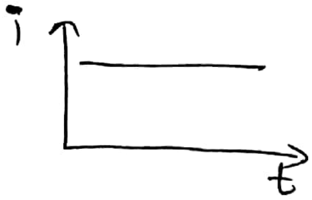
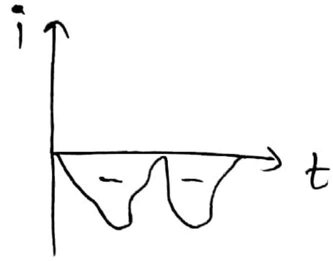
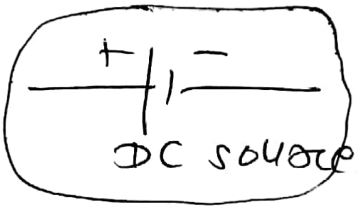
Alternating Current (AC) :-

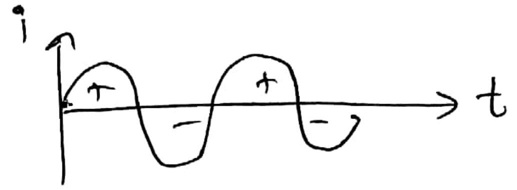
* Direct current :-
→ flows in one direction.
→ flows only in one direcⁿ

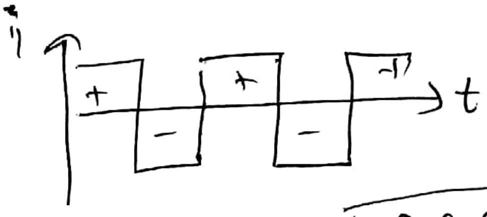


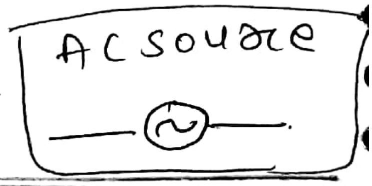




* Alternating current :-
→ This will in both direction
(i.e. changes its direcⁿ.)







* If any quantity depends on time or it's function of time ⇒ average value is given by:-

i.e. $y = f(t)$

$$\therefore y_{avg} = \frac{\int y\,dt}{\int dt}$$

→ $||^{arly}$ $$\boxed{i_{avg} = \frac{\int i\,dt}{\int dt}}$$

Q.1) If $i = 3t^2$, find avg i in 2sec.

$\cancel{i = 3(2)^2 = 3(4) = 12}$

$$i_{avg} = \frac{\int_0^2 i\,dt}{\int_0^2 dt}$$

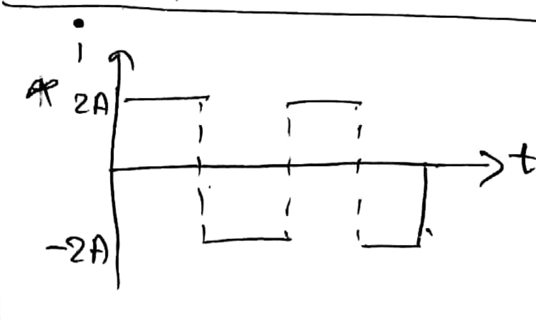
$$= \frac{\int_0^2 3t^2\,dt}{\int_0^2 dt}$$

$$= 3\left(\frac{t^3}{3}\right)_0^2 \Big/ (t)_0^2$$

$$= (8-0)/(2-0)$$

$$= \underline{4\,A}$$

*

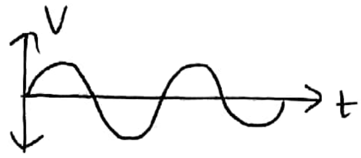


⊙ $i_{avg} = \langle i \rangle = \bar{i} = 0$ (full cycle)

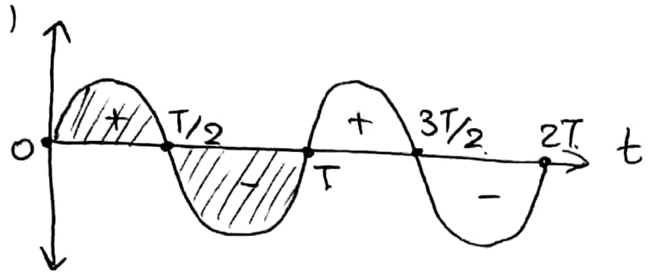
⊙ $i_{avg} = |\langle i \rangle| = 2A$ (Half cycle)

⊙ $\langle i^2 \rangle = \overline{i^2} = 4A$

AC generator :-

$V = V_0 \sin\omega t$ 

$i = i_0 \sin\omega t$ 



(Here; $\underset{\text{(full cycle)}}{i_{avg}} = 0$)

Proof:- $i_{avg} = \dfrac{\int_0^T i\,dt}{\int_0^T dt}$

$= \dfrac{\int_0^T i_0 \sin\omega t\,dt}{\int_0^T dt}$

$= \dfrac{i_0\left(-\frac{\cos\omega t}{\omega}\right)_0^T}{T}$

$= \dfrac{\frac{-i_0}{\omega}(\cos\omega t - \cos 0)_0^T}{T}$

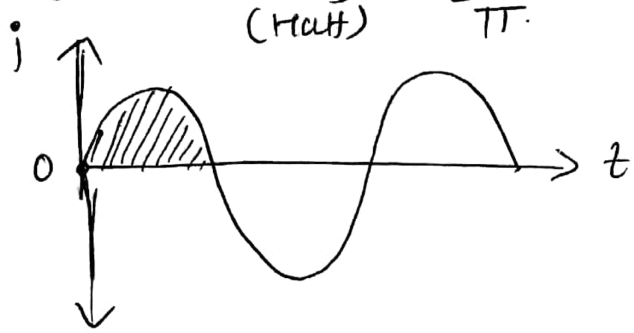
$= \dfrac{-i_0}{\omega T}(\cos\omega(T) - \cos 0)$

$= \dfrac{-i_0}{\omega T}\left(\cos\omega\left(\frac{2\pi}{\omega}\right) - \cos 0\right)$

$= \dfrac{i_0}{\omega T}(+1 - 0)$

$i_{avg} = \underline{\underline{0.}}$

* Find average value of AC current in Half cycle. $\underset{\text{(Half)}}{i_{avg}} = \dfrac{2i_0}{\pi}$



Ans:- $i_{avg} = \int_0^{T/2} i\,dt \Big/ \int_0^{T/2} dt$

$= \int_0^{T/2} i_0 \sin\omega t\,dt \Big/ (t)_0^{T/2}$

$= i_0\left(-\frac{\cos\omega t}{\omega}\right)_0^{T/2} \Big/ (T/2)$

$= \dfrac{\frac{-i_0}{\omega}\left[\cos\omega\frac{T}{2} - \cos 0\right]}{T/2}$

$= -\dfrac{2i_0}{T\omega}\left[\cos\omega\frac{2\pi}{2\omega} - \cos 0\right]$

$= -\dfrac{2i_0}{T\omega}[-1 - 1]$

$= -\dfrac{2i_0(-2)}{\frac{2\pi}{\omega}\omega}$

$\boxed{i_{avg} = \dfrac{+2i_0}{\pi}}$ 1/2 cycle.

similarly;

$\boxed{V_{avg} = \dfrac{+2V_0}{\pi}}$ for 1/2 cycle.

Rms value: (Root mean square)

1) do square
2) do average (mean)
3) do root.

$$\boxed{\begin{aligned} i_{rms} &= \sqrt{\langle i^2 \rangle} \\ V_{rms} &= \sqrt{\langle V^2 \rangle} \end{aligned}}$$

Main Formula.

sinusoidal

$\because V = V_0 \sin\omega t \Rightarrow V_{rms} = \frac{V_0}{\sqrt{2}}$

$i = i_0 \sin\omega t \Rightarrow i_{rms} = \frac{i_0}{\sqrt{2}}$

* Prove: For sinusoidal current $i = i_0 \sin\omega t$; ~~[illegible]~~ rms value of curr. is $i_{rms} = \frac{i_0}{\sqrt{2}}$

Ans:- $i_{rms} = \sqrt{\langle i^2 \rangle}$

$$= \sqrt{\langle i_0^2 \sin^2\omega t \rangle}$$

$$= \left(\frac{\int_0^T i_0^2 \sin^2\omega t \, dt}{\int_0^T dt} \right)^{1/2}$$

$$= \left(i_0^2 \int_0^T \frac{\sin^2\omega t \, dt}{T} \right)^{1/2}$$

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

$$= \left(\frac{i_0^2}{2T} \left(t - \frac{\sin 2\omega t}{2\omega} \right)_0^T \right)^{1/2}$$

(3)

$$i_{rms} = \left[\frac{i_0^2}{2T} \left(T - \frac{\sin 2\omega T}{2\omega} - 0 + 0 \right) \right]^{1/2}$$

$$= \left(\frac{i_0^2}{2T} \left[T - \frac{\sin 2\omega \left(\frac{2\pi}{\omega}\right)}{2\omega} \right] \right)^{1/2}$$

$$= \left(\frac{i_0^2}{2T} \left[T - \frac{\sin 4\pi}{2\omega} \right] \right)^{1/2}$$

$$= \left(\frac{i_0^2}{2T} [T - 0] \right)^{1/2}$$

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

if $50\,Hz = f$, $V = 220V$

$\because V_{RMS} = \frac{V_0}{\sqrt{2}}$

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

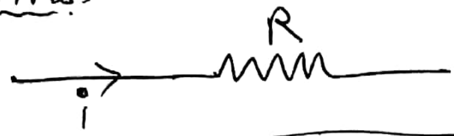
$= 220\sqrt{2}$

$V_0 = 311$ volt

V_0 = peak voltage.

• If in exam not given what kind of V is? Vavg, V_0, V_{rms} ? $\Rightarrow V_{Rms}$

* Energy dissipated in a resistor by current $i = i_0 \sin\omega t$ in time t is same as Energy dissi. by a constant current i_{rms}.



