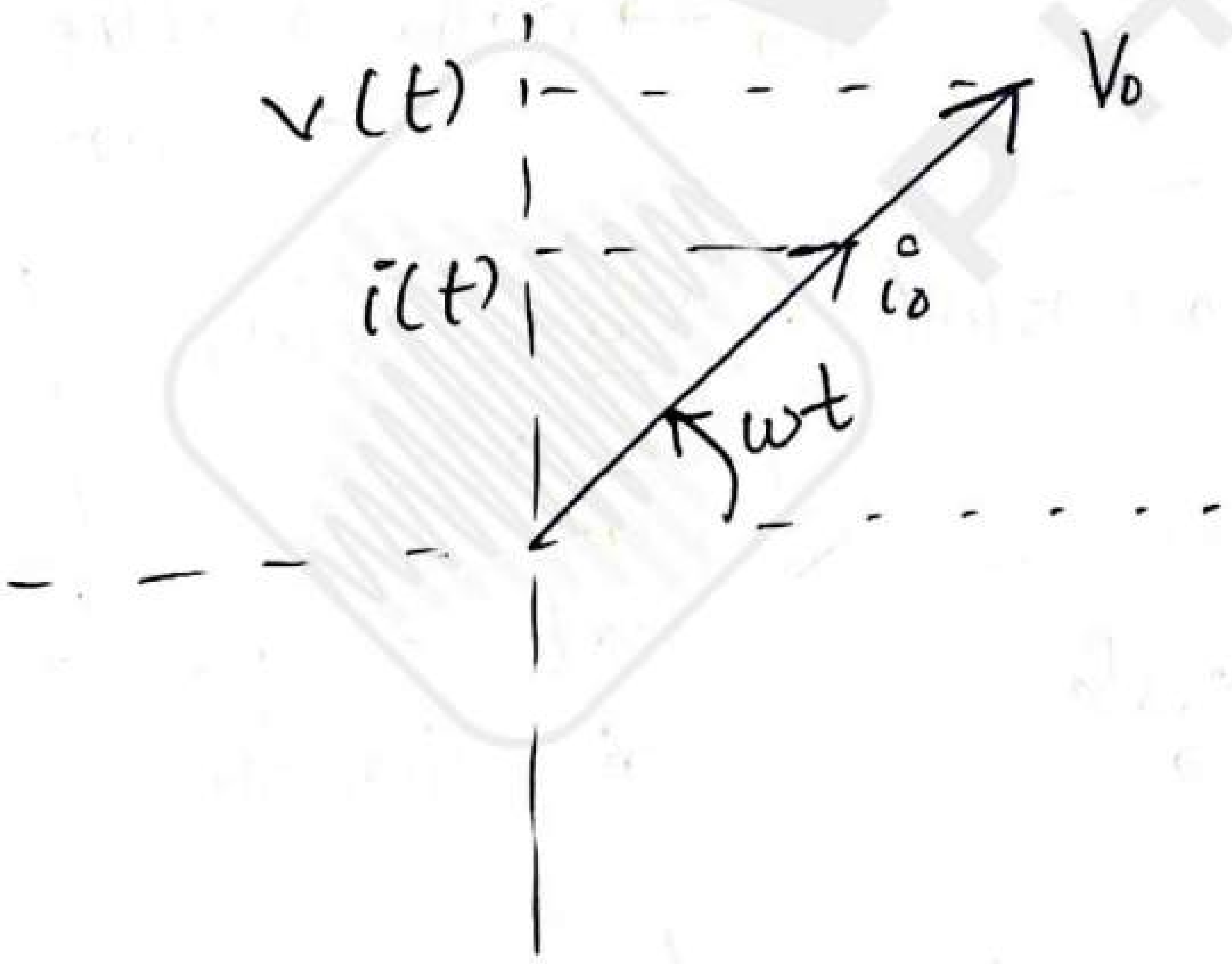
$$\Rightarrow i(t) = \frac{v(t)}{R}$$

$$\Rightarrow i(t) = \left(\frac{V_0}{R}\right) \sin \omega t$$

$\frac{V_0}{R} \rightarrow i_0 \rightarrow$ max value of i

$$\Rightarrow \boxed{i(t) = i_0 \sin \omega t}$$

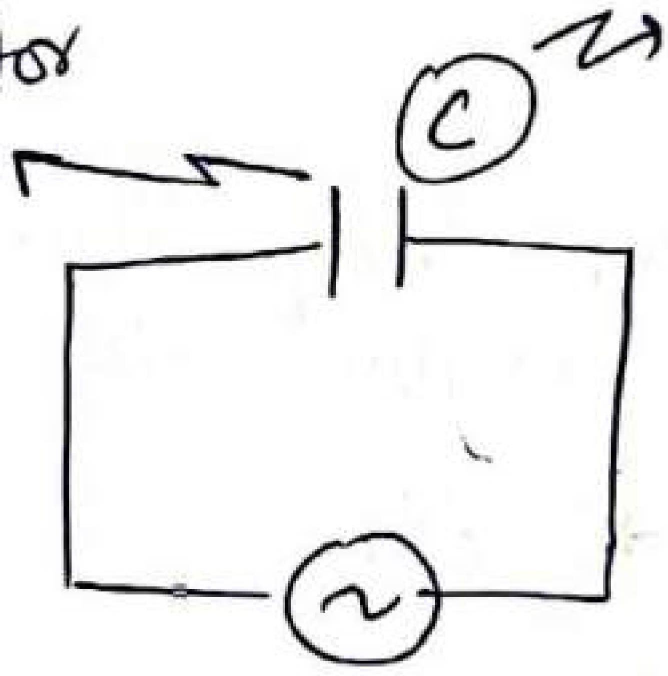
So, voltage across resistor and current through it are in same phase.



★ "that is they achieve their max and min value at same time. And become zero at same time."

Capacitive load

capacitor



C → capacitance

$V(t) = V_0 \sin \omega t$

→ potential across capacitor

so, $\boxed{V_c = V(t)}$

$\Rightarrow \boxed{V_c = V_0 \sin \omega t}$

As we know for capacitor

$$q(t) = C V_c$$

$$\Rightarrow q(t) = C V_0 \sin \omega t$$

now

$$i(t) = \frac{d}{dt}(q(t)) = (C V_0 \omega) \cos \omega t$$

i_0 → max value of current

$\Rightarrow$ $\boxed{i(t) = i_0 \cos \omega t = \frac{V_0}{\left(\frac{1}{C\omega}\right)} \cos \omega t}$

$\left(\frac{1}{C\omega}\right)$ → Sort of resistance for capacitor

Capacitive reactance

$\boxed{X_c = \frac{1}{\omega C}}$ [unit] = Resistance = Ω (ohm)

$\boxed{\text{for } \omega \to 0 \text{ (dc)} \to \text{Open circuit} \quad X_c \to \infty,\ i = 0}$

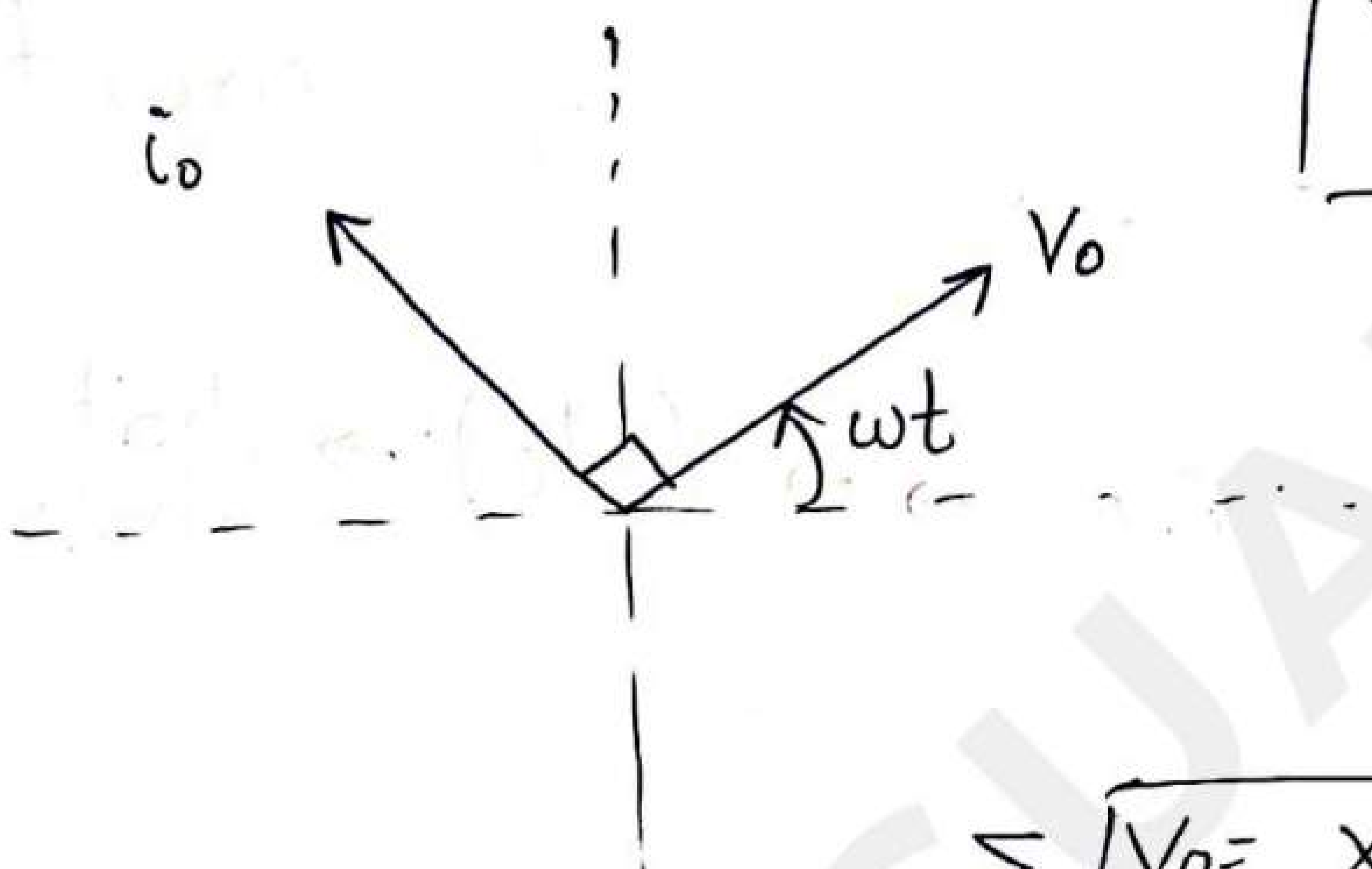
$\boxed{\omega \to \infty \quad X_c \to 0,\ i \to \infty}$ → $\boxed{\text{Capacitor behave as short circuit}}$

Current through capacitor $\Rightarrow$ $i_c(t) = i_0 \sin(\omega t + \pi/2)$

$V_c(t) = V_0 \sin \omega t$

$\rightarrow$ current is ahead of voltage by phase of $\pi/2$

$$\boxed{\begin{matrix} V \rightarrow 0 \\ i \rightarrow i_0 \end{matrix}}$$

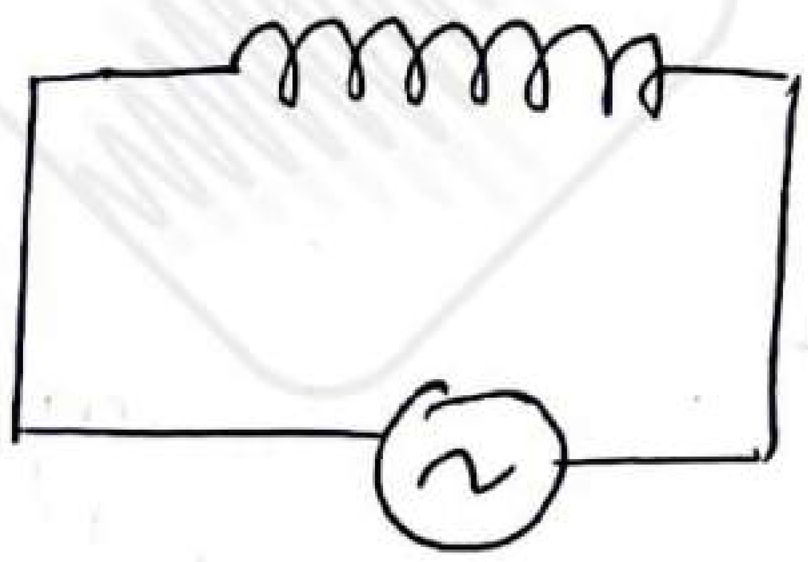


$$\boxed{V_0 = X_c\, i_0}$$

independent on phase

relation between amplitudes

Inductive load



$V_0(t) = V_0 \sin \omega t$

$V_L(t) = V_0(t)$

$$\boxed{V_L(t) = V_0 \sin \omega t}$$

as, $V_L(t) = L \dfrac{di_L}{dt}$

$\Rightarrow i_L = \displaystyle\int_0 \frac{V_L(t)}{L}\, dt$

$\Rightarrow i_L = \dfrac{1}{L} \displaystyle\int V_0 \sin \omega t \, dt$

$i_L = -\dfrac{V_0}{\omega L}(\cos \omega t)$

$i_L(t) = \frac{V_L}{(\omega L)}(-\cos\omega t)$

$\boxed{X_L \rightarrow \text{inductance reactance}}$ ↳ Inductive reactance

$\omega L = X_L$ · unit → (Ohm)

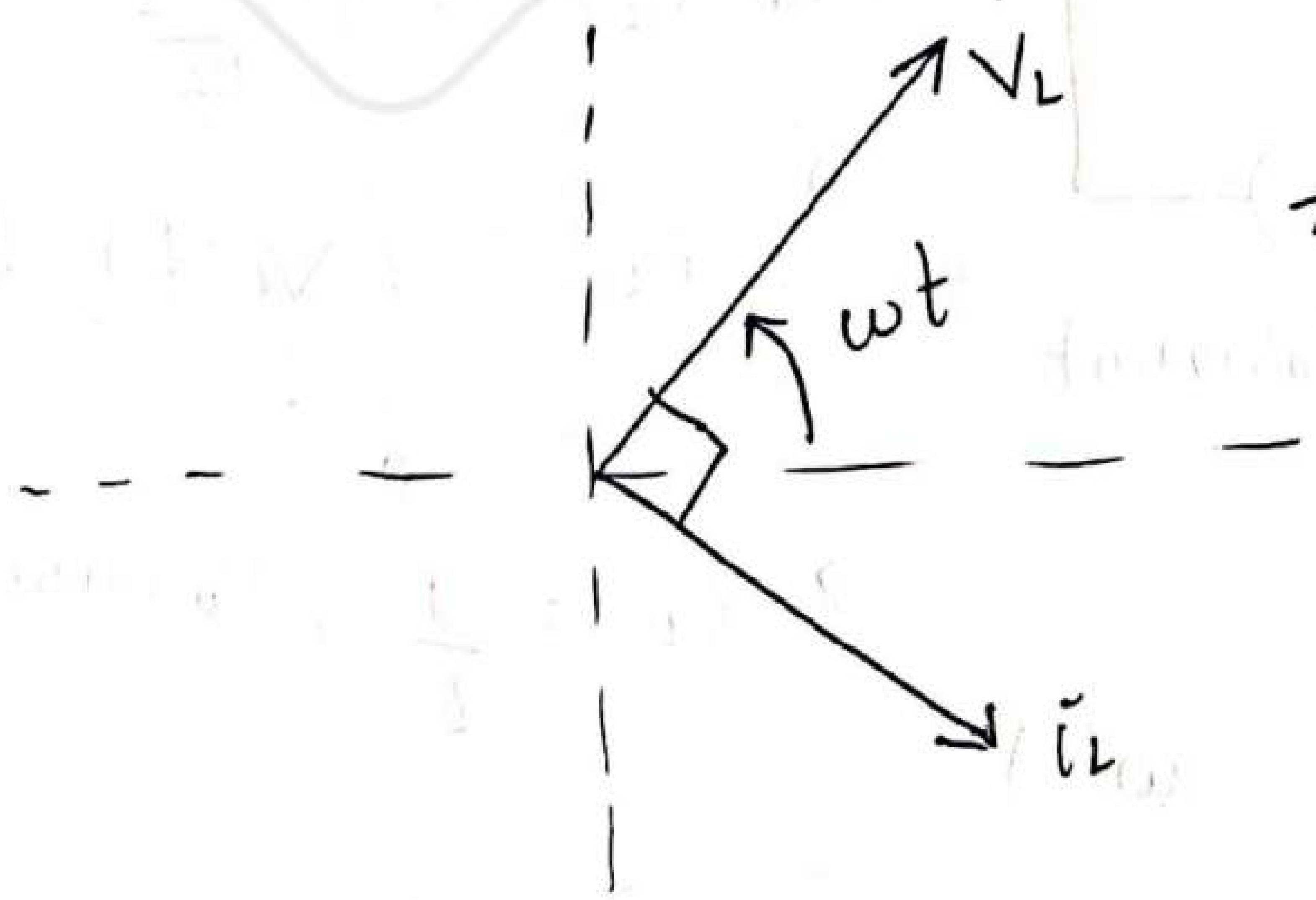
$$\boxed{\begin{aligned} &\Rightarrow \omega \to \infty, \quad \to i_L(t) \to 0 \quad \text{open circuit.} \\ &\quad X_L \to \infty \\ &\Rightarrow \omega \to 0 \quad \to i_L(t) \to \infty \ (dc) \to \text{short circuit} \\ &\quad X_L \to 0 \end{aligned}}$$

