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BY

Asst. Prof. Tarun Kumar Gautam

(B.Tech, M.Tech, PhD (P))

Currently working in Jamia Hamdard, (HSC), Delhi

Working on Nano Technology with Rise University, USA

Author of 8 books regarding Physics and Engineering Subject.

Ex-Faculty of Rajshree Institute of Management & Technology (RMIT), Braeilly, Uttar Prdesh

Ex-Faculty of Assistant professor in Krishna Engineering Collage (KEC), Ghaziabad, Uttar Prdesh
Member of Educational Project in University of Petroleum and Energy Studies (UPES), UK

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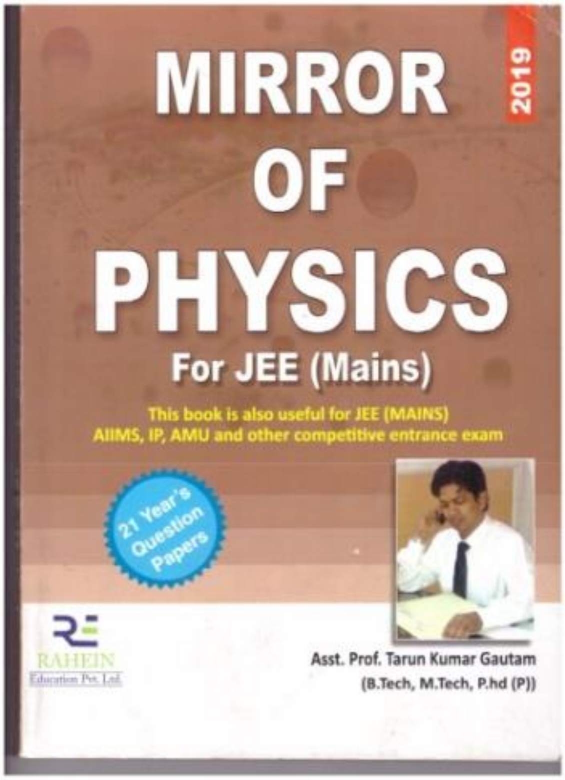