Dissipated Energy $\boxed{E = i_{rms}^2 R t}$

proof:- Energy dissipated in small time 'dt'.

$$\int dE = \int i^2 R\, dt$$

$$\therefore E = R \int i^2 dt$$

$$\left(i_{rms} = \sqrt{\langle i^2 \rangle} = \sqrt{\frac{\int i^2 dt}{\int dt}} \right)$$

★ Suppose, Here i_{rms} (const curr.) flows.

* To measure AC current, AC voltage,
⇒ Hot wire Voltmeter & current meters are used
They measure RMS value

⇒ we are not able to measure AC with DC devices.

Q: A - Find RMS for:

$$i = i_0 + i_0 \sin\omega t$$

$$i_{rms} = \sqrt{\langle i^2 \rangle} \neq \left(\frac{\int i^2 dt}{\int dt} \right)^{1/2}$$

Shortcut:- (for full cycle)
1) $\langle \sin\omega t \rangle = \overline{\sin\omega t} = 0$
2) $\langle \cos\omega t \rangle = \overline{\cos\omega t} = 0$
3) $\langle \sin^2\omega t \rangle = 1/2$
4) $\langle \cos^2\omega t \rangle = 1/2$

Q: B Find RMS i for: $i = i_0 \sin\omega t$.

$$i_{rms} = \sqrt{\langle i^2 \rangle} = \sqrt{\langle i_0^2 \sin^2\omega t \rangle}$$
$$= \sqrt{\langle i_0^2 \rangle \langle \sin^2\omega t \rangle}$$
$$= \sqrt{\langle i_0^2 \rangle \frac{1}{2}}$$
$$= \frac{i_0}{\sqrt{2}}$$

Ans. A: $i_{rms} = \sqrt{\langle i^2 \rangle}$

$$= \sqrt{\overline{i_0^2 + i_0^2 \sin^2\omega t + 2 i_0^2 \sin\omega t}}$$
$$= \sqrt{\overline{i_0^2} + \overline{i_0^2}\, \overline{\sin^2} + 2\overline{i_0^2}\, \overline{\sin}}$$
$$= \sqrt{i_0^2 + \frac{i_0^2}{2} + 2 i_0^2 \times 0}$$
$$= i_0 \sqrt{\frac{3}{2}}$$

Q C: $i = i_1 \sin\omega t + i_2 \cos\omega t$
(Home work)

Ans: $\sqrt{\dfrac{i_1^2 + i_2^2}{2}}$

Hint: $2\sin\theta\cos\theta = \sin 2\theta$
$2\sin\omega t \cos\omega t = \sin 2\omega t$

* what is phase?

$V = V_0 \sin(\omega t)$; $i = i_0 \sin(\omega t)$

Phase.

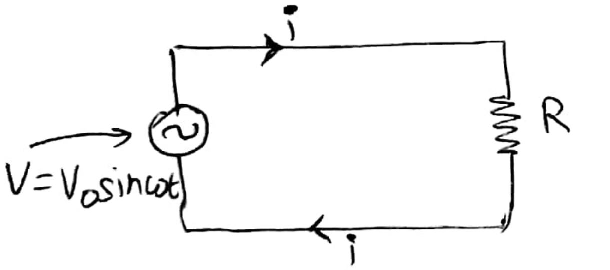
$$\boxed{\text{Phase difference} = \left|\text{Phase of } V - \text{phase of } i\right|}$$

$= |\omega t - \omega t| = 0$

---

* CIRCUIT THEORY :-

① Pure Resistive circuit



• Applying K-V-L:

$\therefore V - iR = 0$

$\therefore V = iR$

$\therefore i = \dfrac{V}{R} = \dfrac{V_0 \sin \omega t}{R}$

$\therefore i = \left(\dfrac{V_0}{R}\right) \sin \omega t$

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

where; $\left(i_0 = \dfrac{V_0}{R}\right)$; i_0 = Peak I, V_0 = Peak V.

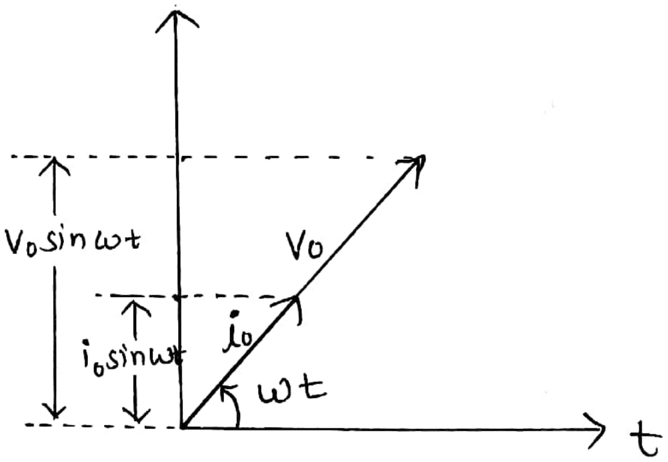
• Phase difference = $\left|\text{Phase of } V - \text{Phase of } i\right|$

$= |\omega t - \omega t|$

$= 0.$

Here; current is in phase with voltage.

PHASOR DIAGRAM :-

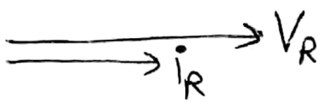


→ Here; i_0 is small because $(i_0 = V_0/R)$.

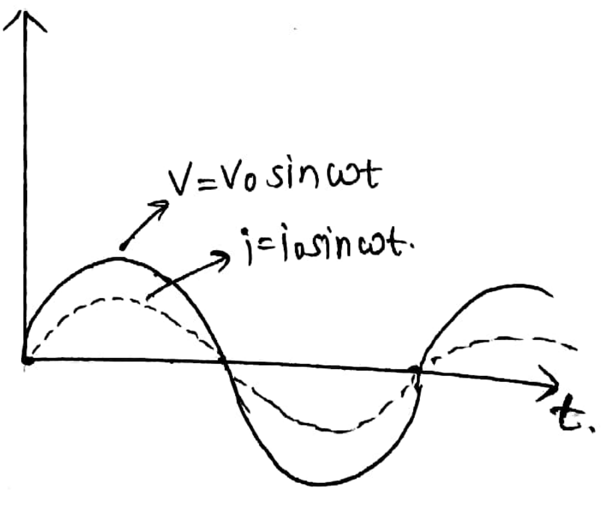
→ Length of Arrow → Peak value

→ Projection on Y axis → instantaneous $V = V_0 \sin \omega t$ & $i = i_0 \sin \omega t$

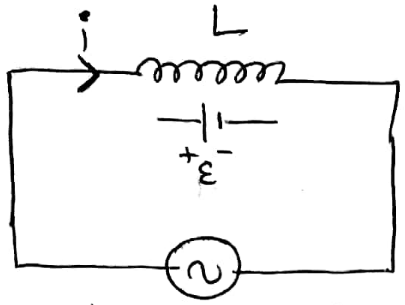
• simply for Example



WAVE DIAGRAM :-



②. Pure Inductive CKT :-



$V = V_0 \sin\omega t$

Here; inductor opposes the change so it becomes Battery (produce i in opposite direcⁿ) of emf $\varepsilon = L\frac{di}{dt}$.

$\therefore V - \varepsilon = 0$

$\therefore V - L\frac{di}{dt} = 0$

$\therefore di = \frac{V}{L}dt = \frac{V_0 \sin\omega t}{L} dt$

$\therefore \int di = \frac{V_0}{L}\int \sin\omega t \, dt$

$\therefore i = \frac{V_0}{L}\left(\frac{-\cos\omega t}{\omega}\right)$

$\therefore i = \frac{-V_0}{\omega L}\cos\omega t$

$\therefore \boxed{i = -i_0 \cos\omega t}$

where; $i_0 = \frac{V_0}{\omega L} = \frac{V_0}{X_L}$

; $\{X_L = \omega L\}$ = Inductive Reactance (its like resistance of Inductor.)

unit → Ω.

($\because \sin(90 - \theta) = \cos\theta$)

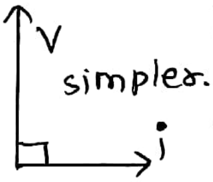
$\therefore i = -i_0 \sin(90° - \omega t)$

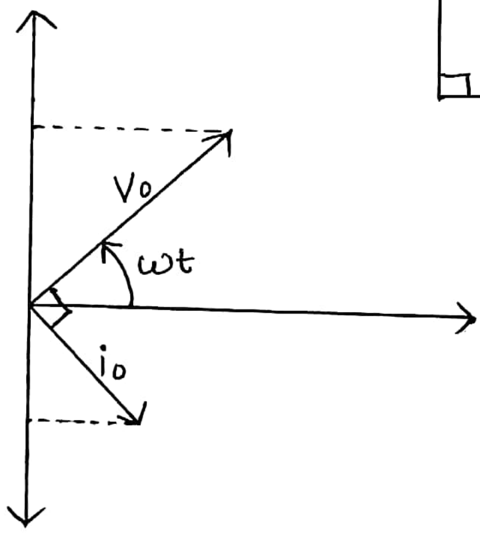
$\therefore i = -i_0 \left(\sin\left(\frac{\pi}{2} - \omega t\right)\right)$

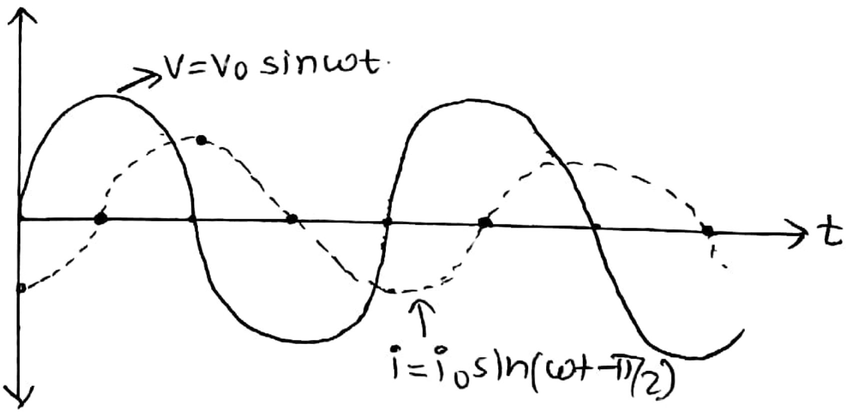
$\therefore \boxed{i = i_0 \sin\left(\omega t - \pi/2\right)}$

"Current Lags behind Potential by 90°"

PHASOR DIAGRAM :-

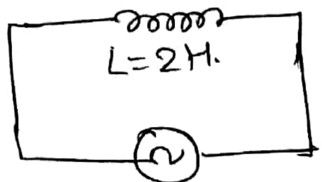






curr → max → Pot → min.