$$\Rightarrow i_L(t) = \frac{V_L}{X_L}\boxed{\sin(\omega t - \pi/2)} = \frac{V_L}{X_L}(-\cos\omega t)$$

as

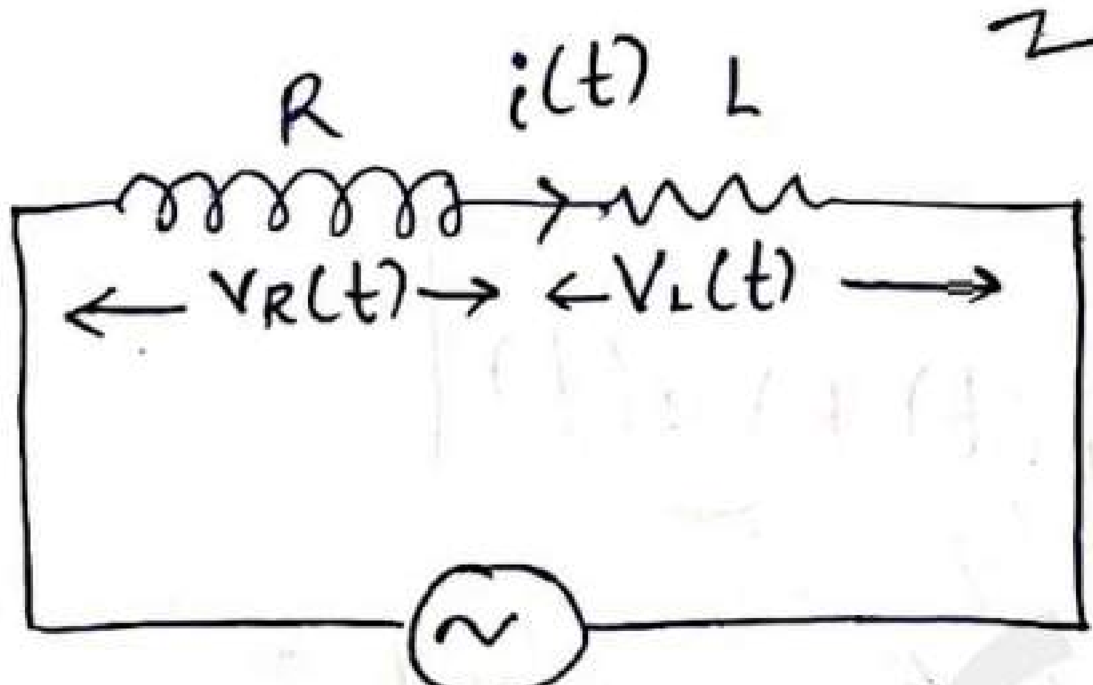
⇒ Current is behind voltage by $\pi/2$ phase.

through $\boxed{i_0 = \frac{V_0}{X_L}}$ → no relation to phase



→ Current is $\pi/2$ behind V_L

Series R-L



$v(t) = V_0 \sin(\omega t)$

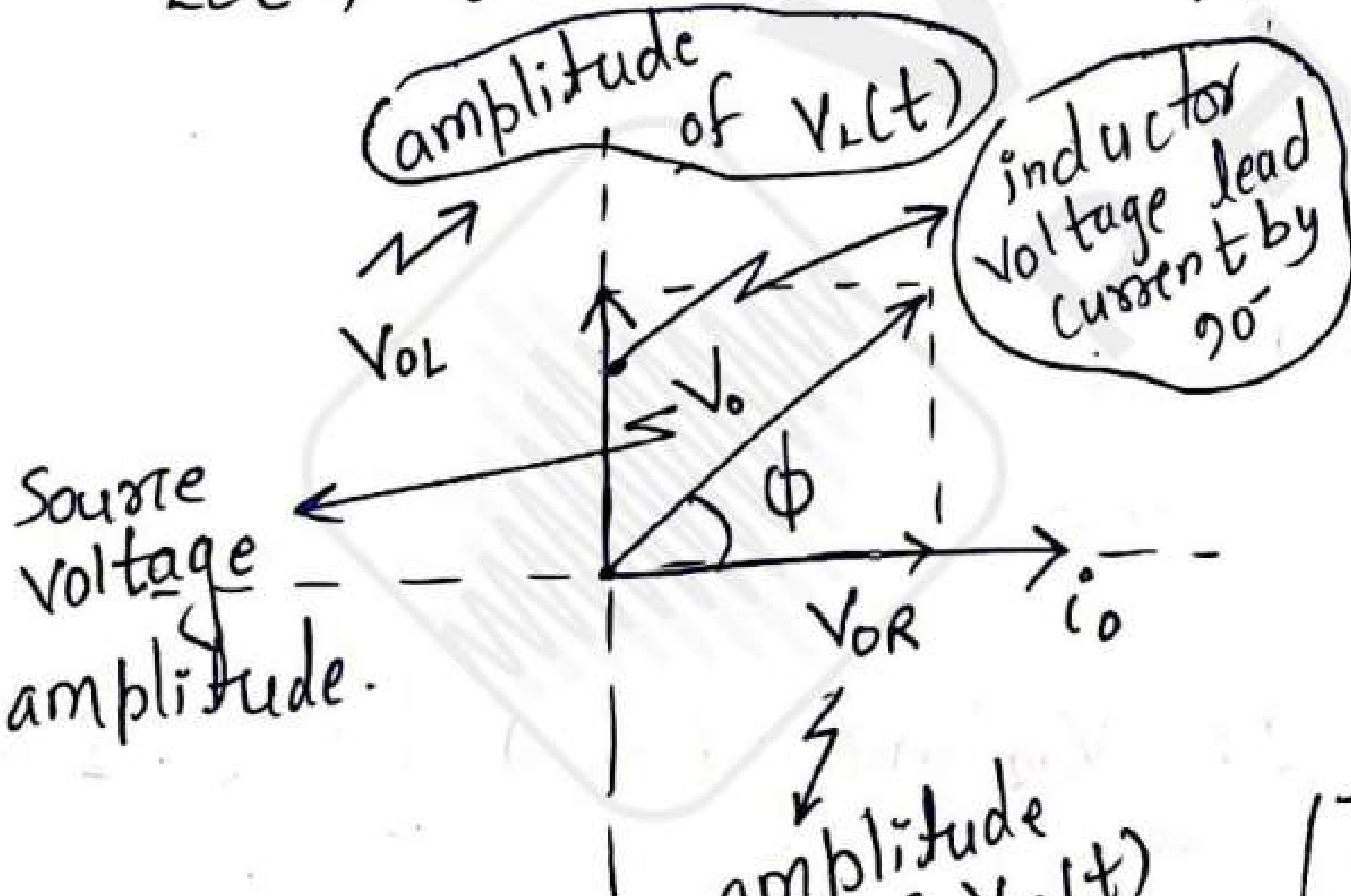
in series, so current in each element will be same at any instant.

Now at any instant

$$\boxed{V(t) = V_R(t) + V_L(t)}$$

↳ krichhoff's rule.

Let, $i(t) = i_0 \sin(\omega t - \phi)$



now,

as, $V_0^2 = V_{0R}^2 + V_{0L}^2$

as $V_{0R} = R\, i_0$

& $V_{0L} = X_L\, i_0$

So,

$$\boxed{V_0 = i_0 \sqrt{R^2 + X_L^2}}$$

So, $\boxed{\dfrac{V_0}{i_0} = \sqrt{R^2 + X_L^2}}$

Impedence of circuit

↳ Total resistance.

$$Z = \sqrt{R^2 + X_L^2} = \text{Impedence}$$

$X_L \rightarrow \Omega$, $R \rightarrow \Omega$

but $Z \neq \underline{R + X_L}$ — they add up with their phase.

NOW $\boxed{\tan\phi = \frac{V_L}{V_R} = \frac{X_L}{R}}$

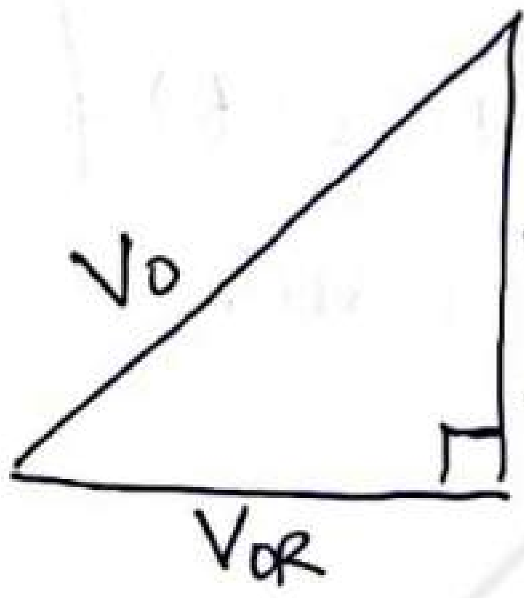
ϕ → phase diff between V & I

☆ for RL circuit voltage leads current by some phase.

☆ $V_0 \neq V_L + V_R$

But, $\boxed{V(t) = V_L(t) + V_R(t)}$

Instantaneous values get add up to give value of instant source voltage



→ voltage traingle

<u>for exact mathematical derivation</u>

$$v(t) = V_0 \sin(\omega t)$$
$$i_0(t) = i_0 \sin(\omega t - \phi)$$

as, $V_R(t) = i(t) R = V_{0R} \sin(\omega t - \phi)$ $[V_{0R} = i_0 R]$

As we know
$$\boxed{\begin{aligned} V_L(t) &= V_{0L} \sin(\omega t) \\ i_L(t) &= i_{0L} \sin(\omega t - \pi/2) \end{aligned}}$$
current lags by 90°

Now, we can also say

$$V_L(t) = V_{0L}\sin\left(\omega t - \phi + \pi/2\right)$$ V_L leads by $90°$

if $i_L(t) = i_0 \sin(\omega t - \phi)$

as, we know $\sin\left(\pi/2 + \omega t - \phi\right) = \cos(\omega t - \phi)$

so, $V_L(t) = V_{0L}\cos(\omega t - \phi)$

also, $V_{0L} = i_0 X_L$

As $V_s(t) = V_R(t) + V_L(t)$

$$\boxed{V_0 \sin\omega t = V_{0R}\sin(\omega t - \phi) + V_{0L}\cos(\omega t - \phi)} \quad -(i)$$

This will always be valid.

so if $t = t + T/4$, still valid

so, $\omega\left(T/4\right) = \pi/2$ = phase.

$$\Rightarrow V_0 \sin\left(\omega t + \pi/2\right) = V_{0R}\sin\left(\omega t - \phi + \pi/2\right) + V_{0L}\cos\left(\omega t - \phi + \pi/2\right)$$

so or

$$V_0\cos(\omega t) = V_{0R}\cos(\omega t - \phi) + \left[-V_{0L}\sin(\omega t - \phi)\right]$$

$$\boxed{V_0\cos(\omega t) = V_R\cos(\omega t - \phi) - V_{0L}\sin(\omega t - \phi)} \quad -(ii)$$

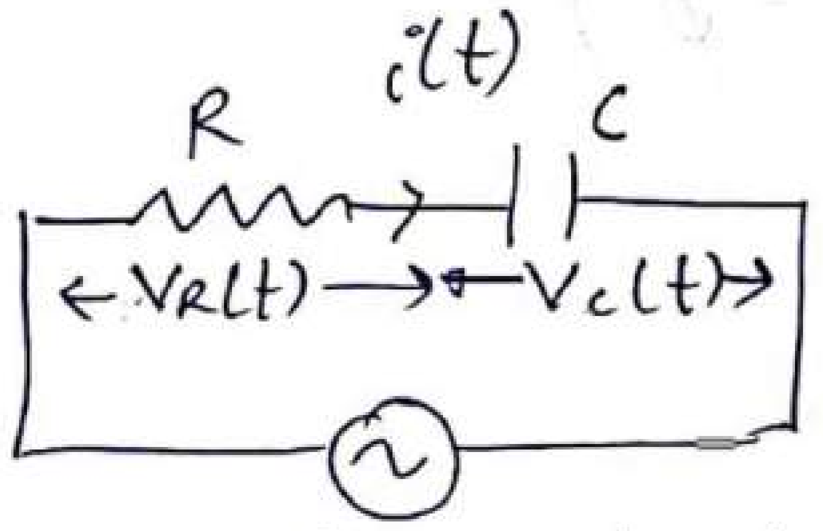
now $(i)^2 + (ii)^2$

We will get:

$$\boxed{V_0^2 = V_{0R}^2 + V_{0L}^2} \rightarrow \text{Same as per phasor analysis.}$$

Same result!

Series R-C circuit:

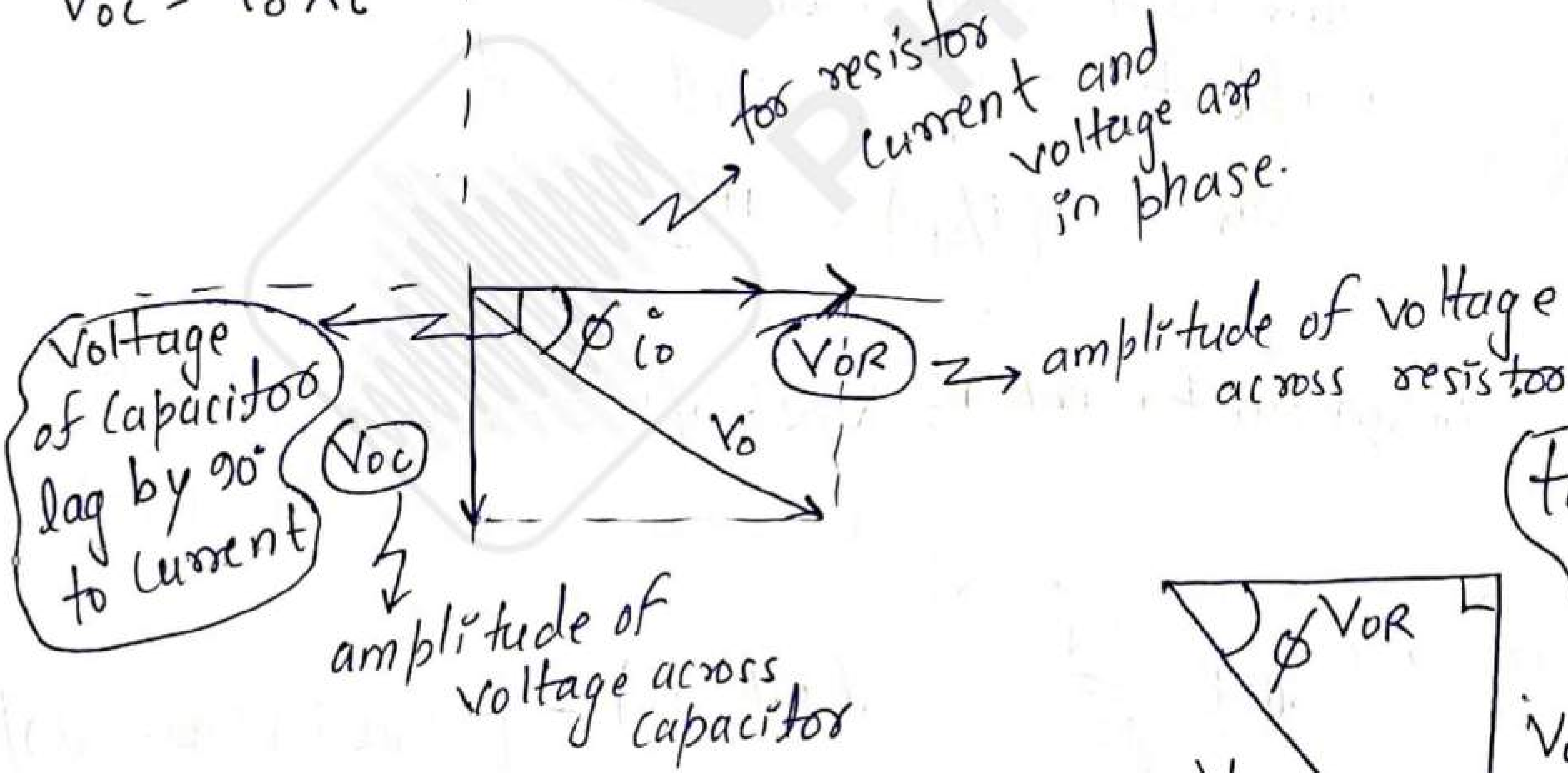


$V(t) = V_0 \sin\omega t$

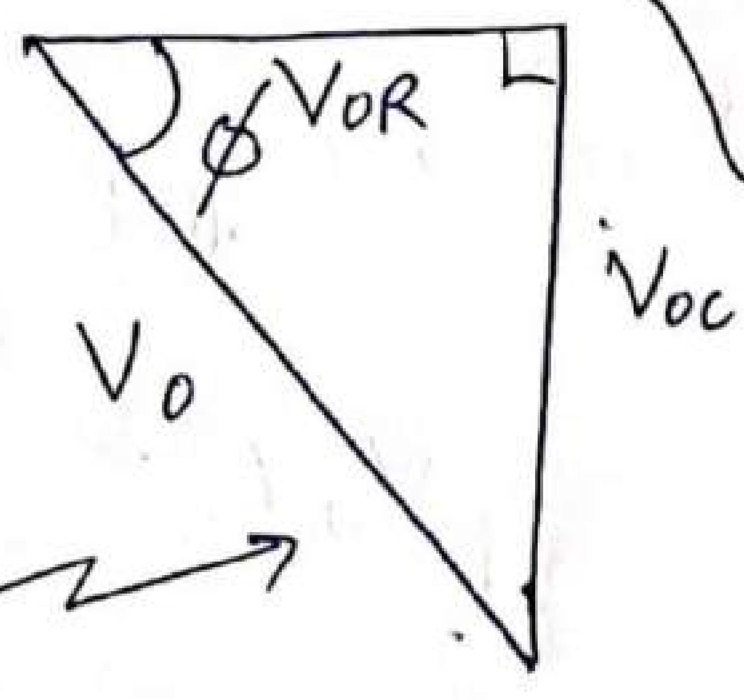
$V(t) = V_0 \sin\omega t$ & $\boxed{V(t) = V_R(t) + V_c(t)}$ → Krichhoff's law

$V_{0R} = i_0 R$

$V_{0C} = i_0 X_c$



$$\tan\phi = \frac{V_{0C}}{V_{0R}} = \frac{X_c}{R}$$



Now here again

Impedence ⇒ $\boxed{Z = \sqrt{R^2 + X_c^2}}$

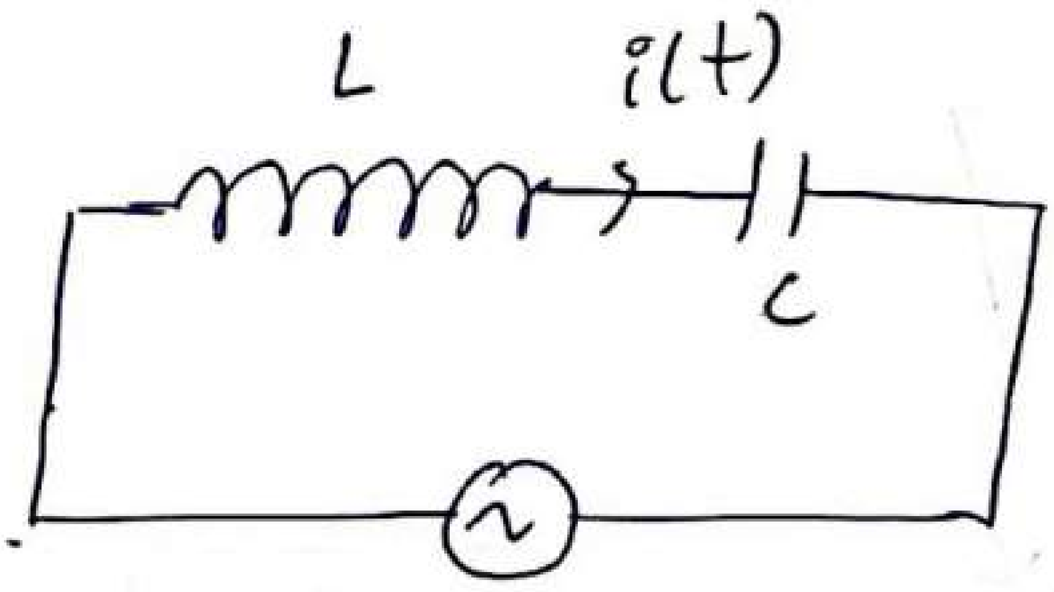
Voltage traingle →

And from voltage traingle

$$\boxed{V_0^2 = V_{0R}^2 + V_{0C}^2}$$

but $\boxed{V_0 \neq V_{0R} + V_{0C}}$, $\boxed{V_0(t) = V_R(t) + V_C(t)}$

Series LC Circuit :

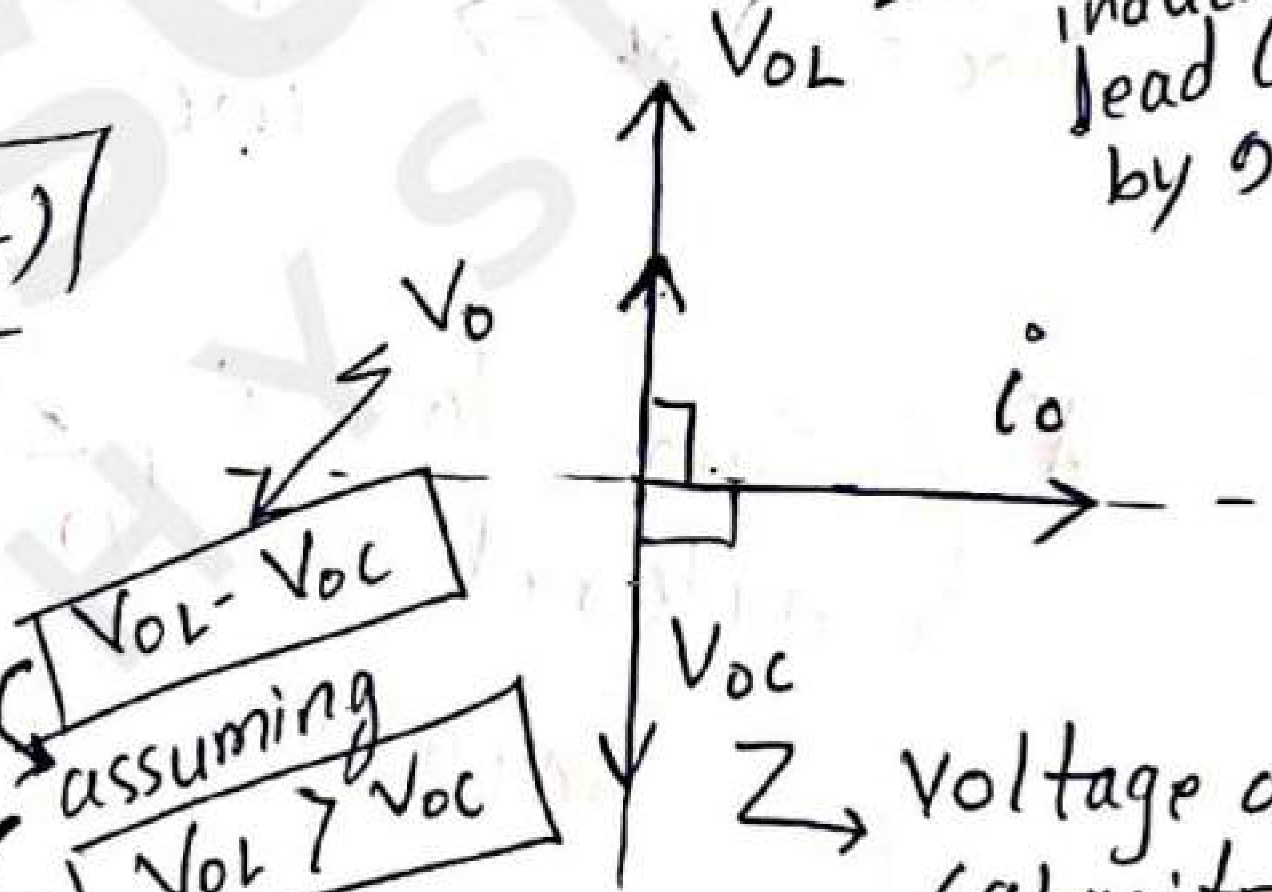


$V(t) = V_0 \sin(\omega t)$

$\boxed{V_0(t) = V_L(t) + V_C(t)}$

Krichhoff's law

from phasor

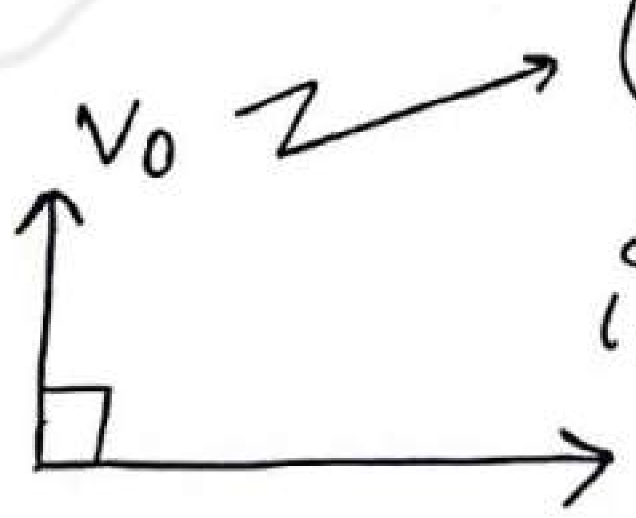


$\Rightarrow \boxed{V_0 = V_{0L} - V_{0C}}$

for $V_{0L} > V_{0C}$

& $\boxed{V_0 = V_{0C} - V_{0L}}$ for $V_{0C} > V_{0L}$

so,



net voltage still lead or lag by 90° from current depending on which is greater V_{0L} or V_{0C}

so, $Z = X_L - X_C$ or $X_C - X_L$ depending

or $\boxed{|Z| = |X_L - X_C|}$

it is possible that :

$$V_{0L} > V_0 \ \& \ V_{0C} > V_0$$

so if $V_{0L} > V_{0C}$ (circuit is more Inductive)

if $V_{0C} > V_{0L}$ (circuit is more capacitive)

if $V_{0C} = V_{0L}$

then $Z = 0$, so current $i \to \infty$

as, $\boxed{i_0 = \dfrac{V_0}{Z}}$

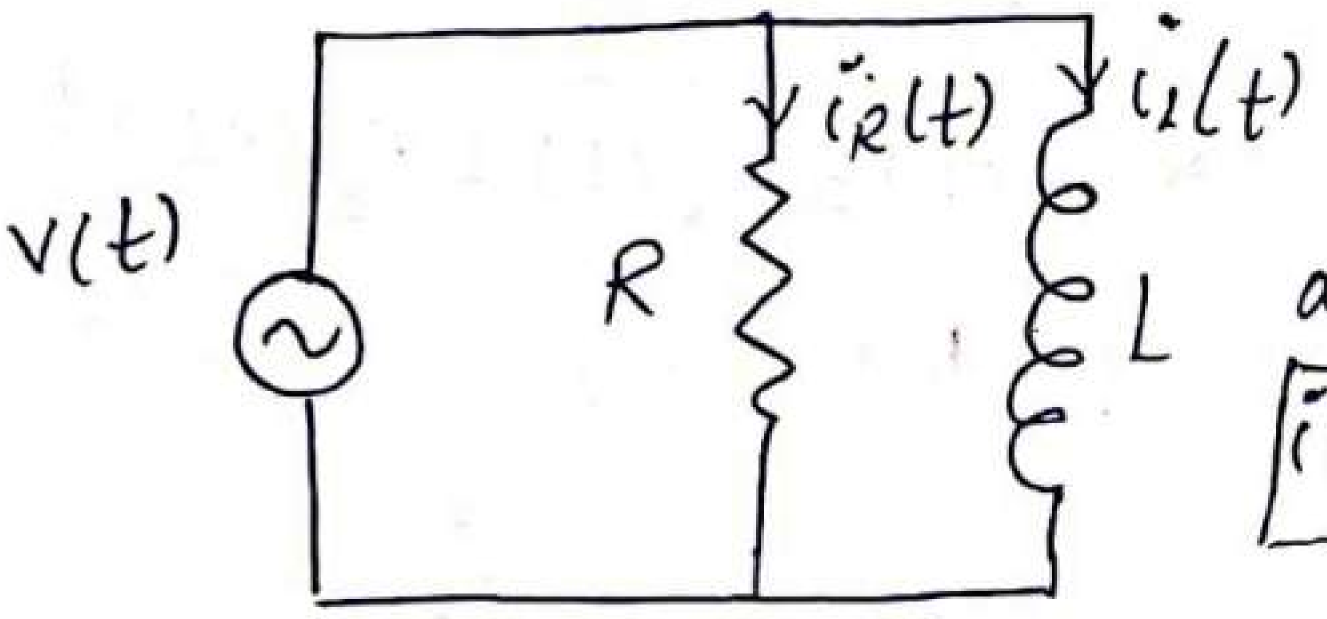
$V_{0C} = V_{0L} \Rightarrow \dfrac{1}{\omega C} = \omega L$ or $\boxed{\omega = \sqrt{\dfrac{1}{LC}}} = \omega_0$