Q:- A



$V = 10\sin(10t+30)$.

Find Eqⁿ of current v/s time

Also $i_{rms} = ?$

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

∴ compare with

$V = 10\sin(10t+30)$

∴ $V_0 = 10,\ \omega = 10,\ \phi = 30°$.

→ Now:- $i_0 = \frac{V_0}{X_L} = \frac{10}{(10)(2)} = 0.5\,A$

$X_L \to (\omega L)$

→ $i_{rms} = \frac{i_0}{\sqrt{2}} = \frac{0.5}{\sqrt{2}}$.

→ current lags behind voltage:- by 90°

∴ $i = 0.5\sin(10t + 30° - 90°)$

$\boxed{i = 0.5\sin(10t - 60°)}$

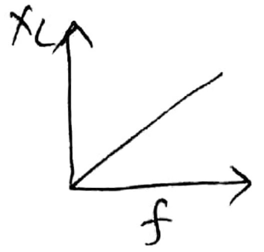
Error:- $i = \frac{V}{X_L}$ ✗ → i & V are varying

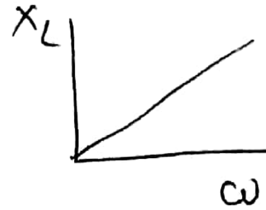
we can't use this Eqⁿ

we can use $i_0 = \frac{V_0}{X_L}$.

$X_L = \omega L$

$X_L = (2\pi f)L \quad (\because \omega = 2\pi f)$





$f\uparrow \Rightarrow X_L \uparrow \Rightarrow i_0 \downarrow$.

For const. current / DC current

⑦

$f = 0$

$\omega = 0$

$X_L = 0$

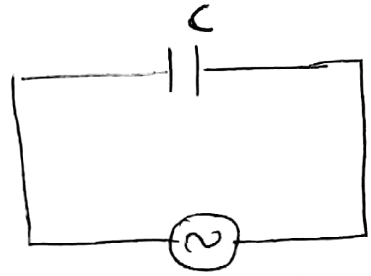
i.e in DC Battery NO Inductive Reactance produced.

Q:- B Find Inductive Reactance of an inductor L=2H. connected to an AC freq. of 50Hz.

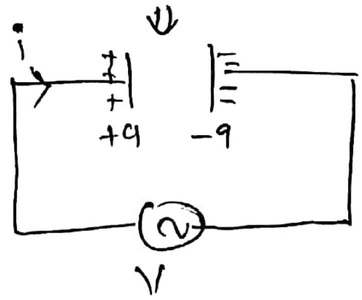
$X_L = \omega L = 2\pi f L = 2\pi \times 50 \times 2$

$\boxed{X_L = 200\pi\ \Omega}$

③ PURE CAPACITIVE CIRCUIT :-



$V = V_0 \sin\omega t$.



∴ $V - \frac{q}{C} = 0$ (K-V-L)

∴ $q = CV$.

∴ $q = C V_0 \sin\omega t$

∴ $\frac{dq}{dt} = CV_0 \frac{d}{dt}(\sin\omega t)$

∴ $i = CV_0 \cos\omega t \times \omega$

$i = (\omega C V_0)\cos\omega t$

$i = (i_0)\cos\omega t$.

let; $i_0 = \omega C V_0 = \dfrac{V_0}{(1/\omega C)}$

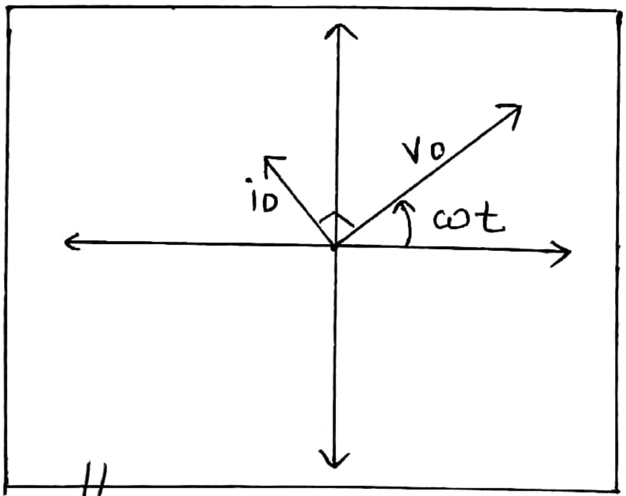
where; $\left(\dfrac{1}{\omega C} = X_C = \text{capacitive Reactance}\right)$ Ω

∴ $i = i_0 \cos\omega t$

$$\boxed{i = i_0 \sin(\omega t + \pi/2)}$$

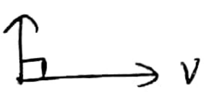
"current leads Potential by 90°".

PHASOR :-

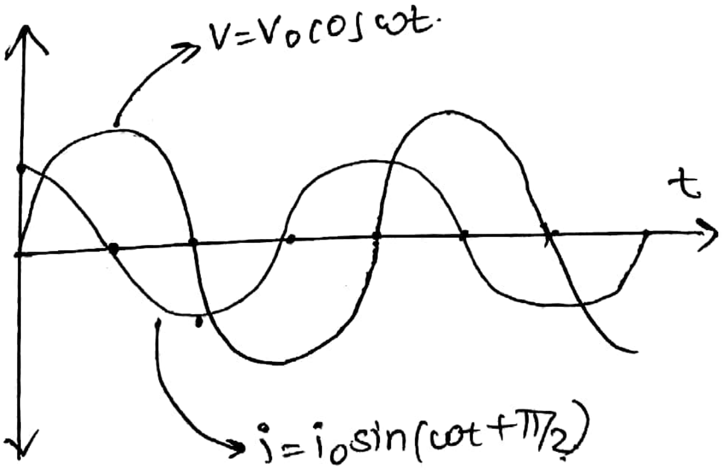


⇓

simply ⇒

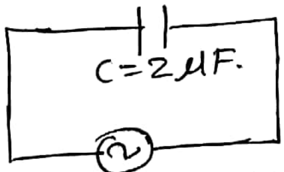


wave diagram :-



I → max ⇒ V → min & vice versa

Q A :- Find Equation of I v/s t. calculate i_{avg} for
i) Full cycle ii) Half cycle.



$V = 10 \sin 10t$.

Here; $V_0 = 10$, $\omega = 10$

∴ $i_0 = \dfrac{V_0}{X_C} = \dfrac{V_0}{1/\omega C} = \dfrac{V_0}{1/(10\times2\times10^{-6})}$

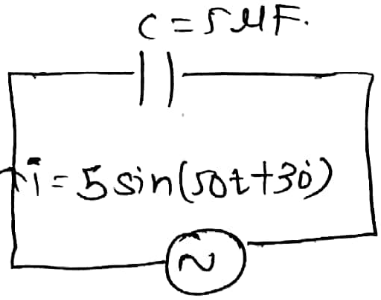
∴ $i_0 = 10(10\times2\times10^{-6})$
$= 200\times10^{-6}$

$$\boxed{i_0 = 2\times10^{-4} A}$$

i) Full cycle $i = 0$
ii) Half $i = \dfrac{2 i_0}{\pi} = \dfrac{2\times2\times10^{-4}}{\pi}$

(Here; also $i(t) = \dfrac{V(t)}{X_C}$ not possible bcw its not in phase (V & i))

Q B :-



V = ?

Find Eqn of V v/s time.

i is 90° ahead to V
i.e V lags

∴ $V = V_0 \sin(50t + 30° - 90°)$
$= V_0 \sin(50t - 60°)$

∴ $V_0 = i_0(X_C) = 5\left(\dfrac{1}{\omega C}\right) = \cancel{5}\left(\dfrac{1}{50\times\cancel{5}\times10^{-6}}\right)$

Pure Resistive

$V = V_0 \sin\omega t$

$i = i_0 \sin\omega t$

$i_0 = \frac{V_0}{R}$

R is independent of frequency.