* Same to be natural angular frequency of LC circuit

So if outside frequency ω, reach ω_0 circuit is in resonance

parallel R-L circuit

As elements are in parallel voltages amplitude across the elements will be same

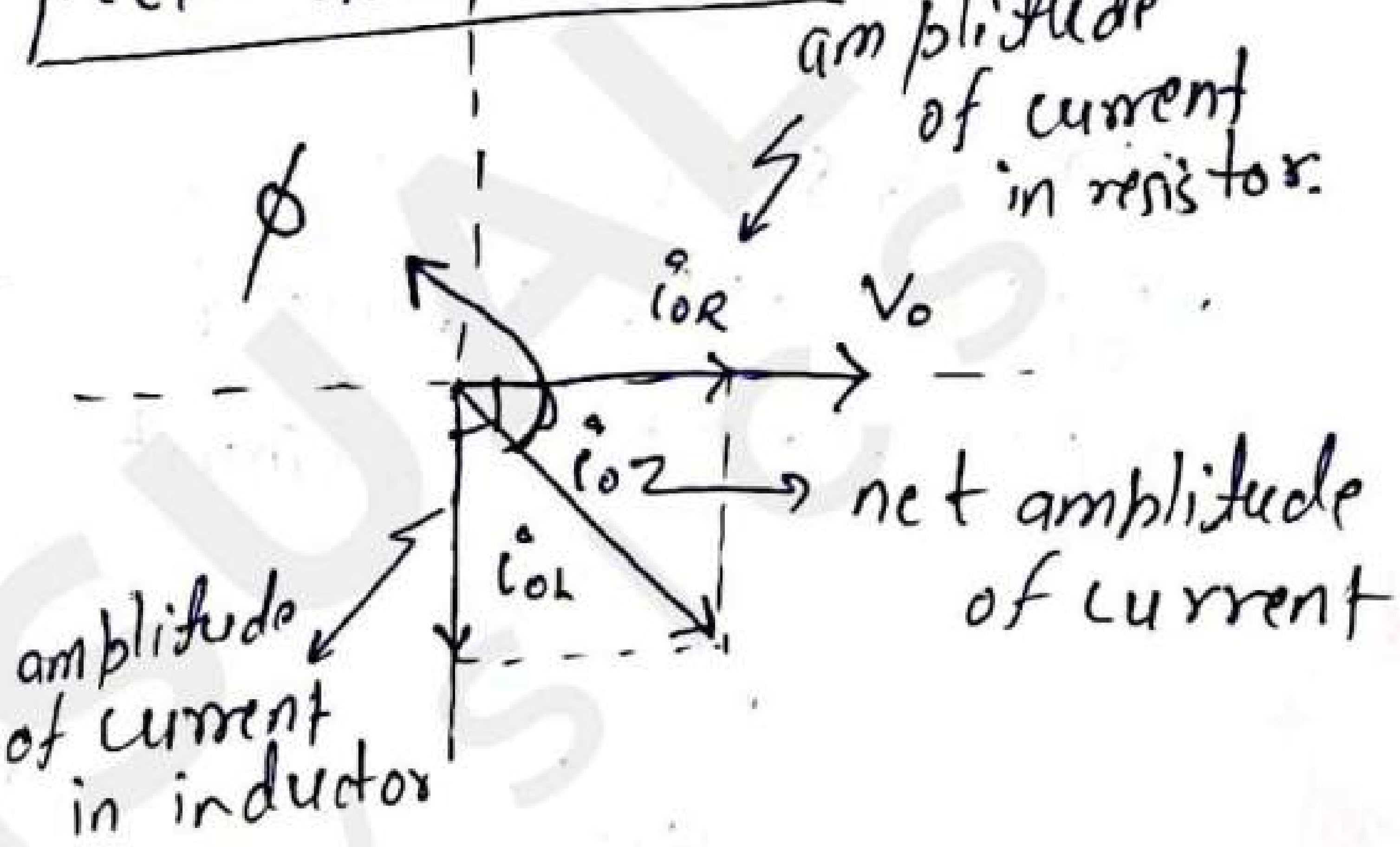


at any instant: krichhoff's law

$$\boxed{i(t) = i_R(t) + i_L(t)}$$

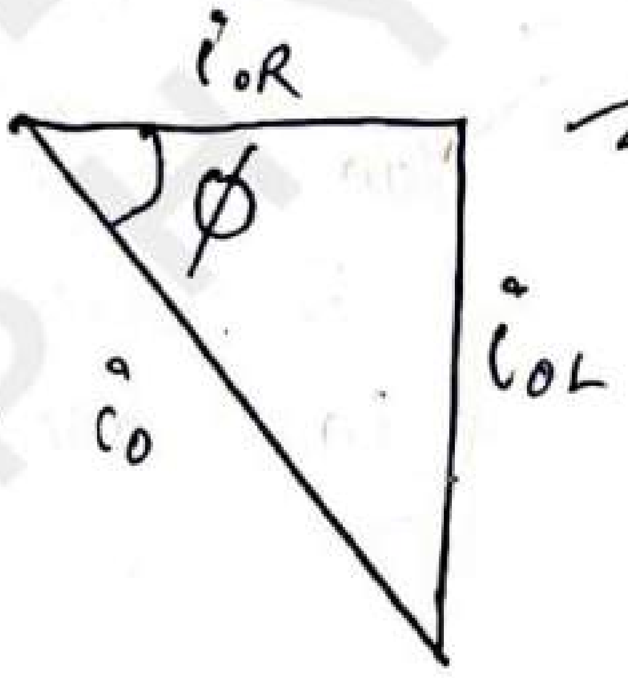
$v(t) = V_0 \sin\omega t$

$V_R(t) = V_0 \sin\omega t = V_L(t)$



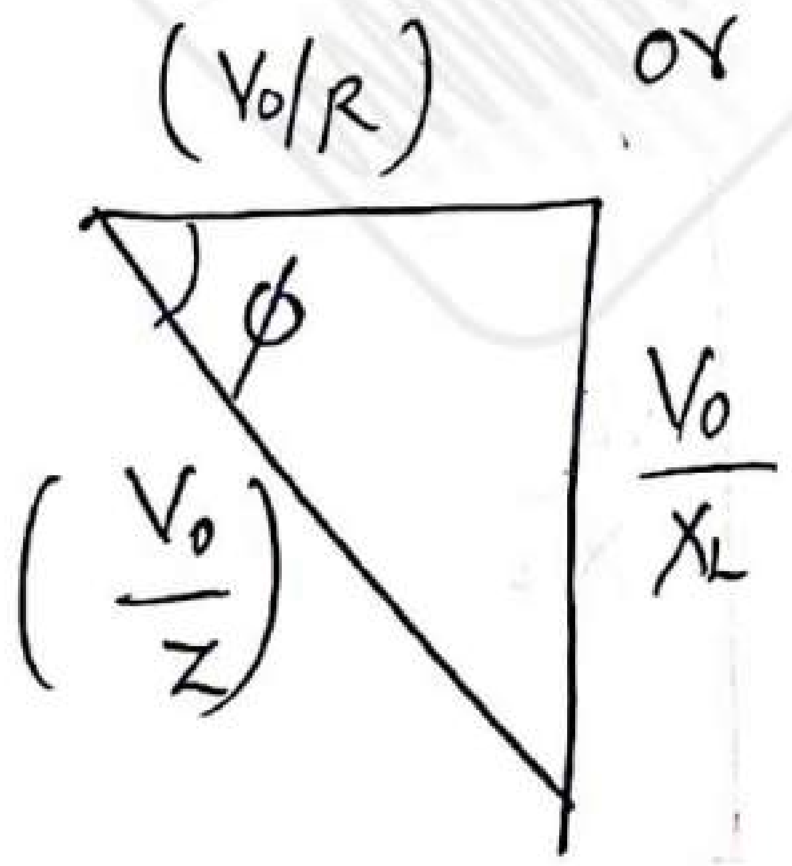
$i_{0R} = \dfrac{V_0}{R} = \dfrac{V_{0R}}{R}$

$i_{0L} = \dfrac{V_0}{X_L} = \dfrac{V_{0L}}{X_L}$

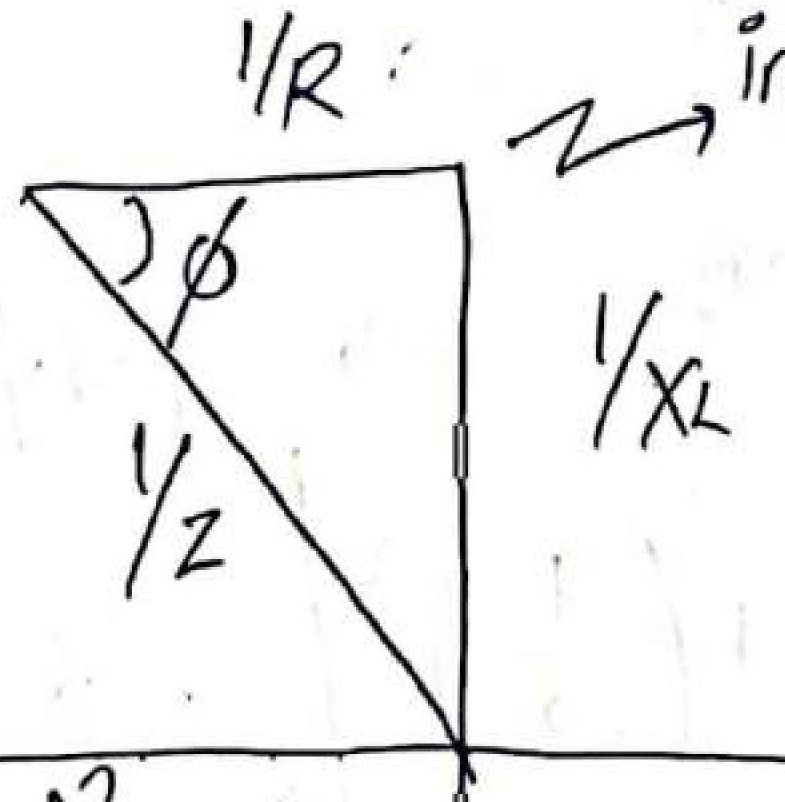


Current traingle

$$i_0^2 = \sqrt{(i_{0R})^2 + (i_{0L})^2}$$



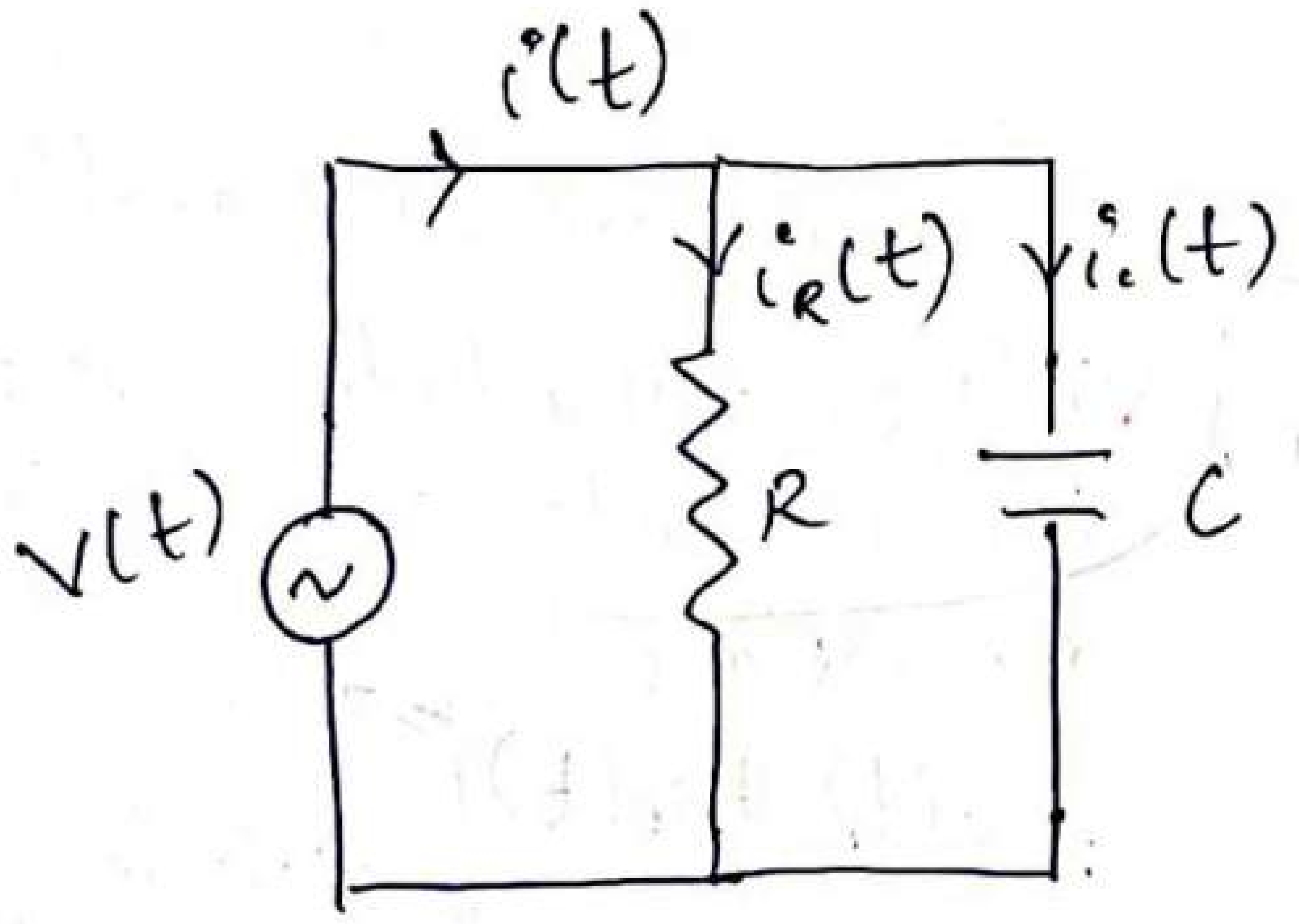
or



inverse impedence traingle

$$\boxed{\left(\frac{1}{Z}\right)^2 = \left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L}\right)^2}$$

parallel R-C circuit :



similarly as dissussed for parallel R-L circuit:

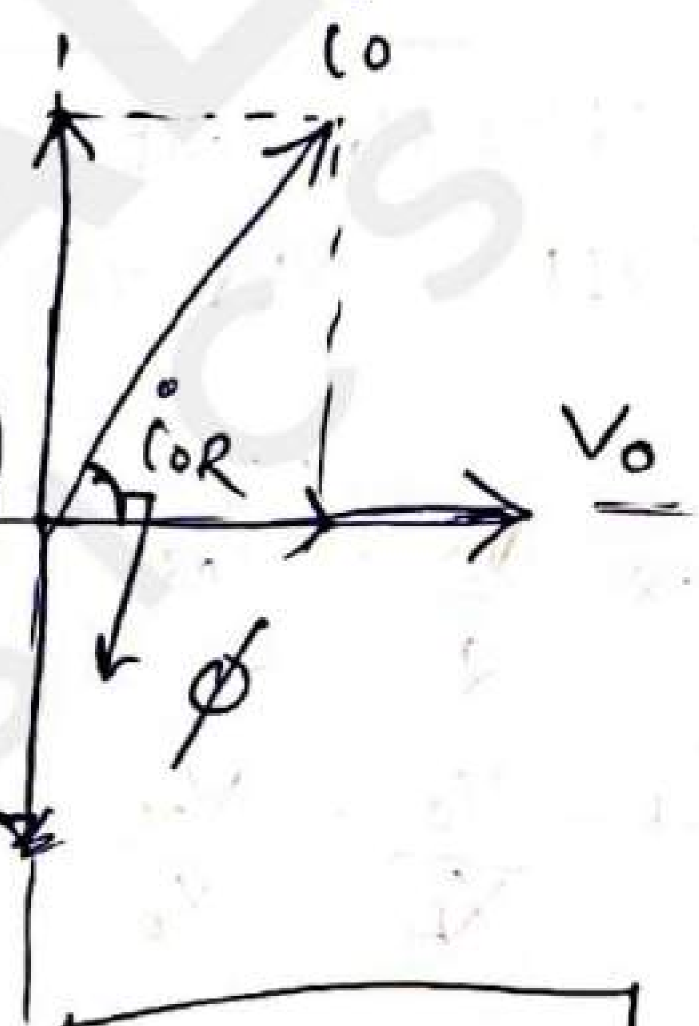
$$\Rightarrow \boxed{i(t) = i_R(t) + i_c(t)}$$

Krichhoff's junction law

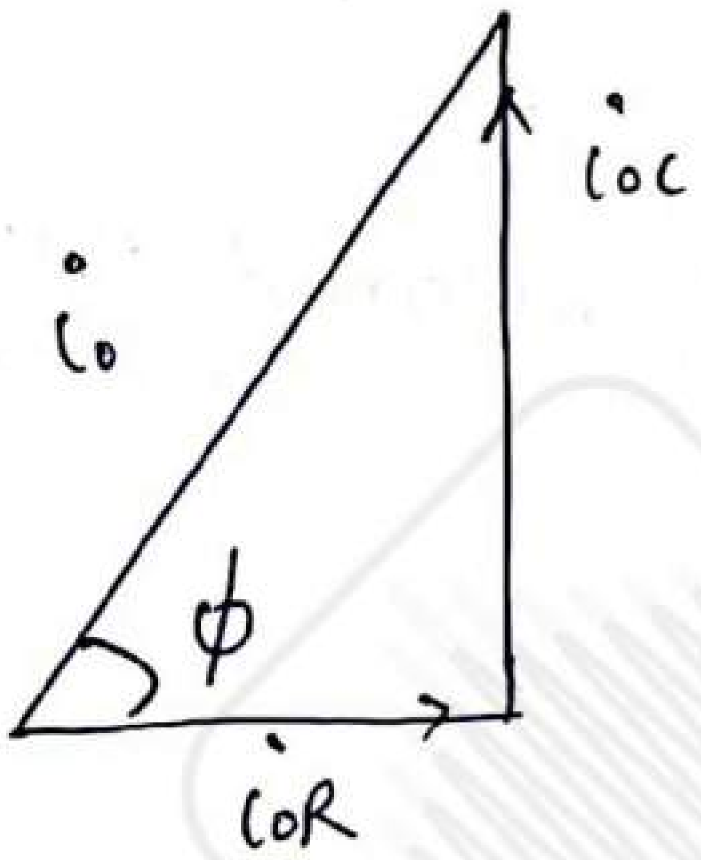
$V(t) = V_0 \sin\omega t$

$V_R(t) = V(t) = V_0 \sin\omega t$

$V_L(t) = V(t) = V_0 \sin\omega t$



as current lead by 90° to voltage



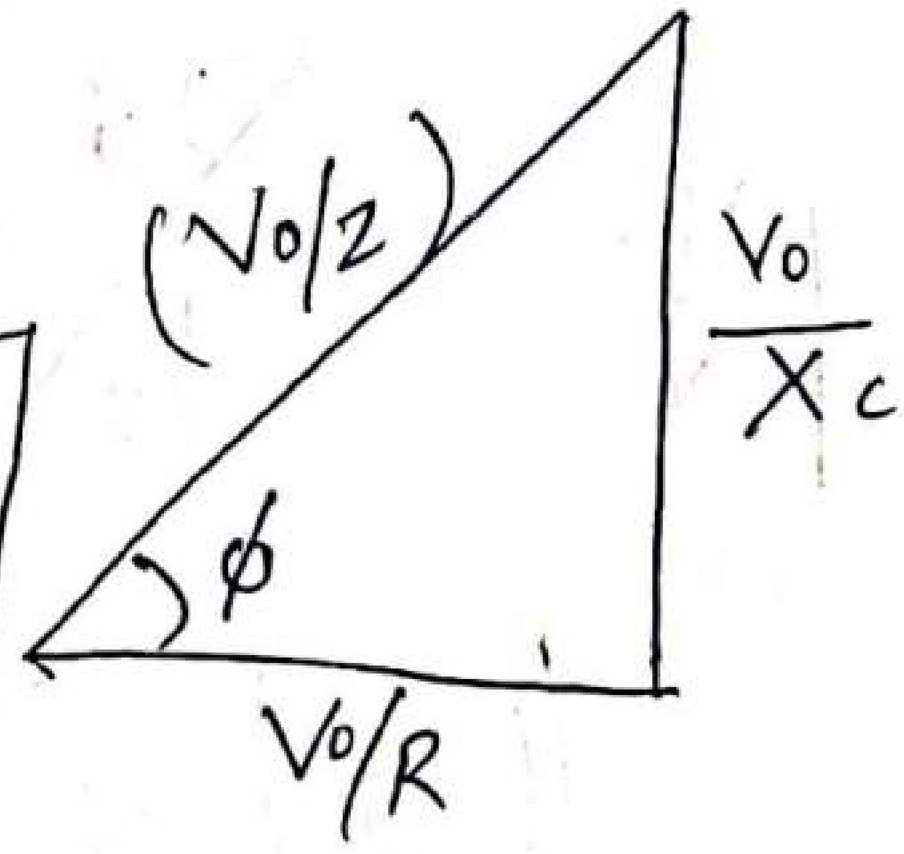
i_{oc} → amplitude of current in capacitor

i_{oR} → amplitude of current in resistor.

$$\boxed{i_{oc} = \frac{V_0}{X_c}}$$

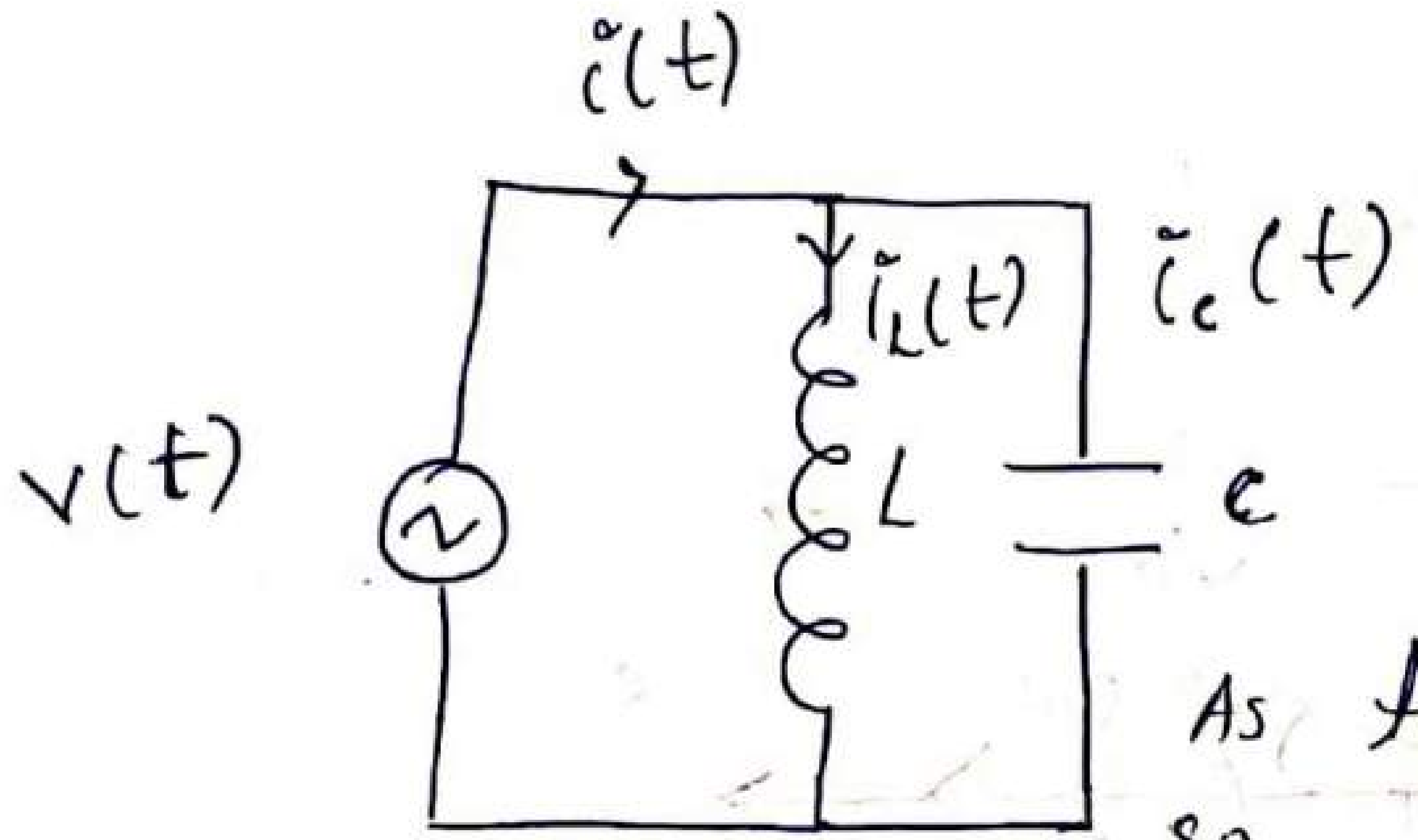
$$\boxed{i_{oR} = \frac{V_0}{R}}$$

so,



$$\boxed{\left(\frac{1}{Z}\right)^2 = \left(\frac{1}{X_c}\right)^2 + \left(\frac{1}{R}\right)^2}$$

parallel C-L circuit:



at any instant

$$\boxed{i(t) = i_L(t) + i_c(t)}$$

↓

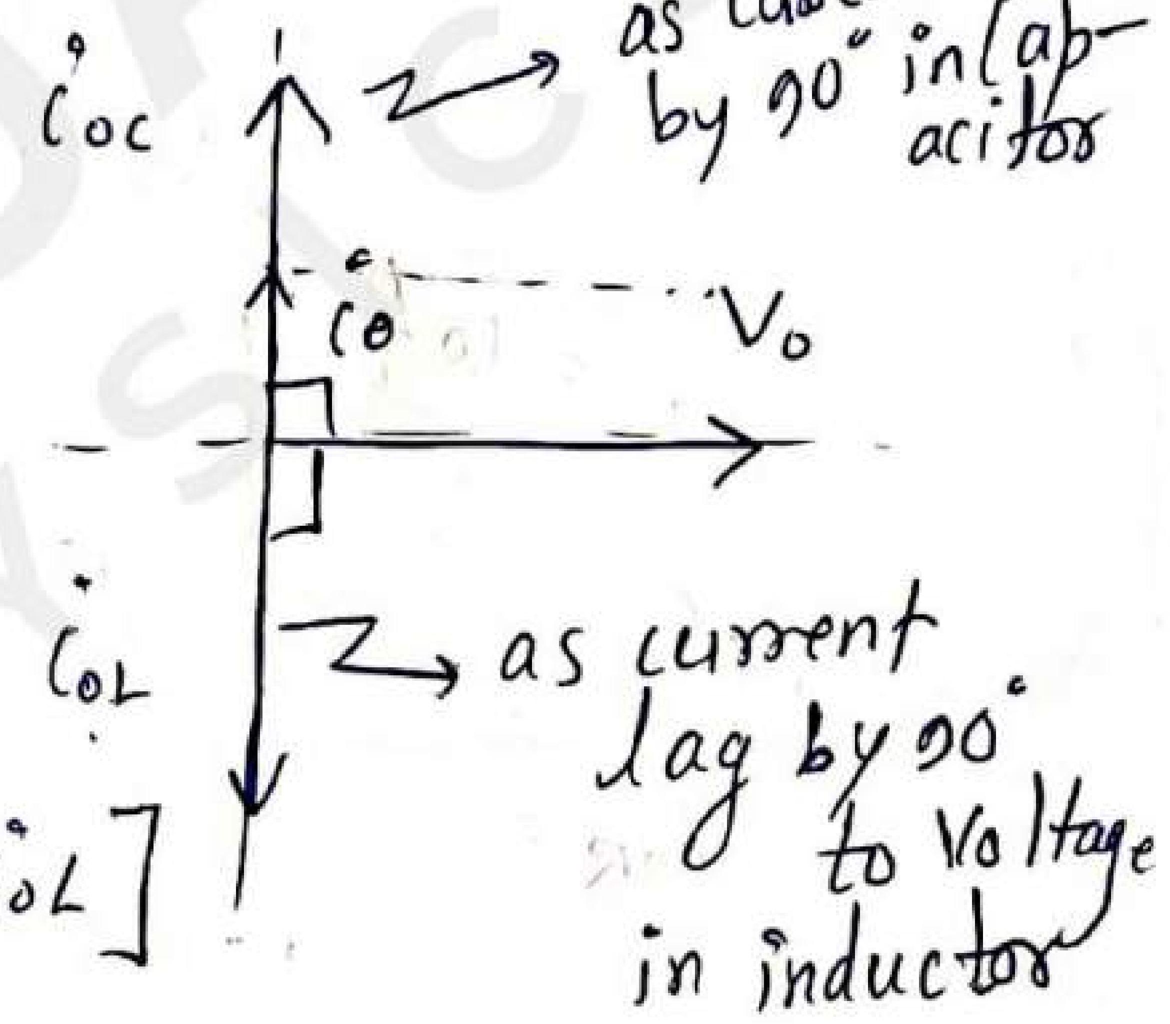
krichhoff's junction law:

As the elements are in parallel:

so, $V(t) = V_L(t) = V_C(t)$

$$V(t) = V_0 \sin\omega t = V_L(t) = V_c(t)$$

$$i_{0L} = \frac{V_0}{X_L}, \quad i_{0C} = \frac{V_0}{X_C}$$

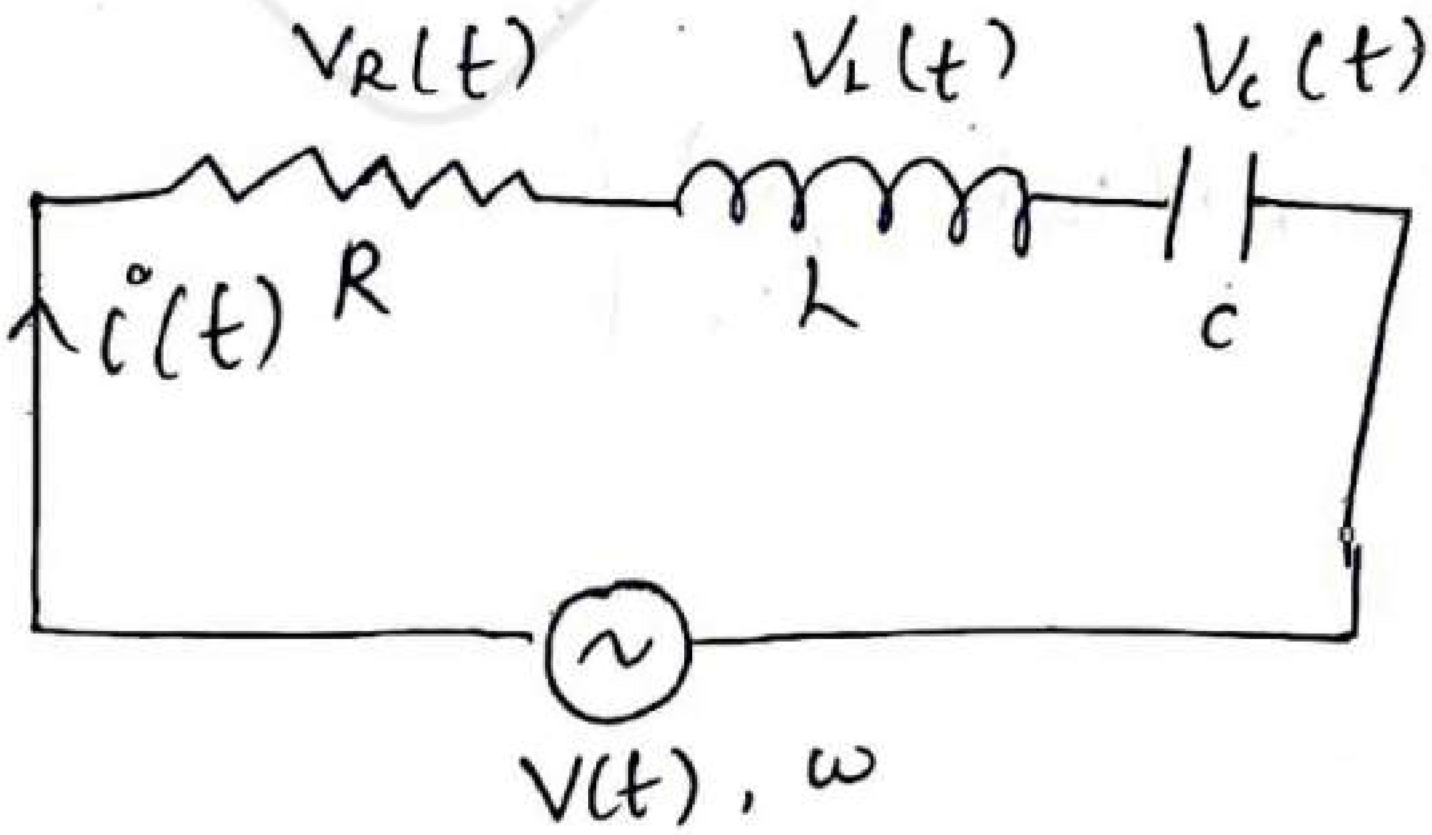


Net amplitude of current

$$i_0 = i_{0C} - i_{0L} \quad [\text{if } i_{0C} > i_{0L}]$$

$$\boxed{Z = X_C - X_L}$$

Series R-L-C circuit:



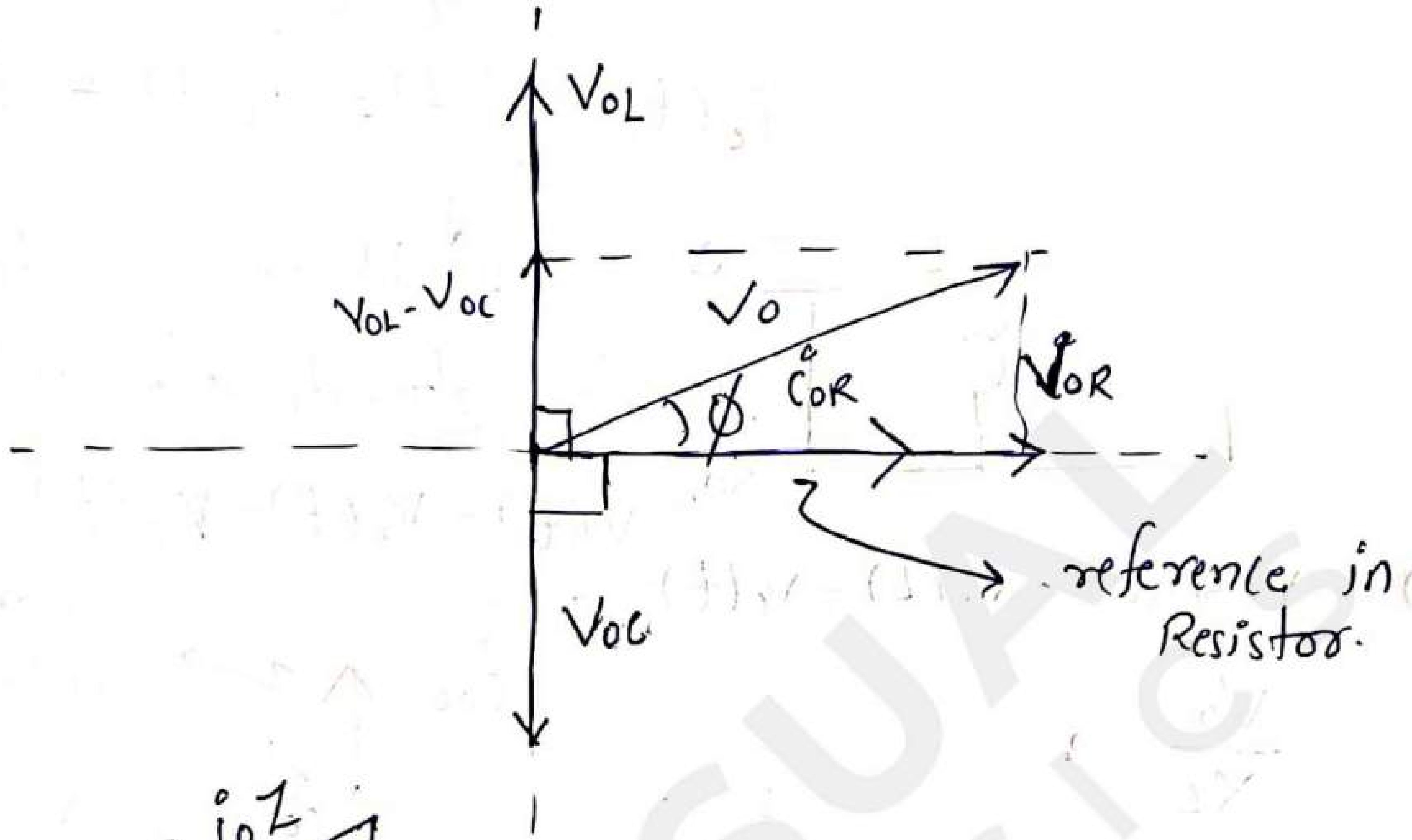
so,

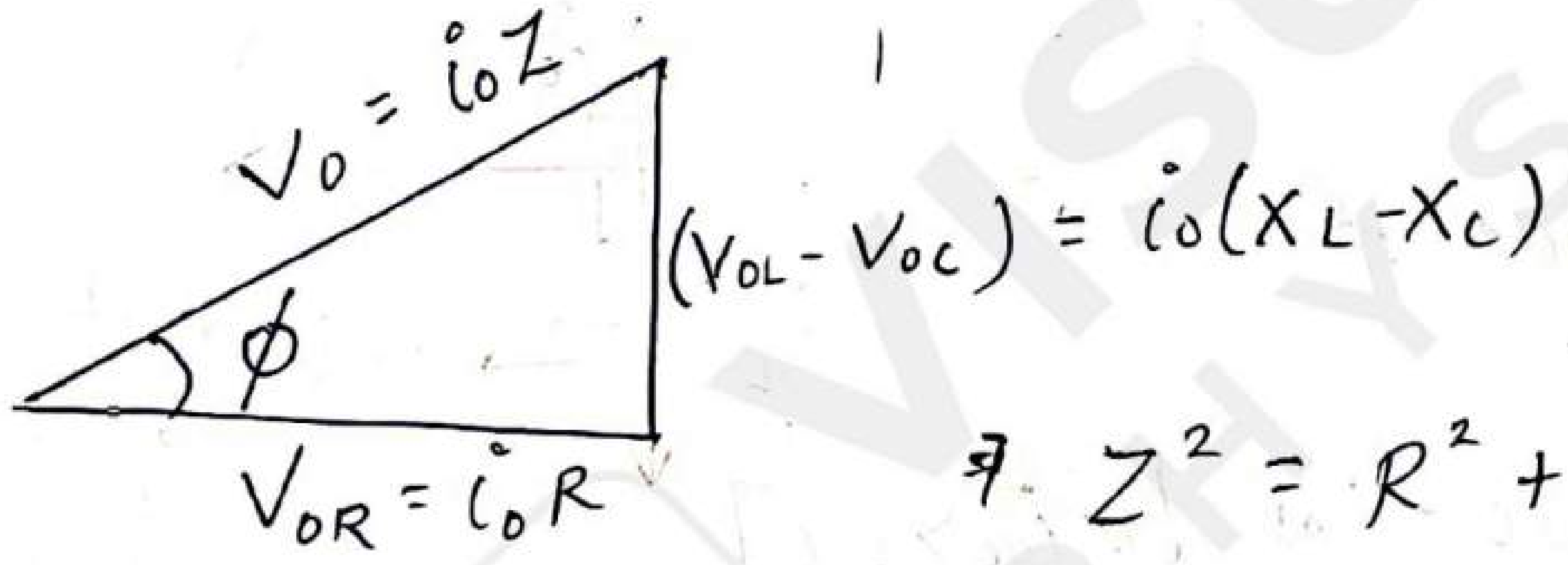
$$V(t) = V_R(t) + V_L(t) + V_c(t)$$

$V(t)$, ω

$$V(t) = V_0 \sin\omega t$$

$$i_{oR} = \frac{V_{oR}}{R} \quad , \quad i_{oL} = \frac{V_{oL}}{X_L} \quad , \quad i_{oC} = \frac{V_{oC}}{X_C}$$





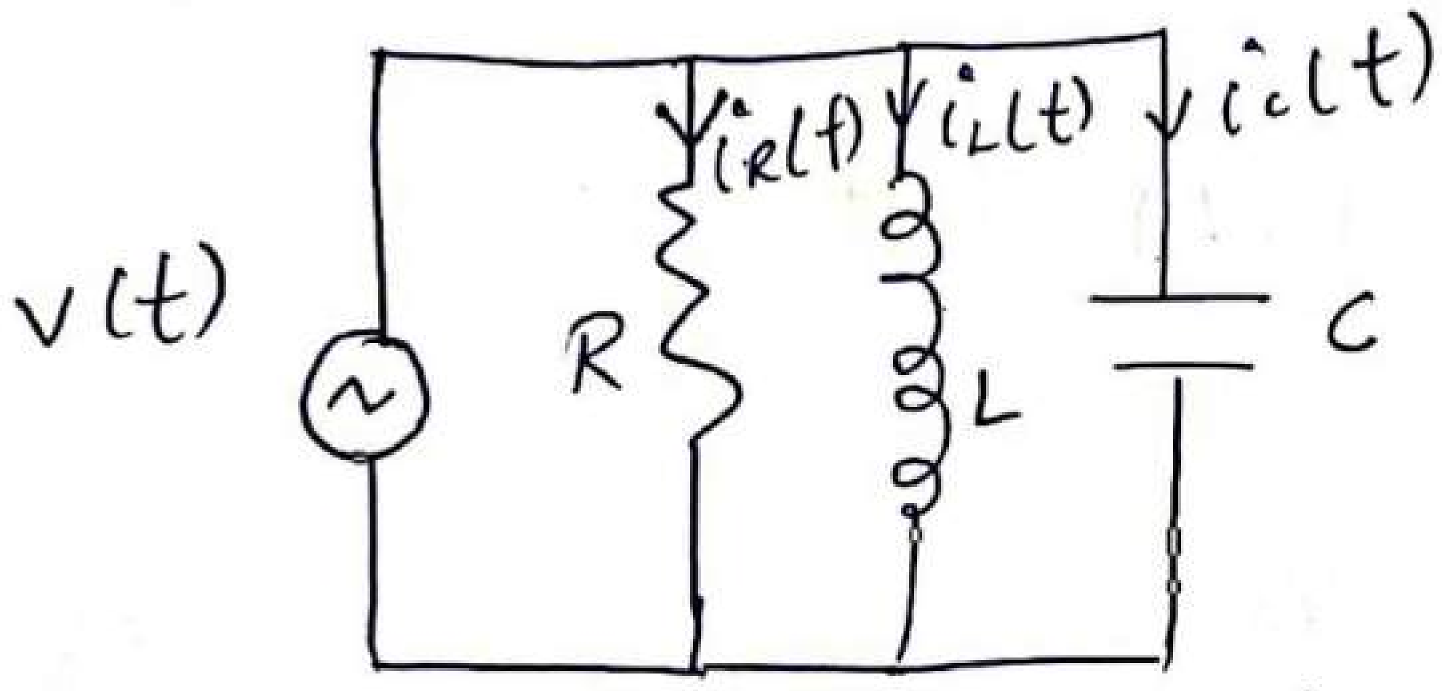
$$\Rightarrow Z^2 = R^2 + (X_L - X_C)^2$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$\left(i_o = \frac{V_o}{Z}\right) \qquad \tan\phi = \frac{(X_L - X_C)}{R}$$

$$\text{so,} \quad \boxed{i = i_o \sin(\omega t - \phi)}$$

Parallel RLC circuit



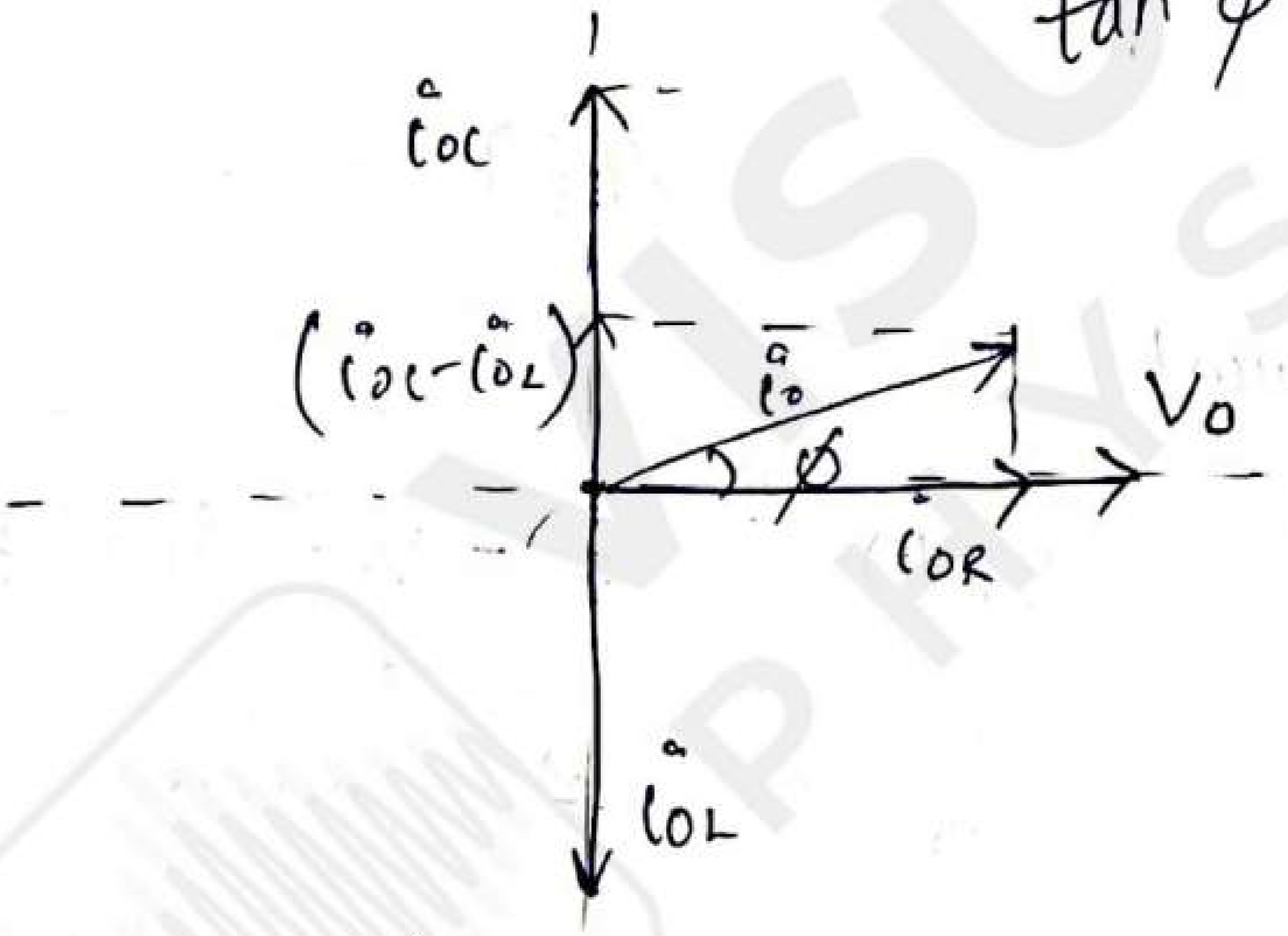
$$\boxed{v(t) = v_R(t) = v_L(t) = v_C(t)}$$

$$\boxed{i_0(t) = i_R(t) + i_L(t) + i_C(t)}$$

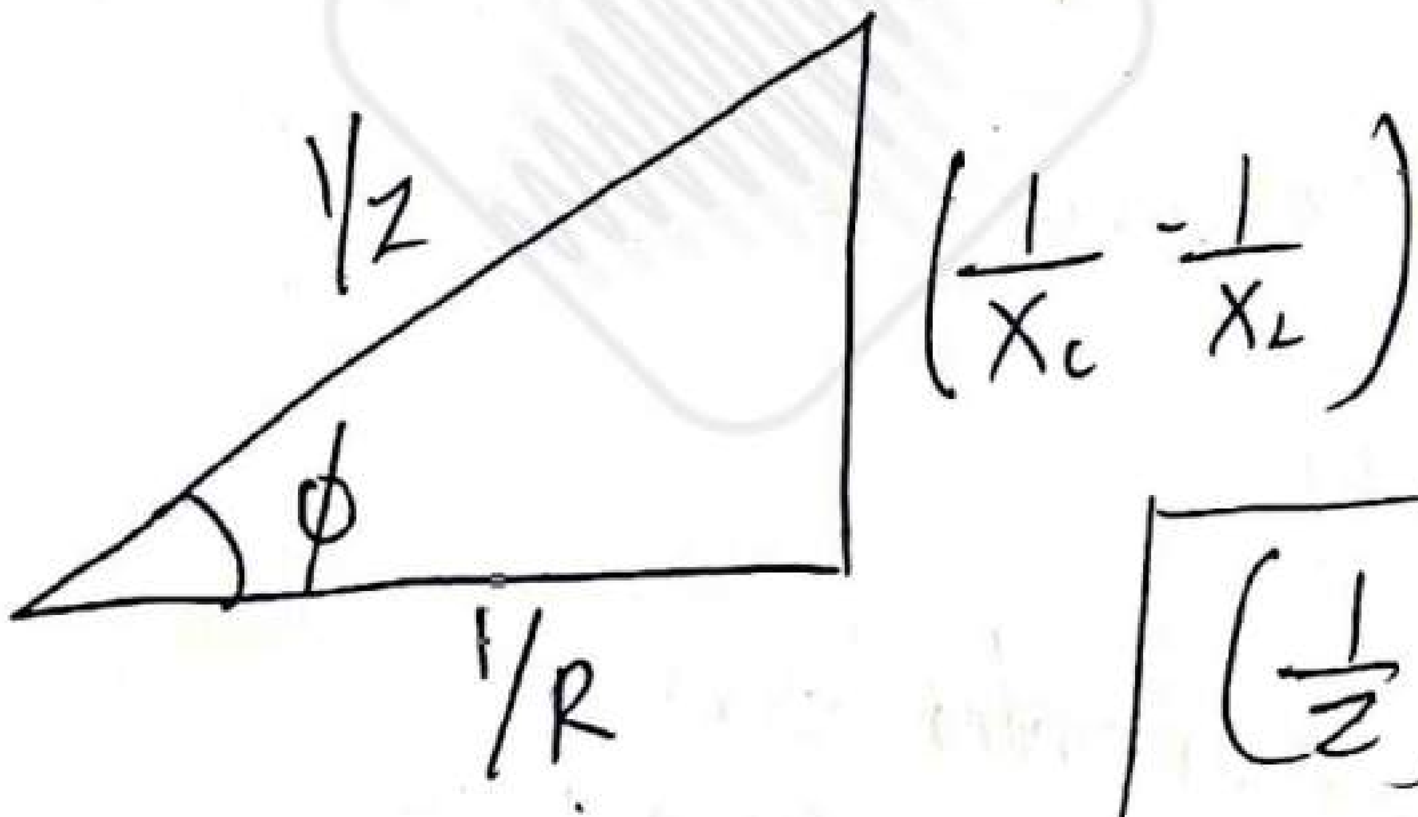
→ kirchhoff's junction law

$$i_{0R} = \frac{V_0}{R}, \quad i_{0L} = \frac{V_0}{X_L}, \quad i_{0C} = \frac{V_0}{X_C}$$

$$\tan\phi = \frac{(i_{0C} - i_{0L})}{i_{0R}}$$



$$\boxed{\tan\phi = \left(\frac{\frac{1}{X_C} - \frac{1}{X_L}}{\frac{1}{R}}\right)}$$



inverse Impedency traingle:

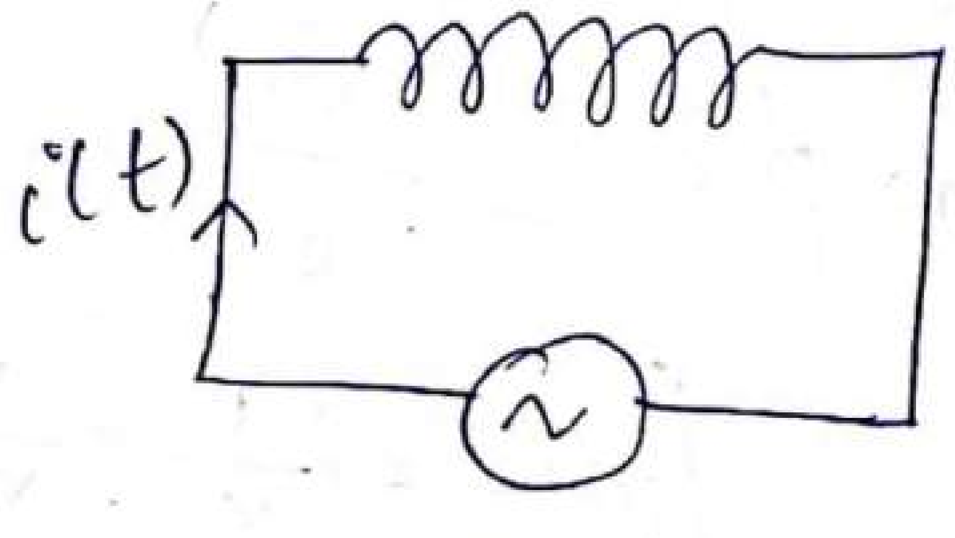
$$\boxed{\left(\frac{1}{Z}\right)^2 = \left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_C} - \frac{1}{X_L}\right)^2}$$

Power

Power supplied by source at any instant:

$$\boxed{P(t) = V(t)\, i(t)}$$

for Inductor:



$v(t) = V_0 \sin\omega t$

& $i(t) = i_0 \sin(\omega t - \pi/2)$ $\pi/2$ phase lag to $v(t)$

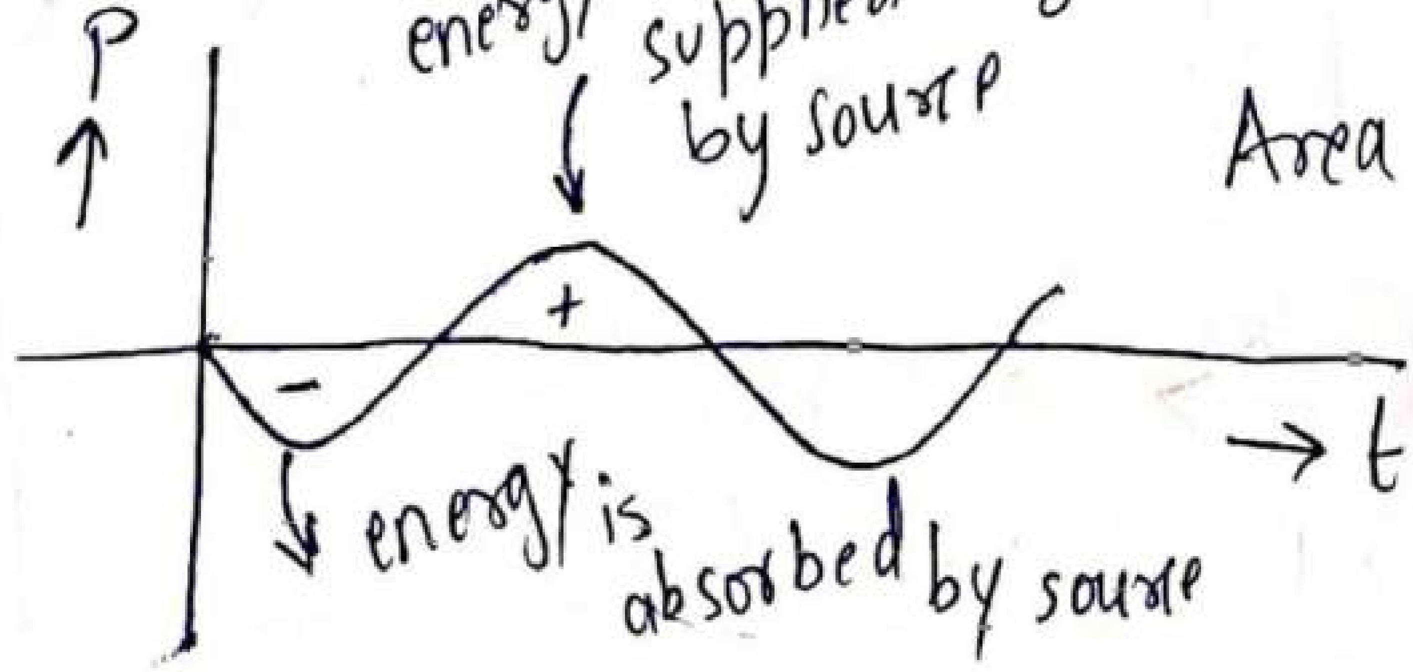
or $i(t) = -i_0 \cos\omega t$

so, $$\boxed{P(t) = v(t)\, i(t) = -V_0 i_0 \sin\omega t \cos\omega t}$$

for average power lost in one complete cycle:

$$\langle p(t) \rangle = \frac{-\int_0^T V_0 i_0 \sin\omega t \cos\omega t \, dt}{\int_0^T dt} = 0$$

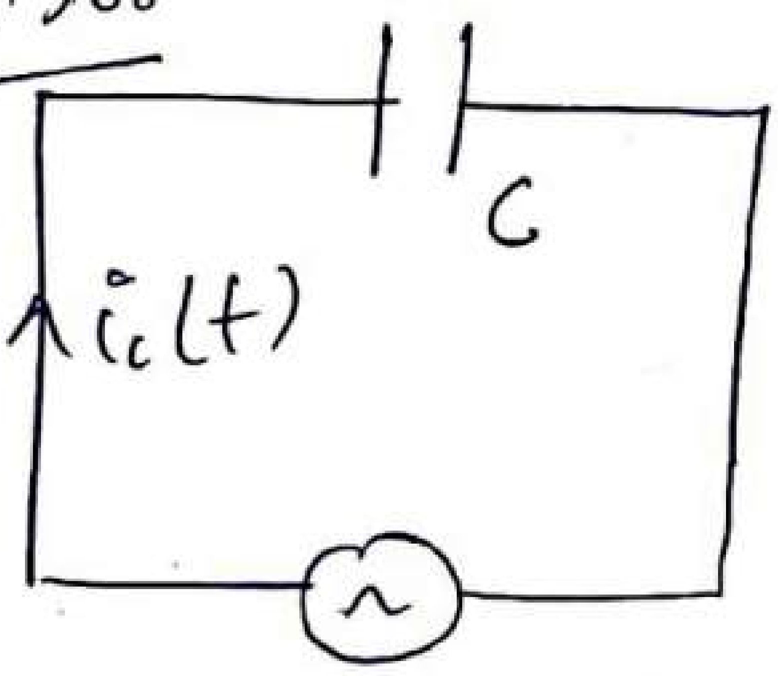
(integeration gives)



Area under power time graph gives value.

So power lost by pure Inductor in 1 time period is zero.

for Capacitor:



$V(t) = V_0 \sin\omega t$

(90° phase lead)

$$i_c(t) = i_0 \sin(\pi/2 + \omega t)$$
$$= i_0 \cos\omega t$$

So instantaneous power lost $P(t) = V_0 \sin\omega t \, i_0 \cos\omega t$

So, $$\langle P(t) \rangle = \frac{\int_0^T i_0 V_0 \sin\omega t \cos\omega t \, dt}{\int_0^T dt}$$

as, $$\int_0^T \sin\omega t \cos\omega t \, dt = 0$$

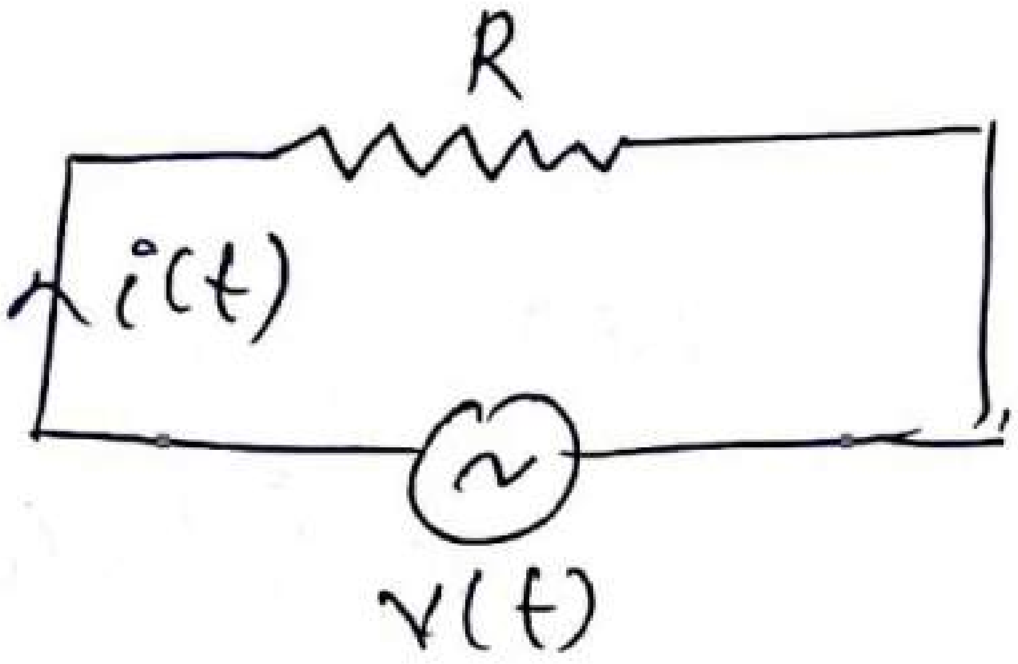
so, $\langle P(t) \rangle = 0$

So similar for the case of inductor, here also power loss in Capacitor for one complete cycle is:

$\langle P(t) \rangle = 0$ → power lost in one complete cycle

★ In both the element, power given by source get absorb or stored in form of magnetic & Electric field in inductor and capacitor resp.

for resistor:



$v(t) = v_0 \sin\omega t$

$i(t) = i_0 \sin\omega t$

$p(t) = v(t)\, i(t) = (v_0 \sin\omega t)(i_0 \sin\omega t)$

$p(t) = v_0 i_0 \sin^2\omega t$

so, $\langle p(t) \rangle = \dfrac{\int_0^T v_0 i_0 \sin^2\omega t\, dt}{\int_0^T dt}$

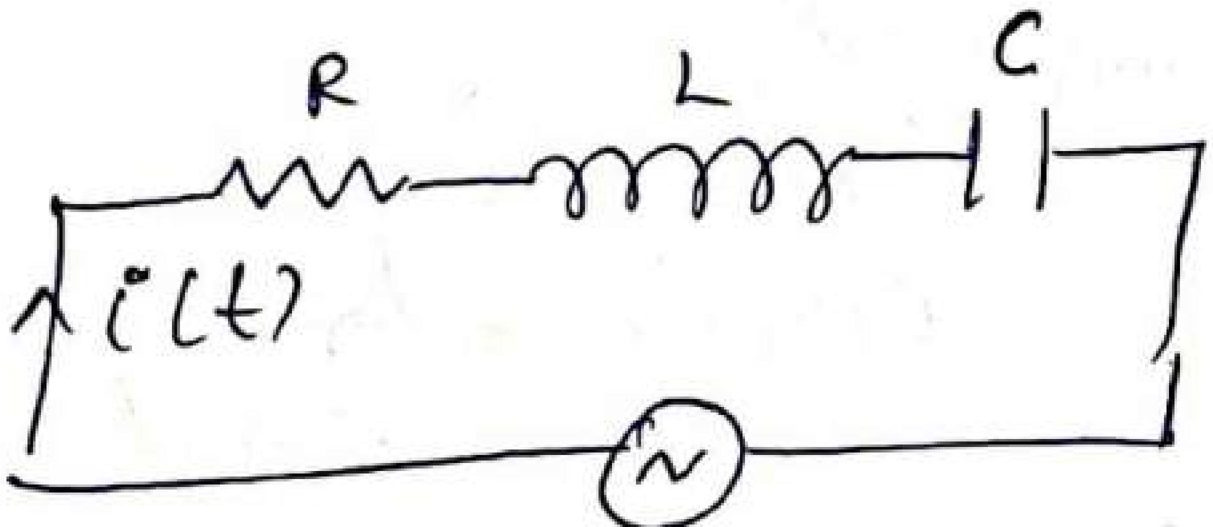
$\langle p(t) \rangle = \dfrac{v_0 i_0 (1/2)\, T}{T}$

as, $\int_0^T \sin^2\omega t\, dt = (1/2)T$

$$\boxed{\langle p(t) \rangle = \left(\frac{v_0}{\sqrt{2}}\right)\left(\frac{i_0}{\sqrt{2}}\right) = V_{rms}\, i_{rms}}$$

So, resistor element lost the power in 1 cycle by $\boxed{V_{rms}\, i_{rms}}$

Now power lost in RLC series!



$v(t) = V_0 \sin\omega t$

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

so, now $i(t) = i_0 \sin(\omega t - \phi)$

Power lost in any instant

$$P(t) = v(t)\, i(t)$$
$$= V_0 \sin\omega t \; i_0 \sin(\omega t - \phi)$$

so,
$$\langle P(t) \rangle = \frac{\int_0^T i_0 V_0 \sin\omega t \sin(\omega t - \phi)\, dt}{\int_0^T dt}$$

average power lost in 1 cycle

$$\langle P(t) \rangle T = i_0 V_0 \int_0^T \sin\omega t \left[\sin\omega t \cos\phi - \cos\omega t \sin\phi \right] dt$$

$$= i_0 V_0 \left[\cos\phi \underbrace{\int_0^T \sin^2\omega t \, dt}_{(1/2)} - \sin\phi \underbrace{\int_0^T \sin\omega t \cos\omega t \, dt}_{\text{zero}} \right]$$

$$\langle p(t) \rangle \cancel{T} = \frac{i_0 V_0 \cos\phi}{2} \cancel{T}$$

$$\langle P(t)\rangle = \frac{V_0 i_0}{2}\cos\phi$$

$$\boxed{\langle P(t)\rangle = V_{rms}\, i_{rms} \cos\phi}$$

power lost

power factor of the circuit

Also, $\boxed{V_0\cos\phi = V_{0R}}$ $\longrightarrow$ Voltage drop component across resistor.