Pure Inductive

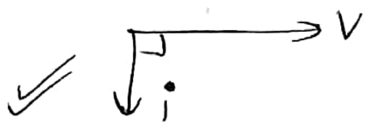
$V = V_0 \sin\omega t$

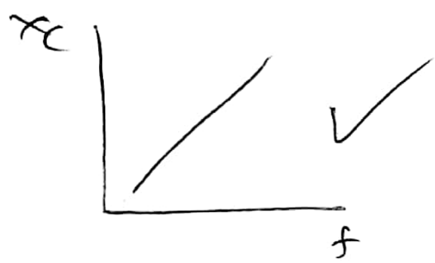
$i = i_0 \sin(\omega t - \pi/2)$

$i_0 = \frac{V_0}{X_L}$

$X_L = 2\pi f L = \omega L$

or





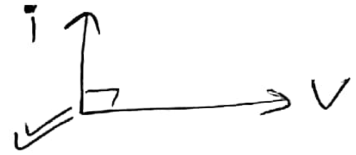
Pure Capacitive

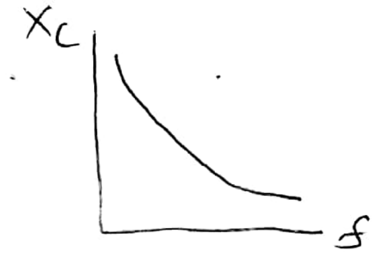
$V = V_0 \sin\omega t$

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

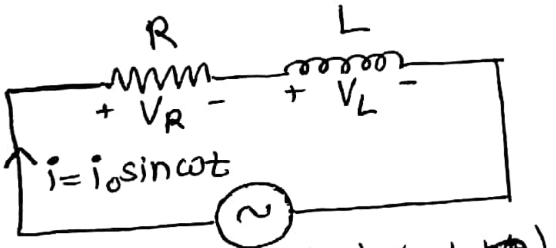
$i_0 = \frac{V_0}{X_C}$

$X_C = \frac{1}{\omega C}$





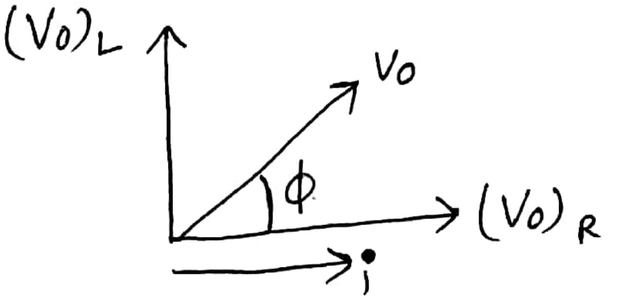
① Series L-R circuit :-



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

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

$V_L(t) = (V_0)_L \sin(\omega t + \pi/2)$



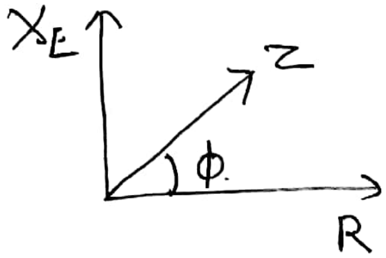
$\therefore V_0^2 = (V_0)_R^2 + (V_0)_L^2$

$\therefore V_0 = \sqrt{V_{0R}^2 + V_{0L}^2}$

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

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

$\boxed{V_0 = i_0 \times Z}$



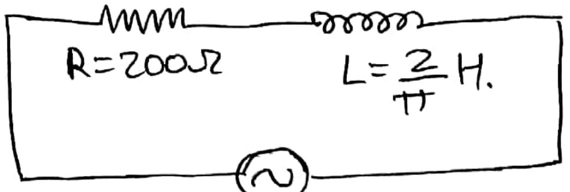
i.e. $\boxed{Z = \sqrt{R^2 + X_L^2}}$

$\boxed{\tan\phi = \frac{X_L}{R}}$

i.e. $|Z| = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + \omega^2 L^2}$

$\phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{\omega L}{R}\right)$

Q A:



$V = 200 \sin 100\pi t.$

Find i) inductive Reactance X_L.

ii) impedance.

iii) Peak current i_0.

iv) $i(t) = ?$

Ans i) $X_L = \omega L = (100\pi)\frac{2}{\pi} = 200H$

ii) $Z = \sqrt{R^2 + X_L^2} = \sqrt{200^2 + 200^2}$

$= \sqrt{200(400)}$

$20\sqrt{100 \times 2}$

$= 20 \times 10 \times \sqrt{2}$

$= \cancel{282}\ \Omega = 200\sqrt{2}.$

iii) $i_0 = \frac{V_0}{Z} = \frac{200}{282} = 0.707$

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

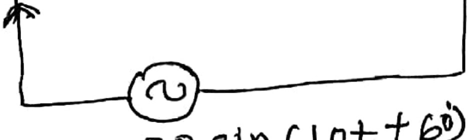
$i(t) = (0.707) \sin(100\pi t - \phi)$

where; $\phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{200}{200}\right)$

$= 45°$

$\therefore i(t) = 0.707 \sin(100\pi t - 45°)$

Q B:



$\mathcal{E} = 20 \sin(10t + 60°)$

Find. i) X_L ii) Z iii) i_0

iv) $i(t)$ v) $V_R(t)$. & $V_L(t)$.

$V_0 = 20V.$, $\omega = 10$, ~~...~~

i) $X_L = \omega L = 10(0.4) = 4H$

ii). $Z = \sqrt{R^2 + X_L^2} = \sqrt{9 + 16} = 5$

iii) $i_0 = \frac{V_0}{Z} = \frac{20}{5} = 4A.$

iv) $i(t) = i_0 \sin(\omega t + 60° - \phi)$

$\rightarrow \phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{4}{3}\right)$

$(\phi = 53°)$

$\therefore i(t) = 4 \sin(10t + 60° - 53°)$

$[i(t) = 4 \sin(10t + 7°)]$

v) $V_R(t) = V_{0R} \sin(10t + 7°)$

$= (i_{0R} \times R) \sin(10t + 7°)$

$= (4 \times 3) \sin(10t + 7°)$

$\boxed{V_R(t) = 12 \sin(10t + 7°)}$

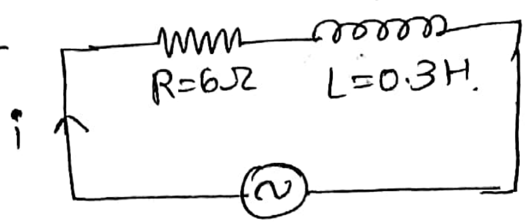
vi) $V_L(t) = V_{0L} \sin(10t + 97°)$

$= (i_{0L} \times X_L)$ "

$= (4 \times 4)$ "

$\boxed{V_L(t) = 16 \sin(10t + 97°)}$

Q C:



$i = 10 \sin(20t + 30°)$

Find i) X_L ii) Z iii) V_0 iv) $V(t)$

v) $V_R(t)$ vi) $V_L(t)$

$\because i_0 = 10$

$\because \omega = 20$

$\rightarrow X_L = \omega L = 0.3(20) = 6\Omega.$

$\rightarrow Z = \sqrt{R^2 + \omega^2 L^2} = \sqrt{36 + 36} = 6\sqrt{2}.$

$V_0 = i_0 Z$
$= 10(6\sqrt{2}) = 60\sqrt{2}$

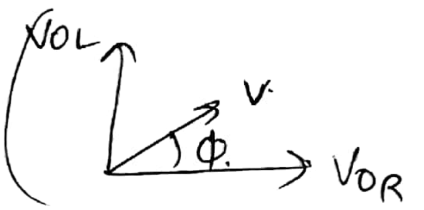
• $V_R(t) = V_{0R} \sin(\omega t + 30^\circ)$
$= (i_0 \times R) \sin(\omega t + 30^\circ)$
$= (10 \times 6) \sin(20t + 30^\circ)$
$V_R(t) = 60 \sin(20t + 30^\circ)$

• $V_L(t) = V_{0L} \sin(\omega t + 30^\circ + 90^\circ)$
$= (X_L i_0) \sin(20t + 120^\circ)$
$V_L(t) = 60 \sin(20t + 120^\circ)$

$\phi = \frac{X_L}{R} = \frac{6}{6} = 1 \Rightarrow \phi = 45^\circ$

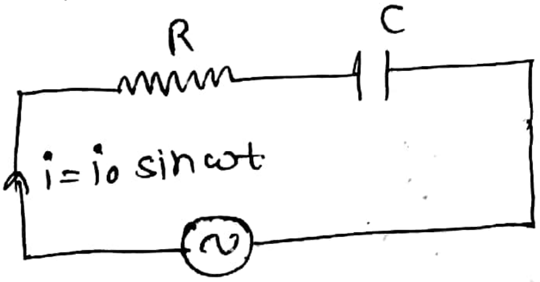
$\therefore V(t) = 60 \sin(20t + 30 + \phi)$

voltage leads current so +ve ϕ

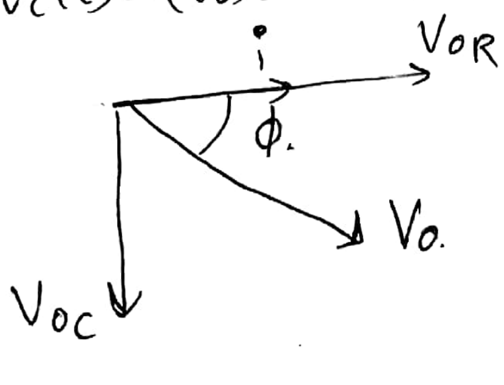


$\therefore V(t) = 60 \sin(20t + 30 + 45^\circ)$

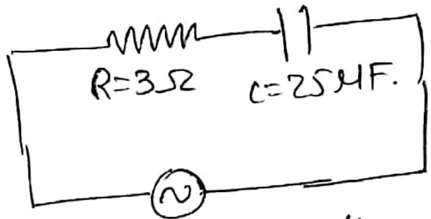
② Series C-R circuit :-



$V_R(t) = (V_0)_R \sin\omega t$
$V_c(t) = (V_0)_c \sin(\omega t - \pi/2)$



$V_0 = \sqrt{V_{0R}^2 + V_{0C}^2}$
$V_0 = \sqrt{i_0^2 R^2 + i_0^2 X_c^2}$
$V_0 = i_0 \sqrt{R^2 + X_c^2}$
$\therefore V_0 = i_0 \sqrt{X_c^2 + R^2}$
$\therefore \boxed{V_0 = i_0 Z}$
Z = impedence $= \sqrt{X_c^2 + R^2}$
→ current leads potential by ϕ.
→ $\boxed{\tan\phi = \frac{X_c}{R}}$

①


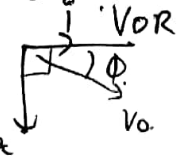
$V = 10 \sin(10^4 t + 30^\circ)$
Find i) X_c ii) Z, i_0, $i(t)$, $V_R(t)$, $V_c(t)$.

→ $X_c = \frac{1}{\omega C} = \frac{1}{10^4 (25 \times 10^{-6})} = 0.04 \times 100 = 4\Omega$.
→ $Z = \sqrt{R^2 + X_c^2} = \sqrt{3^2 + 4^2} = 5\Omega$
→ $i_0 = \frac{V_0}{Z} = \frac{10}{5} = 2A$.
→ $\phi = \tan^{-1}\frac{X_c}{R} = \tan^{-1}\left(\frac{4}{3}\right) = 53^\circ$
→ $i(t) = i_0 \sin\omega t$
$= 2 \sin(10^4 t + 30^\circ + \phi)$
$= 2 \sin(10^4 t + 30^\circ + 53^\circ)$
→
$\cancel{V_R(t) = (V_0)_R \sin(10^4 t + 30^\circ)}$
$\cancel{= (i_0 \times R) \sin(10^4 t + 30^\circ)}$
$\cancel{V_R(t) = 6 \sin(10^4 t + 30^\circ)}$
→ $V_c(t) = V_{0c} \sin$

$i(t) = 2\sin(10^4 t + 83^\circ)$ (12)

$\rightarrow V_R(t) = V_{OR}\sin(10^4 t + 83^\circ)$
$= i_0 \times R$ "
$= 6$

$\rightarrow V_C(t) = V_{OC}\sin(10^4 t + 83^\circ - 90^\circ)$
$= i_0 \times X_C \sin(10^4 t - 7^\circ)$
$= 8\sin(10^4 t - 7^\circ)$



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* POWER IN A.C. :-

→ In current Electricity we use,

$$P = VI$$

→ Now; for AC suppose,

$V = V_0 \sin\omega t$
$i = i_0 \sin(\omega t + \phi)$

→ Here; in AC V & i both varies with time, so. P(power) also varies with t.

→ ∴ Instantaneous power (1)

$$P(t) = V(t)\, i(t)$$

$$P(t) = V_0\sin\omega t\; i_0 \sin(\omega t + \phi)$$

* To Find average power

$$P_{avg} = \overline{V_0 \sin\omega t\, i_0 \sin(\omega t + \phi)}$$

$$= V_0 i_0\, \overline{\sin\omega t \cdot \sin(\omega t + \phi)}$$

Hint:- $\sin(A+B) = \sin A\cos B + \cos A \sin B$

$$= V_0 i_0\, \overline{\sin\omega t\,(\sin\omega t \cos\phi + \cos\omega t \sin\phi)}$$

$$= V_0 i_0\, \overline{(\sin^2\omega t \cos\phi + \sin\omega t \cos\omega t \sin\phi)}$$

$$= V_0 i_0 \left(\overline{\sin^2\omega t \cos\phi + \frac{2\sin\omega t\cos\omega t \sin\phi}{2}}\right)$$

$$= V_0 i_0 \left(\overline{\sin^2\omega t \cos\phi + \frac{\sin 2\omega t\, \sin\phi}{2}}\right)$$

$$= V_0 i_0 \left[\overline{\sin^2\omega t}\,\overline{\cos\phi} + \frac{\overline{\sin 2\omega t}\,\overline{\sin\phi}}{2}\right]$$

$$= V_0 i_0 \left[\frac{1}{2}\cos\phi + 0\right]$$

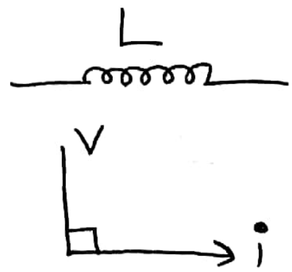
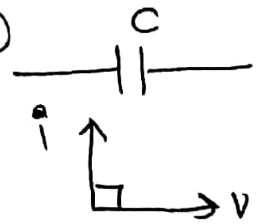
$$= \frac{V_0 i_0}{2}\cos\phi$$

$$= \frac{V_0}{\sqrt{2}}\frac{i_0}{\sqrt{2}}\cos\phi$$

$$\therefore \boxed{P_{average} = V_{rms}\, i_{rms} \cos\phi}$$

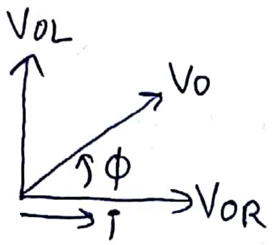
$\cos\phi$ = power factor.

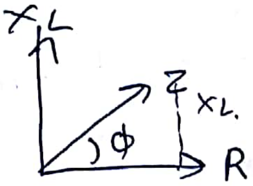
- If not mentioned then assume ~~xxxx~~ power average
- I & V → rms i & rms V.

circuit	ϕ	power factor $\cos\phi$
(1) R 	0	1
(2) L 	90°	0
(3) C 	90°	0.

Ckt	ϕ	$\cos\phi$
(4) R L	ϕ	$\boxed{\cos\phi = \frac{R}{Z}}$
(5) R C	ϕ	$\boxed{\cos\phi = \frac{R}{\cancel{X_C}}}$

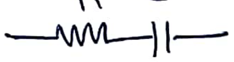
(4)

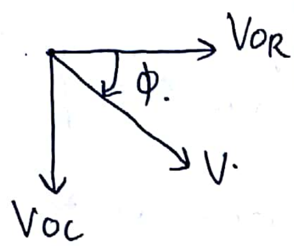


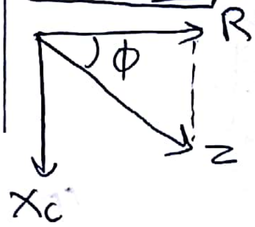


$\left(\cos\phi = \frac{R}{Z}\right)$

(5)







$\boxed{\text{Remember: Always } \cos\phi = \frac{R}{Z}}$

i.e. Avg. Power $= V_{rms}\, i_{rms} \cos\phi$

$= V_{rms}\, i_{rms} \left(\frac{R}{Z}\right)$

$$\boxed{\begin{aligned} P_{avg} &= i_{rms}^2 R \\ P_{avg} &= \frac{V_{rms}^2 R}{Z} \end{aligned}}$$

2

$\left(\because i_{rms} = \frac{V_{rms}}{Z}\right)$

* Apparent power $= V_{rms}\, i_{rms}$ — (3)

CHOKE COIL

- In India household supply is 220V, some device like Tubelight can't stand this much high voltage

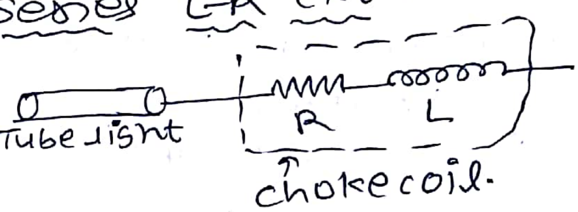
→ To reduce voltage we can use Resistor.

→ But Resistor will create too much power.

$P = V_{rms} \times i_{rms} \times \underline{1}$ } $\cos\phi = 1$ High.

→ To solve this problem we uses a choke coil.

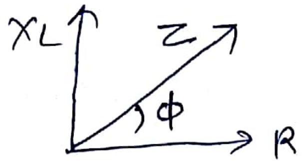
* Series LR ckt :-



- Choke coil can reduce voltage to Tube if it's impedance Z is High.
- $Z = \sqrt{X_L^2 + R^2}$
- But R should be small.

$R \downarrow$ & $Z \uparrow$ i.e. X_L must be $\uparrow$

i.e L must $\uparrow$.



$\cos\phi = \frac{R}{Z}$

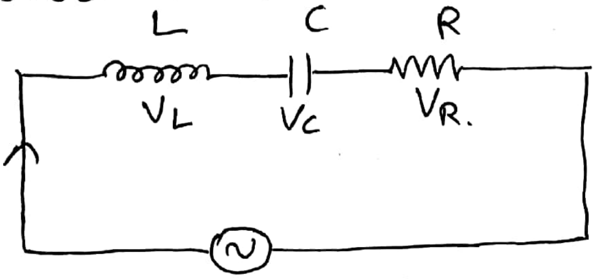
$$\cos\phi = \frac{R}{\sqrt{X_L^2 + R^2}}$$

$$= \frac{1}{\sqrt{\left(\frac{X_L}{R}\right)^2 + 1}} \to \infty$$

i.e $= \frac{1}{\infty} \to 0$

$\boxed{\cos\phi \approx 0}$ very small.

SERIES LCR circuit:-



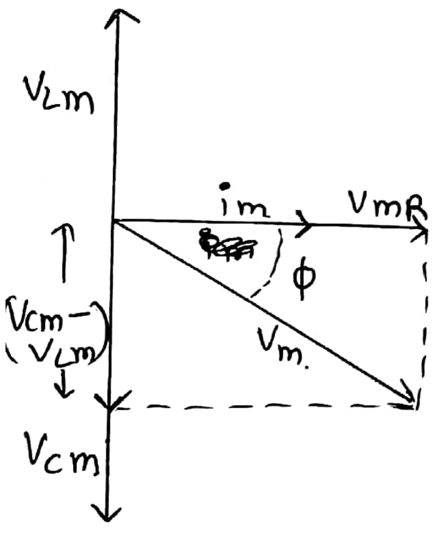
$V = V_m \sin\omega t$.

- To Find current we use here two method.
  1. Phasor method
  2. Analytic method.

- PHASOR-diagram solution:-

→ let; current i(t) is same in all 3 L & C & R is $\boxed{i = i_m \sin(\omega t + \phi)}$ —— (1).

where; ϕ = Phase diff. b/w. source V & i.