Q - factor

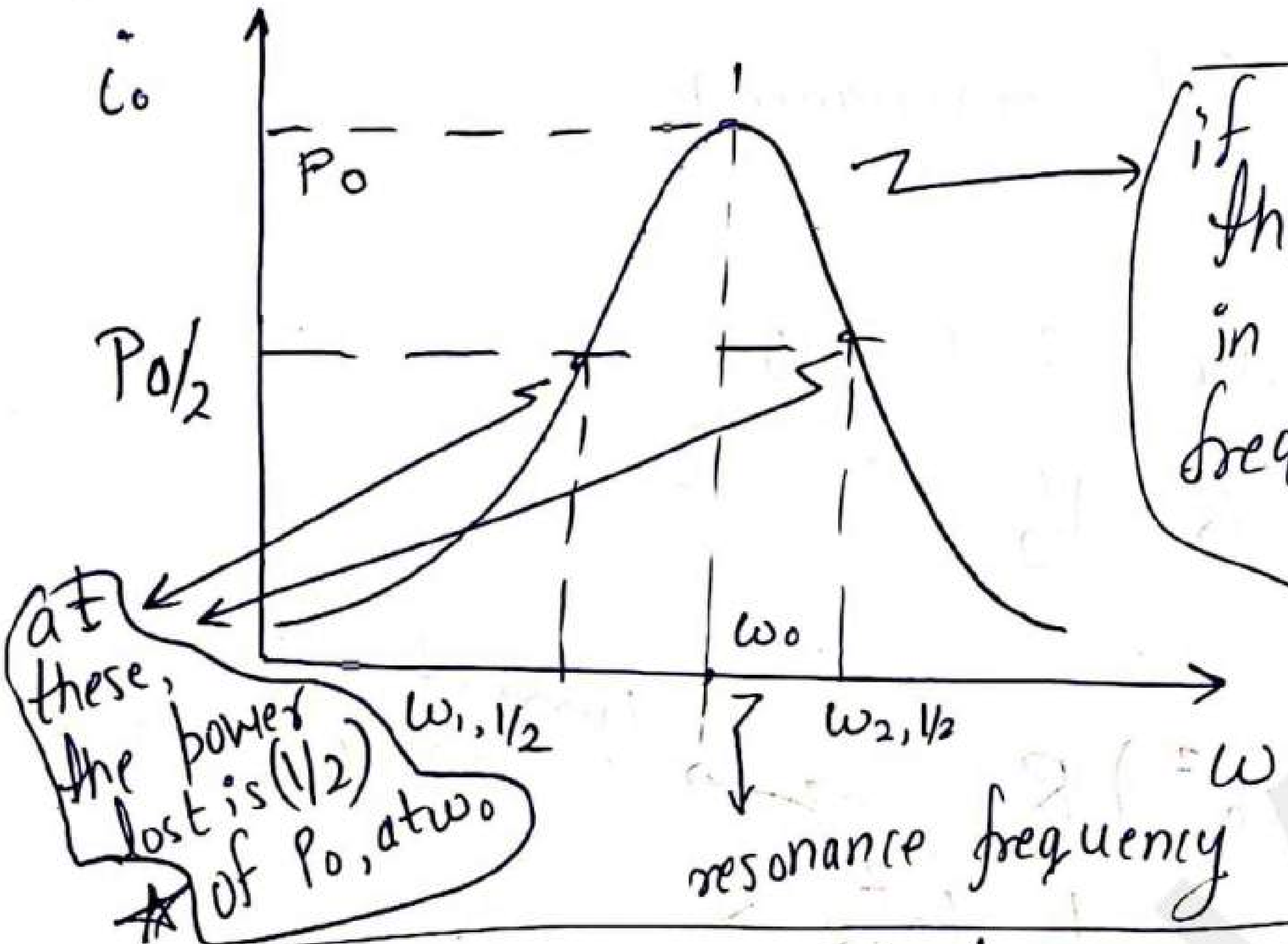
for series RLC circuit

$$i_0 = \frac{V_0}{Z} = \frac{V_0}{\sqrt{R^2 + (X_L - X_C)^2}}$$

or

$$\boxed{i_0 = \frac{V_0}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}}$$

So if we plot the variation of current with respect to frequency we get:



if this region is broad than we find difficulties in setting the perticular frequency (ω_0), as for frequency near to (ω_0) i_0 is still comparable

for tunning we set the resonance frequency(ω_0) for perticular signal.

So we need the region to be very sharp, so that we find the signal and set ~~to~~ the RLC circuit easily to its resonance frequency.

sharpness of Resonance curve is measured by Q-factor

$$Q = \frac{\omega_0}{\omega_{2,1/2} - \omega_{1,1/2}}$$

Higher Q, sharper Q

Typically 10 : 100

at resonance, $X_C = X_L$

$i_0 = \frac{V_0}{R}$ (at resonance)

$P_0 = (i_0)^2 R$

now at $\omega_{1,1/2}$ & $\omega_{2,1/2}$

$i_{1/2}$ is the current

$\Rightarrow (i_{1/2})^2 R = \frac{1}{2} P_0 = \frac{1}{2} (i_0)^2 R$

$\Rightarrow \boxed{i_{1/2} = \frac{i_0}{\sqrt{2}}}$

now as we know

$$i = \frac{V_0}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

so,

$$\frac{i_{1/2}}{\sqrt{2}} = \frac{(V_0/R)}{\sqrt{2}} = \frac{V_0}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$$

* as $i_{1/2} = V_0/R$

on solving

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

$$\omega L - \frac{1}{\omega C} = \pm R$$

$$\omega^2 LC - 1 = \pm \omega RC$$

$$\omega^2 LC \pm \omega RC - 1 = 0$$

$$\omega = \frac{\pm RC \pm \sqrt{R^2C^2 + 4LC}}{2LC}$$

as for ω to be positive

$$\sqrt{R^2C^2 + 4LC} > 0$$

$$\Rightarrow \quad \omega_{1,1/2} = \frac{\sqrt{R^2C^2 + 4LC} - RC}{2LC}$$

$$\omega_{2,1/2} = \frac{\sqrt{R^2C^2 + 4LC} + RC}{2LC}$$

so, $$\left|\omega_{2,1/2} - \omega_{1,1/2}\right| = \frac{2RC}{2LC} = R/L$$

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

$$\Rightarrow Q = \frac{1/\sqrt{LC}}{R/L} = \frac{L}{R}\frac{1}{\sqrt{LC}}$$

$$\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

Also,
$$Q = \frac{V_L \text{ or } V_C \text{ (at resonance)}}{\underbrace{V_0}_{\text{Source voltage amplitude}}}$$

We still get
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Also, $Q = 2\pi \left[\frac{\text{Max energy stored in 1 cycle}}{\text{Energy dissipated in 1 cycle}}\right]$

max energy stored $= \frac{1}{2} L i_0^2$
& energy dissipated $= \left(\frac{1}{2}\right) i_0^2 R T$

$\Rightarrow Q = \frac{2\pi}{T}\frac{L}{R}$

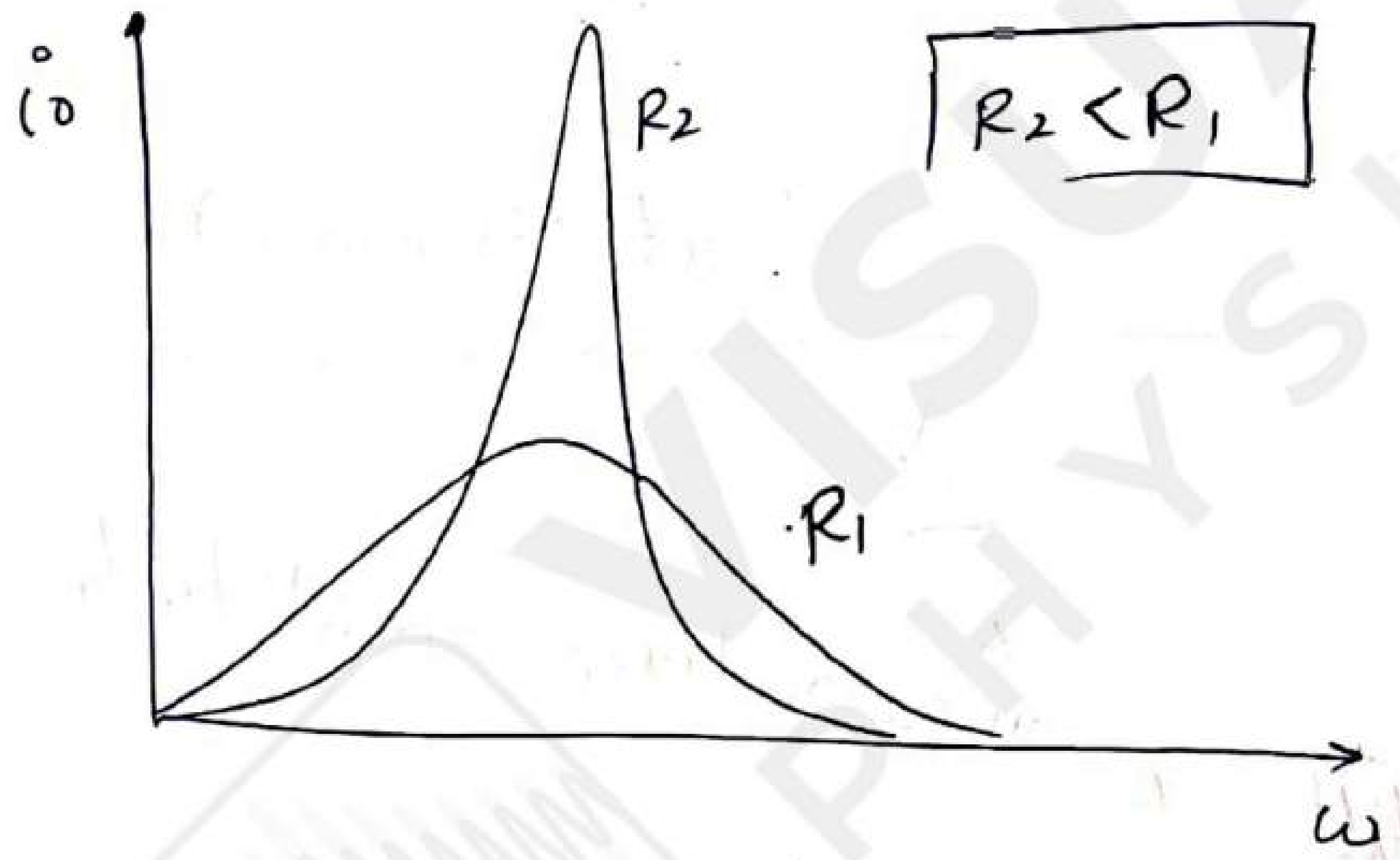
$$\boxed{Q = \omega L/R}$$

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

so, $\boxed{Q = \frac{1}{R}\sqrt{\frac{L}{C}}}$

as $\boxed{Q \propto 1/R}$ so $R\downarrow$ $Q\uparrow$ $\rightarrow$ sharper curve

high current at resonance.



$\boxed{R_2 < R_1}$

Transformer:

As we know power lost $= i^2 R$

$\Rightarrow$ more the current, more power lost,

now for $(i^2 R)$ loss to reduce we need to reduce (i) in transmission lines.

* so to reduce power loss $i\downarrow$

As,

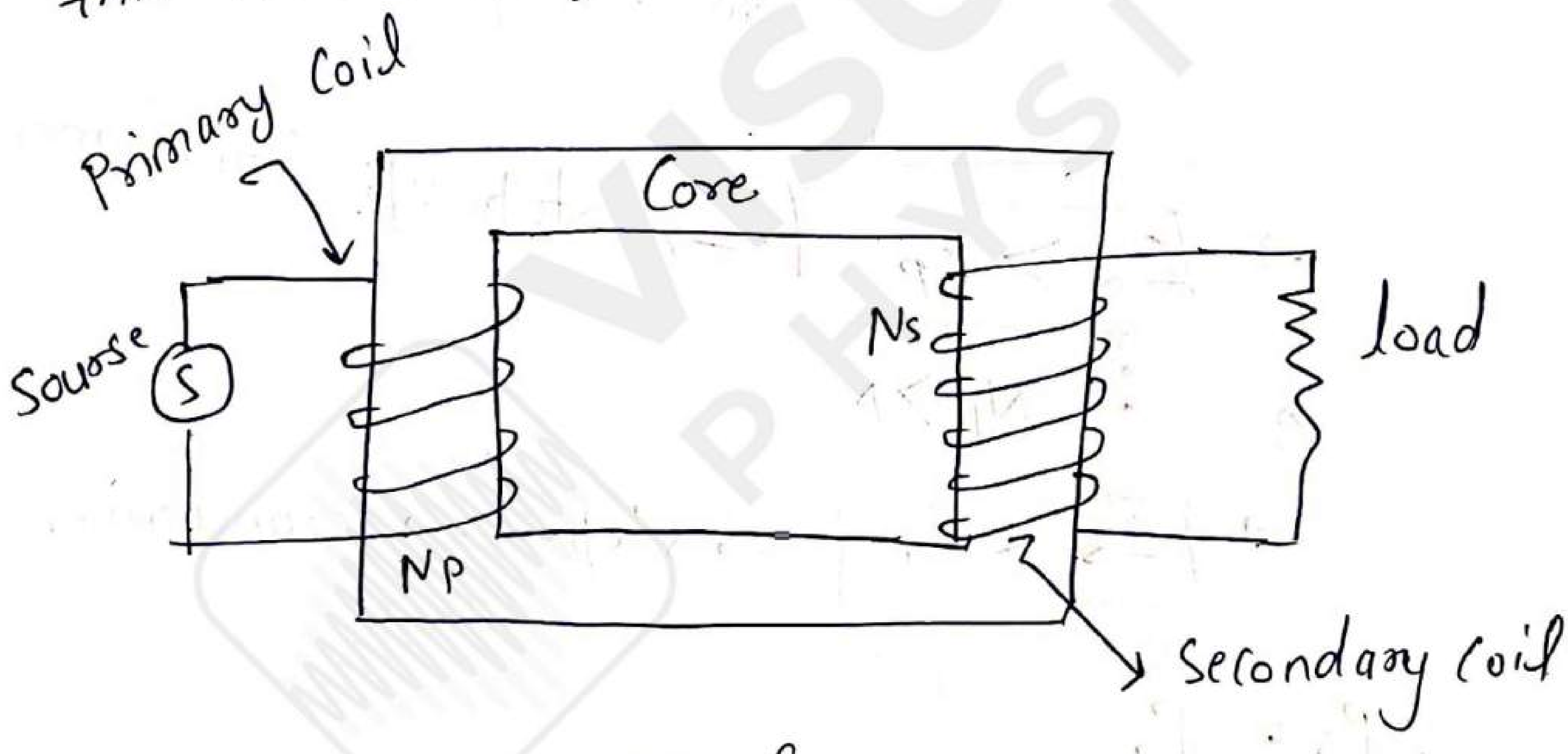
$$P_{ac} = V_{rms}\, i_{rms}$$

* so if $i_{rms} \downarrow$ for same P_{ac}

$V_{rms} \uparrow$

So in transmission, $V_{rms} \uparrow$ so $i_{rms} \downarrow$
and when to home again $i_{rms} \uparrow$ & $V_{rms} \downarrow$

this is done by transformer



Transformer

* now current in primary coil changing and hence flux generated by primary current will change and that changing flux linked with secondary coil through iron core

due to change of flux

$\mathcal{E}_p$ = back emf in primary coil.

$\Rightarrow \quad \mathcal{E}_p = N_p \dfrac{d\phi}{dt}$ → flux linked with one turn

& for secondary coil

$$\mathcal{E}_s = N_s \frac{d\phi}{dt}$$

so, $\boxed{\dfrac{\mathcal{E}_p}{\mathcal{E}_s} = \dfrac{N_p}{N_s}}$ so if $N_p < N_s$

$\Rightarrow \boxed{\mathcal{E}_s > \mathcal{E}_p}$ → step up transformer

& if $N_p > N_s$

$\Rightarrow \boxed{\mathcal{E}_s < \mathcal{E}_p}$ → step down transformer

$$P_s = P_p$$

$$\mathcal{E}_s i_s = \mathcal{E}_p i_p$$

$\Rightarrow \boxed{\dfrac{i_s}{i_p} = \dfrac{N_p}{N_s}}$ so for step up $\boxed{i_s \downarrow}$

and for step dow $\boxed{i_s \uparrow}$

Step-up

$\mathcal{E}_s \uparrow$, $i_s \downarrow$ $\longrightarrow$ used in transmission

Step-down

$\mathcal{E}_s \downarrow$, $i_s \uparrow$ $\longrightarrow$ used between transmission and household.