→ From phasor diagram:-

$\therefore V_m^2 = V_{Rm}^2 + (V_{cm} - V_{Lm})^2$

$\therefore$ where; $V_{Rm} = i_m R$

$V_{cm} = i_m X_C$

$V_{Lm} = i_m X_L$

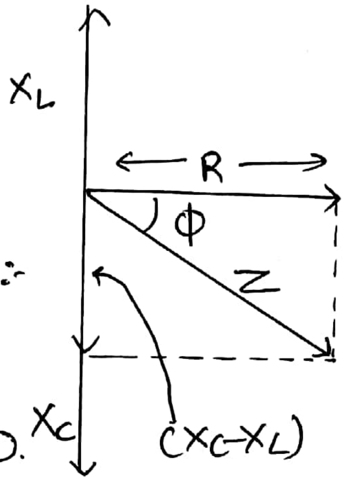
$\therefore V_m^2 = i_m^2 R^2 + (i_m^2 X_C - i_m^2 X_L)^2$

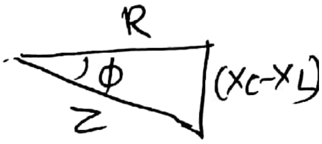
$\therefore V_m^2 = i_m^2 [R^2 + (X_L - X_C)^2]$

$\therefore V_m = i_m \sqrt{R^2 + (X_C - X_L)^2}$

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

$\therefore$

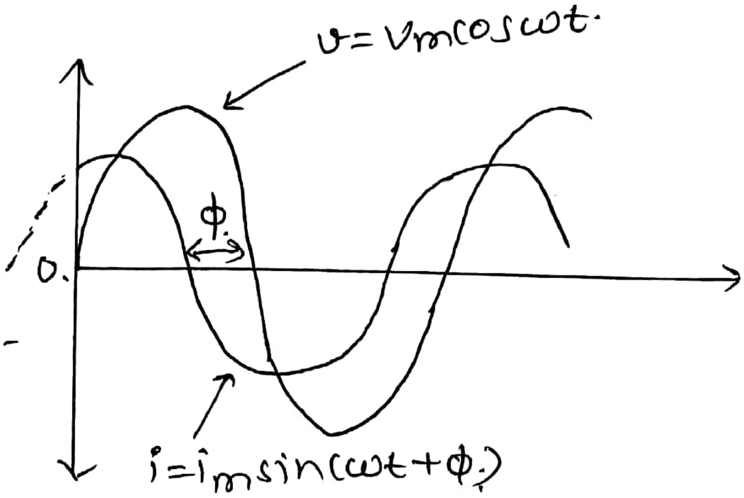




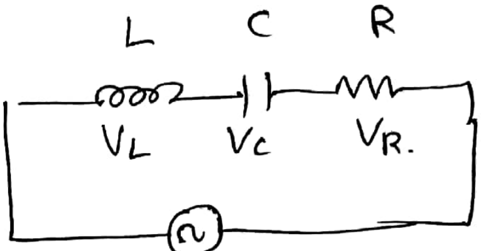
$\therefore \boxed{\tan\phi = \dfrac{X_C - X_L}{R}}$

→ Here; $X_C > X_L \Rightarrow \phi = +ve$. i.e circuit is capacitive so current leads.

→ If $X_L > X_C \Rightarrow \phi = -ve$ i.e ckt is inductive & so current lags behind source voltage.



* Analytical solution :-



$V = V_m \sin\omega t$

→ For series L-C-R AC circuit voltage is given by:

→ $V = V_L + V_C + V_R$

$V = \left(L\frac{di}{dt}\right) + \frac{q}{C} + iR$

→ converting Equation in form of charge q.

$\therefore V = \left(L\frac{d^2q}{dt^2}\right) + \frac{q}{C} + \frac{dq}{dt}R$

$\therefore \boxed{V_m \sin\omega t = L\frac{d^2q}{dt^2} + \frac{q}{C} + \frac{dq}{dt}R}$ —— (2)

→ This Eqn. is like forced damped Harmonic oscillator.

→ let's assume a solution of Eqn. (2) $\boxed{q = q_m \sin(\omega t + \theta)}$ (3)

$\therefore \boxed{\frac{dq}{dt} = q_m \omega \cos(\omega t + \theta)}$ (4) & $\boxed{\frac{d^2q}{dt^2} = -q_m \omega^2 \sin(\omega t + \theta)}$ (5)

→ putting (3), (4), (5) in (2) :-

$\therefore V_m \sin\omega t = L\left(-q_m\omega^2 \sin(\omega t+\theta)\right) + \frac{q_m}{C}\sin(\omega t+\theta) + \frac{q_m \omega}{R} R\cos(\omega t+\theta)$

$\therefore V_m \sin\omega t = q_m \omega \left\{\left[-(\omega L) \times \sin(\omega t+\theta)\right] + \left(\frac{1}{\omega C}\right)\sin(\omega t+\theta) + \frac{R}{R}\cos(\omega t+\theta)\right]$

$V_m \sin\omega t = q_m\omega\left[-X_L \sin(\omega t+\theta) + X_c \sin(\omega t+\theta) + R\cos(\omega t+\theta)\right]$

$\left[\begin{matrix} X_L = \omega L \\ X_c = \frac{1}{\omega C}\end{matrix}\right]$ & $\left[\begin{matrix} \sin(\alpha+\beta) = \sin\alpha\cos\beta + \cos\alpha\sin\beta \\ \sin(\alpha-\beta) = \sin\alpha\cos\beta - \cos\alpha\sin\beta. \\ \cos(\alpha+\beta) = \cos\alpha\cos\beta - \sin\alpha\sin\beta \\ \cos(\alpha-\beta) = \cos\alpha\cos\beta + \sin\alpha \cdot \sin\beta \end{matrix}\right]$

$\therefore V_m \sin\omega t = q_m\omega\left[(X_c - X_L)\sin(\omega t+\theta) + R\cos(\omega t+\theta)\right]$

$\div Z \Rightarrow \frac{V_m}{Z}\sin\omega t = q_m\omega\left[\frac{X_c - X_L}{Z}\sin(\omega t+\theta) + \frac{R}{Z}\cos(\omega t+\theta)\right]$

$\frac{V_m}{Z}\sin\omega t = q_m\omega\left[\sin\phi \cdot \sin(\omega t+\theta) + \cos\phi \cdot \cos(\omega t+\theta)\right]$

$\left(\because \cos\phi = \frac{R}{Z} \text{ \& } \sin\phi = \frac{X_c - X_L}{R}\right)$

(Above foom is like
$\because \cos(\omega t+\theta)\cos\phi + \sin(\omega t+\theta)\cdot\sin\phi = \cos(\omega t+\theta-\phi)$)

$\therefore \frac{V_m}{Z}\sin\omega t = q_m\omega\,[\cos(\omega t+\theta-\phi)]$

$V_m\sin\omega t = (q_m\omega)Z\cos(\omega t+\theta-\phi)$

$\therefore V_m\sin\omega t = i_m Z\cos(\omega t+\theta-\phi)$ $\quad (\because i_m = q_m\omega)$

$\therefore$ we have: $V_m = i_m Z$

$\therefore \sin\omega t = \cos(\omega t+\theta-\phi)$

$\therefore \cos\left(\frac{\pi}{2}-\omega t\right) = \cos(\omega t+\theta-\phi)$

$\therefore \cos(\omega t-\pi/2) = \cos(\omega t+\theta-\phi)$

From above Eqn

$\therefore -\frac{\pi}{2} = \theta-\phi$ $\quad \therefore \boxed{\theta = -\frac{\pi}{2}+\phi} = \boxed{\phi-\pi/2 = \theta}$ — (6)

~~which is the solution of~~

→ Put (6) in (3) :- $\boxed{q = q_m\sin(\omega t+\phi-\pi/2)}$

this is the soln of Eqn. (2).

$\therefore$ current in ckt is :- $i = \frac{dq}{dt} = q_m\omega\cos(\omega t+(\phi-\pi/2))$

$= q_m\omega\cos\left[\frac{\pi}{2}-\omega t-\phi\right]$

$= -q_m\omega\sin(-\omega t-\phi)$

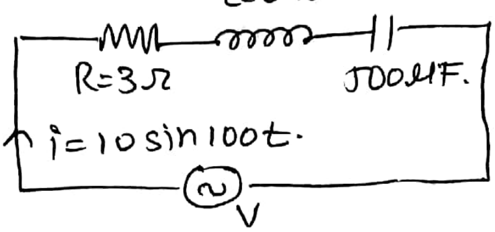
$i = q_m\omega\sin(\omega t+\phi)$

$\therefore \boxed{i = i_m\sin(\omega t+\phi)}$

where; $i_m = \frac{V_m}{Z} = \frac{V_m}{\sqrt{R^2+(X_C-X_L)^2}}$

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

Q.1)



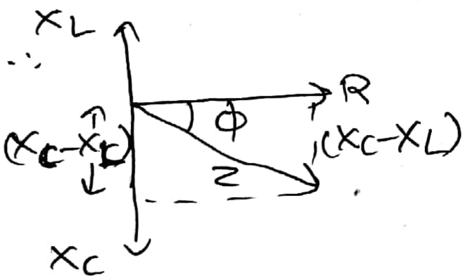
Find.
X_L, X_C, Z, ϕ, V_0, $V(t)$, $V_R(t)$
$V_L(t)$, $V_C(t)$., Power factor.

Ans: (1) $X_L = \omega L = 100(0.16) = \underline{16\Omega}$

(2). $X_C = \frac{1}{\omega C} = \frac{1\times10^6}{100\times500} = 0.2\times10^2 = \underline{20\Omega}$

(3) $Z = \sqrt{R^2+(X_C-X_L)^2}$
$= \sqrt{9+(20-16)^2} = 5\Omega.$

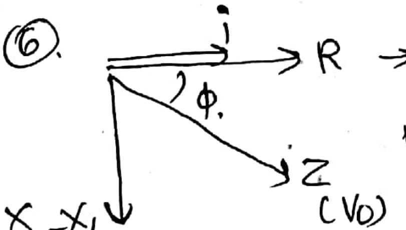
Here; $X_C > X_L$



(5) $\phi = \tan^{-1}\frac{(X_C-X_L)}{R} = \tan^{-1}\frac{4}{3} = 53°$

(5) $V_0 = i_0 Z = 10(5) = \underline{50}.$

(6).



→ i is leads.

if $X_C > X_L$
⇒ net ckt is capacitive
i.e. i(t) leads v(t).

$V(t) = V_0\sin(100t-\phi)$
$V(t) = 50\sin(100t-53°)$

(7) $V_R(t) = (V_0)_R \sin(100t)$
$= (i_0\times R)\sin(100t)$
$= (30)\sin(100t)$

(8). $V_L(t) = (V_0)_L \sin(100t+90°)$
$= i_0\times X_L \sin(100t+90°)$
$= 160\sin(100t+90°)$

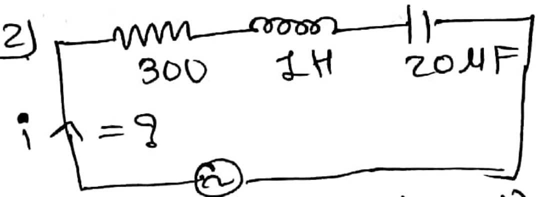
(9) $V_C(t) = (V_0)_C \sin(100t-90°)$
$= i_0 X_C \sin$ "
$= 200$ "

(10) $\cos\phi = \frac{R}{Z} = \frac{3}{5}$

(11) Avg. Power $= V_{rms}\, i_{rms}\cos\phi$
$= \frac{V_0}{\sqrt2}\frac{i_0}{\sqrt2}\cdot\frac{3}{5}$
$= \frac{50}{2}\times10\times\frac{3}{5}$

$\boxed{P_{avg} = 150\text{ W.}}$

Q.2)



$V = 50\sin(100t+30°)$

Find X_L, X_C, Z, ϕ
i_0, $i(t)$, $V_R(t)$, $V_L(t)$, $V_C(t)$
power factor & power.

Ans. $X_L = 100\Omega$, $X_C = 500\Omega$.
$X_C > X_L$ → capacitive ckt.

$Z = 500\Omega$.

$\phi = \frac{X_C-X_L}{R} = \frac{400}{300} = 53°$

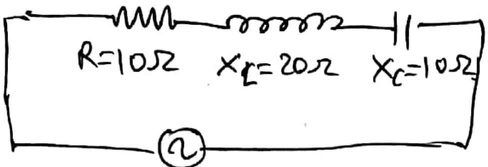
∴ $i_0 = 0.1$ A

$\cos\phi = \frac{3}{5}$

$P_{avg} = 1.5$ W.

$i(t) = 0.1\sin(100t+30°+53°)$
$V_R(t) = 30\sin(100t+83°)$
$V_L(t) = 10\sin(100t+173°)$
$V_C(t) = 50\sin(100t-7°)$

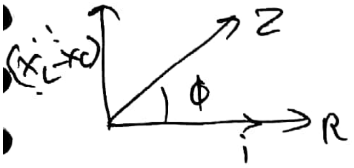
Q.3)



$E = 20\sqrt{2}\sin(100t+30^\circ)$

Find Z, ϕ, i_0, i_{rms}, $(V_{rms})_R$, $(V_{rms})_L$, $(V_{rms})_C$

Ans, Here: $X_L > X_C \Rightarrow$ ckt is inductive.

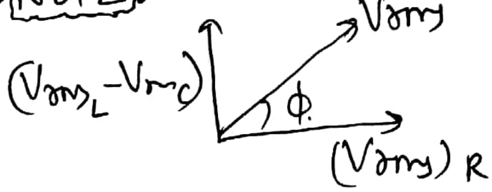


$\Rightarrow Z = \sqrt{R^2 + (X_L - X_C)^2}$
$= \sqrt{10^2 + 10^2} = \underline{10\sqrt{2}\,\Omega}$

- $\tan\phi = \frac{X_L - X_C}{R} = \frac{10}{10} = 1 \Rightarrow \boxed{\phi = 45^\circ}$
- $\underline{i_0 = 2A}$ • $\underline{i_{rms} = \sqrt{2}}$
- $i(t) = 2\sin(100t + 30 - 45^\circ)$
  $\underline{i(t) = 2\sin(100t - 15^\circ)}$
- $(V_{rms})_R = i_{rms} R = 10\sqrt{2}\,V$
- $(V_{rms})_L = i_{rms} X_L = 20\sqrt{2}\,V$
- $(V_{rms})_C = i_{rms} X_C = 10\sqrt{2}\,V$

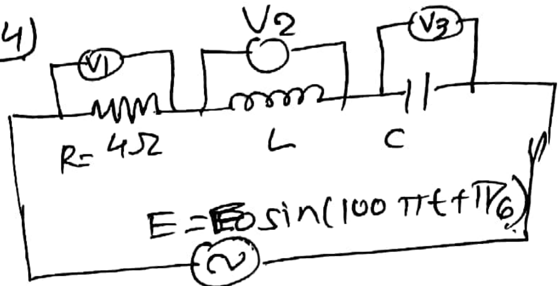
$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{20\sqrt{2}}{\sqrt{2}} = 20V$

• NOTE:-



$\therefore V_{rms} = \sqrt{V_{rms_R}^2 + (V_{rms_L} - V_{rms_C})^2}$
$= \sqrt{(10\sqrt{2})^2 + (20\sqrt{2} - 10\sqrt{2})^2}$
$= \sqrt{(10\sqrt{2})^2 + (10\sqrt{2})^2}$
$= \sqrt{2000 + 2000}$
$= 20V$

Q.4)



$E = E_0 \sin(100\pi t + \pi/6)$

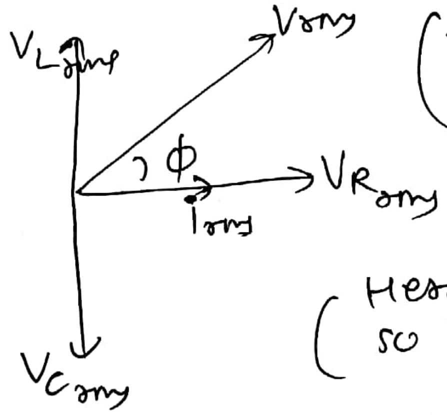
Reading of voltmeters:-
$V_1 = 40V$, $V_2 = 40V$, $V_3 = 10V$
Find (1) i_0, i_{rms} (2) E_0 (3) L & C, i(t)

→ these voltmeters measures V_{rms} in R & L, & C resp^ly.

→ i.e. $(V_{rms})_R = 40V = i_{rms} R$
$\therefore \boxed{i_{rms} = 10A}$

$i_0 = i_{rms}\sqrt{2} = \underline{10\sqrt{2}\,A}$.

→ $i(t) = 10\sqrt{2}\sin(100\pi t$ ---

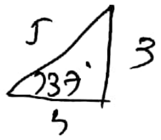


(take all RMS values)

(Here $V_L > V_C$ so it's inductive ckt.)

$\therefore \phi = \tan^{-1}\left(\frac{V_L - V_C}{V_R}\right) = \frac{30}{40} = \frac{3}{4}$

$\therefore \boxed{\phi = 37^\circ}$



$i(t) = 10\sqrt{2}\sin(100\pi t - 37^\circ + \pi/6)$
$= 10\sqrt{2}\sin(100\pi t - 37^\circ + 30^\circ)$
$i(t) = 10\sqrt{2}\sin(100\pi t - 7^\circ)$

$(V_{rms})^2 = V_R^2 + (V_L - V_C)^2$
$= \sqrt{40^2 + (30)^2} = 50$

$V_{rms} = 50 \Rightarrow V_0 = V_{rms}\sqrt{2}$
$\boxed{V_0 = 50\sqrt{2}} = E_0$.

For L&C

$\because (V_{rms})_L = i_{rms} \times X_L$

$\therefore 40 = 10\ \omega L$

$\therefore L = \frac{4}{\omega} = \frac{4}{100\pi} = \frac{1}{25\pi}$ H

→ $V_{rms\,C} = i_{rms} \times X_C$

$\therefore 10 = 10 \frac{1}{\omega C}$

$\therefore C = \frac{1}{\omega} = \frac{1}{100\pi}$ Farad

Resonance in L-C-R series AC circuit :-

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

- when $X_L = X_C$ (or $V_{mL} = V_{mC}$)

⇒ ω_0 is called as Resonant frequency.

→ And, resonance takes place series

→ when $X_L = X_C$

$\therefore \omega_0 L = \frac{1}{\omega_0 C}$

$\therefore \omega_0^2 = \frac{1}{LC}$

$\boxed{\omega_0 = \frac{1}{\sqrt{LC}}}$ Resonance freq.

or $\boxed{f_0 = \frac{1}{2\pi\sqrt{LC}}}$

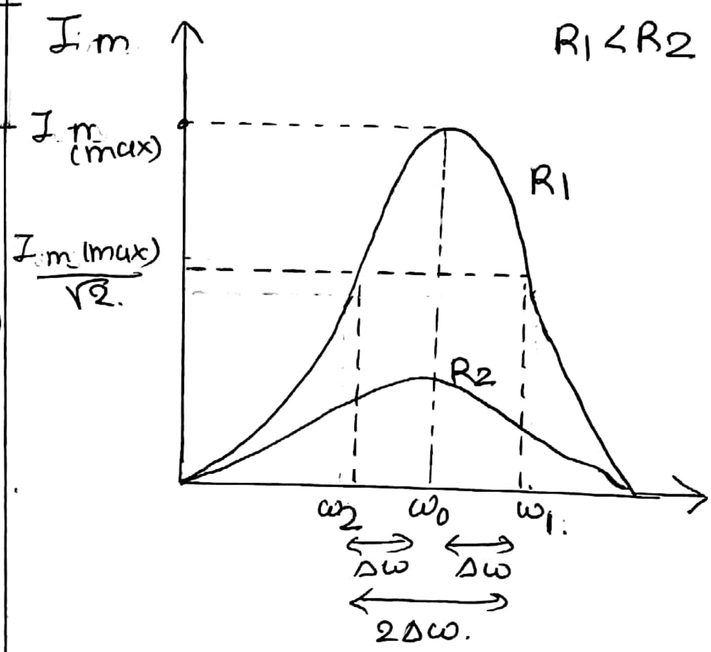
→ At resonance freq, current Amplitude is max. ($i_m = V_m/R$) ($\because Z = R$)

" For some value of ω, of given voltage, ⇒ we get maximum value of current i_{rms} is called as series Resonance."

USES :- (Resonance circuit)
→ in tuning mechanism of a radio or a tv set

Note :- Resonance is exhibited by a circuit only if both L&C are present.
i.e. RL & RC can't have resonance

* SHARPNESS OF RESONANCE —



- when $\omega = \omega_0 = \frac{1}{\sqrt{LC}}$, so current $(i_m)_{max} = \frac{V_m}{R}$ which is maximum.

- Here; $\omega_1 = \omega_0 + \Delta\omega$
  $\omega_2 = \omega_0 - \Delta\omega$

- Band width :- $\omega_1 - \omega_2 = 2\Delta\omega$ is called as Bandwidth.

- sharpness of Resonance : $= \frac{\omega_0}{(2\Delta\omega)} = \frac{R.f}{B.W.}$

→ B.W ↓ ⇒ sharpness ↑.

Half Power B-W :-

→ For any value of ω other than ω_0, current becomes $\frac{1}{\sqrt{2}}$ times of its maximum value.

⇒ power dissipated by ckt becomes half.

⇒ & B·W is called as (2Δ) Half power B·W.

($\because \omega_1 - \omega_2$ = Half P. B·W)

Q-Factor (Quality factor) :-

• Sharpness of curve is known by Q Factor.

→ $Q = \frac{\omega_0}{B\cdot\omega} = \frac{\omega_0}{2\Delta\omega}$ —— ①

→ $\boxed{\Delta\omega = \frac{R}{2L}}$ — ② (deriv^n NCERT page no. 250)

$\therefore$ ② in ① ⇒ $Q = \frac{\omega_0}{2\left(\frac{R}{2L}\right)} = \frac{\omega_0 L}{R}$

$\boxed{Q = \omega_0 \frac{L}{R}}$ or $\boxed{Q = \frac{1}{\omega_0 CR}}$

• sharp the resonance ⇒ selectivity of ckt is good.

• less sharp / wide ⇒ not good.

ie $\boxed{R\downarrow, L\uparrow \Rightarrow Q\uparrow \Rightarrow \text{selectivity}\uparrow}$

$$\boxed{Q = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR} = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

Note :-

• Good Tunning → sharp resonance & small b-w. & large Q

• $\frac{(i_{rms})_{max}}{\sqrt{2}} \rightarrow (i_{rms})_{max} \rightarrow \frac{(i_{rms})_{max}}{\sqrt{2}}$

⇓ ⇓ ⇓

$\frac{P_{max}}{2} \rightarrow P_{max} \rightarrow \frac{P_{max}}{2}$

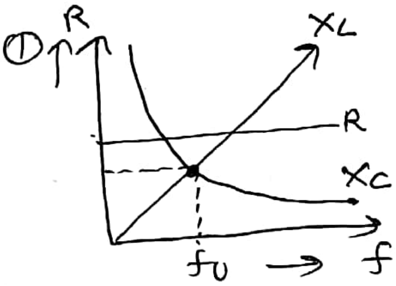
• $P_{max} = \frac{(i_m)^2_{max}}{2} R = (i_{rms})^2_{max} R$

• Q-Factor = $\frac{\text{Reso. freq. } (\omega_0)}{\text{B·W} \cdot (\Delta\omega)}$

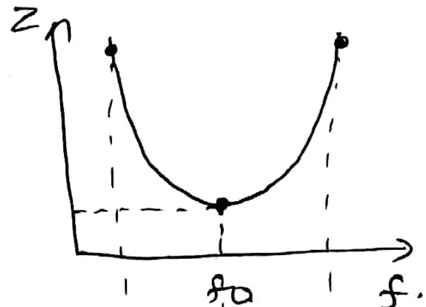
GRAPHS :-

$X_L = \omega L = 2\pi f L$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$.

① 

② $Z \rightarrow f$



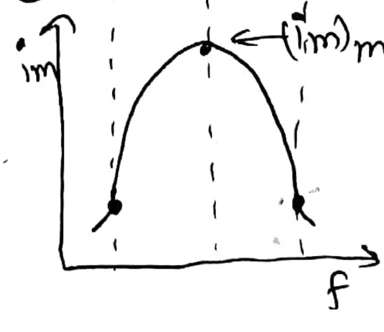
$\because Z = \sqrt{R^2 + (X_L - X_C)^2}$

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

i.e. f small ⇒ Z large

f large ⇒ Z large

③. $i_m \rightarrow f$,



At resonance power is also max

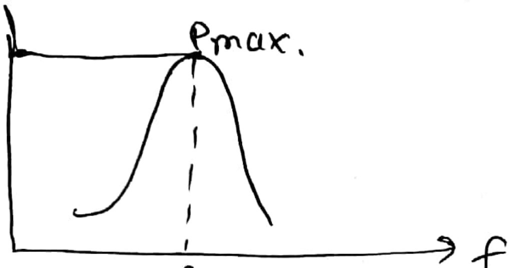
$P = V_{rms}\, i_{rms} \cos\phi$ ← 1 for R

$= \frac{V_m}{\sqrt{2}} \frac{i_m}{\sqrt{2}} (1)$

$P = \frac{(i_m)_{max} R \times (i_m)_{max}}{2}$

$\boxed{P_{max} = \frac{(i_m)^2_{max} \times R}{2}}$

$\boxed{P = (i_{rms})^2_{max} R}$



(1) At resonance, $Z_{min} = R$,

✓ $i_{0max} = V_0/R$,

✓ i & v are in phase.
(∵ it's becomes purely R.ckt)

✓ $P \to max = i_{rms}^2 R = \frac{i^2_{m\,max} \times R}{2}$

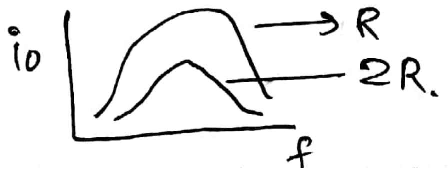
(2) Reso. freq. $\omega_0 = \frac{1}{\sqrt{LC}}$, $f_0 = \frac{1}{2\pi\sqrt{LC}}$

$\therefore X_L = X_C$

✓ The resonant freq. can be changed by changing values of C & L.

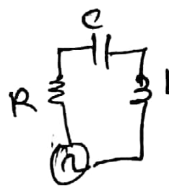
✓ There is no effect on f_0/ω_0 by value of R.

✓ R affects $(i_0)_{max}$.



Radio Tuning :-

- Antenna of radio catches (fig.a) all signals (e.m.s) from atmosphere.



- To select some channel,

→ Rotate Radio knob

⇓

adjust value of C or L

⇓

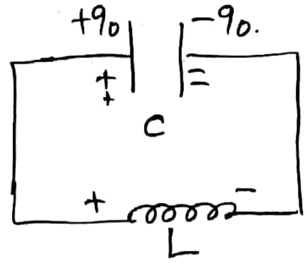
so, we adjust reso. freq. fo.

* Power in AC circuit :-
(NCERT P.no. 252)

* L-C OSCILLATION :-

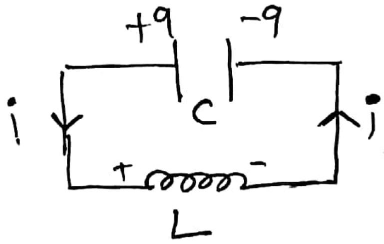
- capacitor can store Electrical Energy & Inductor → Mag. E.
- when fully charged C is connected to inductor, the charge on C & i in ckt starts electrical oscillations.
- consider capa. is fully charged & connected to inductor } q_m

($t=0 \Rightarrow q = q_m$)



- when ckt completed q starts ↓ & i starts ↑.

- at time $t \Rightarrow t$, $q = q$, $i = i$.



Now; applying KVL:

$\therefore +V_C - V_L = 0$

$\therefore \boxed{\frac{q}{C} - \left[L\frac{di}{dt}\right] = 0.}$ —— (1)

Here; $\boxed{i = -\frac{dq}{dt}}$ (charge decreases) —— (2)

→ Put (2) in (1):-

$\therefore \frac{q}{C} - L\left(-\frac{d^2q}{dt^2}\right) = 0$

$\therefore \frac{q}{C} + L\frac{d^2q}{dt^2} = 0.$

$\div L$ $\boxed{\frac{d^2q}{dt^2} + \frac{q}{LC} = 0}$ —— (3)

→ comparing above Eq^n. with Eq^n of S.H. oscillator

$\boxed{\frac{d^2x}{dt^2} + \omega_0^2 x = 0.}$

→ we get; $\boxed{\omega_0^2 = \frac{1}{LC}}$

$\therefore \omega_0 = \frac{1}{\sqrt{LC}}$

→ Now; solution of Eq^n (3) is of the form

$[q = q_m \cos(\omega_0 t + \phi)]$

→ where; q_m = Max value of q.

$t=0 \Rightarrow q = q_m$ i.e $\phi = 0$.

i.e $\boxed{q = q_m \cos(\omega_0 t)}$

→ $i = -\frac{dq}{dt} = -\frac{d}{dt}(q_m \cos\omega_0 t)$

$= -q_m\omega_0(-\sin\omega_0 t)$

$\boxed{i = q_m\omega_0 \sin\omega_0 t}$

$\boxed{i = i_m \sin\omega_0 t}$

where; $i_m = q_m\omega_0$

NCERT- p.no. 256.

Q.1 Analogies b/w Mechanical & Electrical Quantities

Q.2 Transformer. (p.no. 259)

Q.3 In actual transformer, due to which reasons Energy will losses? (p.261)

Q.4 In LC ckt, sum of Energy stored in ckt is const (p.no. 259) IMP.