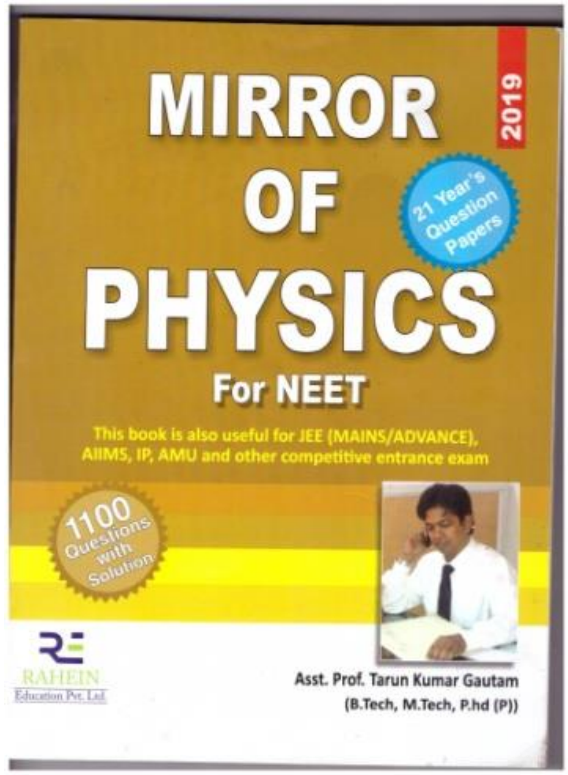

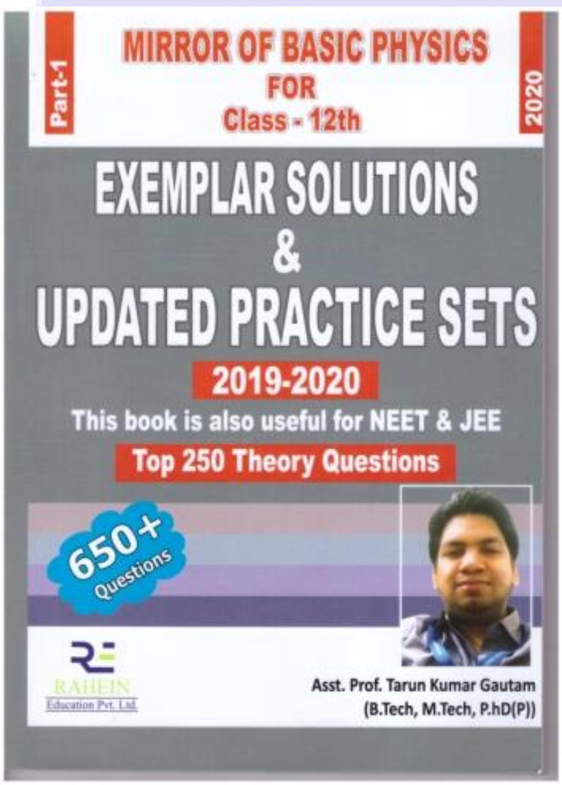

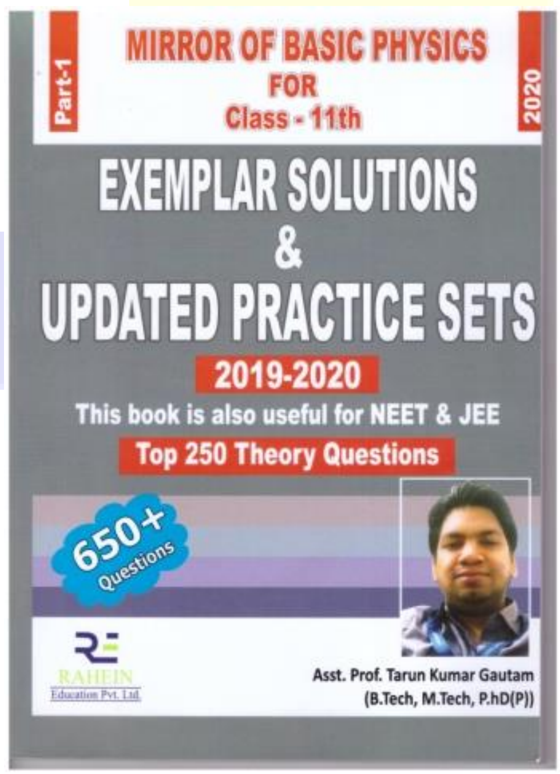

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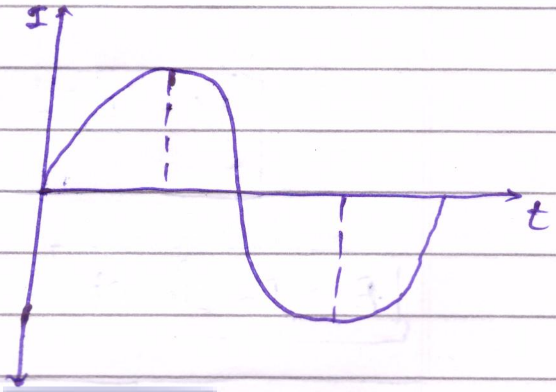
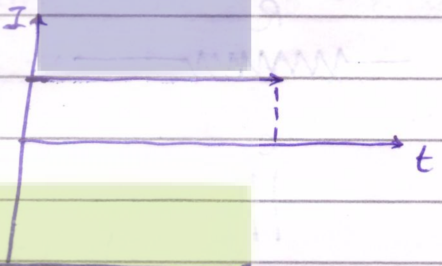
Chapter- 7

(Alternating Currents)

AC → Alternating Current
DC → Direct Current

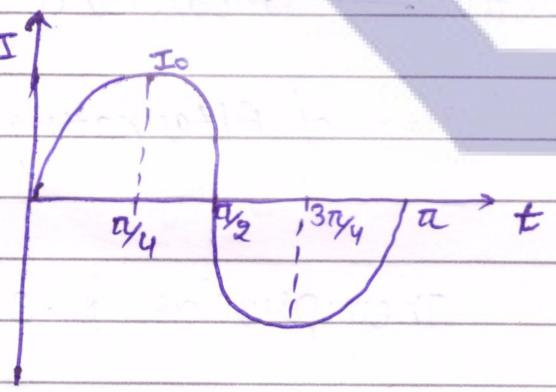


Current change with time is called "Alternating current."

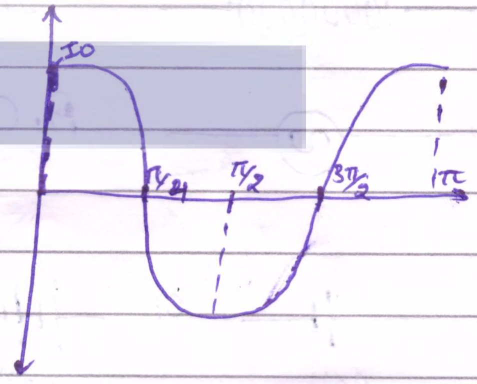


Current not change with time is called "Direct current"

$\boxed{I = I_0 \sin(\omega t)}$, $\boxed{I = I_0 \cos(\omega t)}$



$I = I_0 \sin\omega t$



$I = I_0 \cos\omega t$

$t = T/4$
$t = T/2$
$t = 3T/4$
$t = T$

$T \Rightarrow$ Time period

$t \rightarrow$ Instant time

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Here, $\omega = 2\pi\nu$ ← frequency

$\omega = 2\pi \frac{1}{T}$ ← Time period

$\boxed{V = E = \text{Potential / Emf}}$ $\boxed{V = E = IR}$

$\boxed{E = E_0 \sin\omega t}$, $\boxed{E = E_0 \cos\omega t}$

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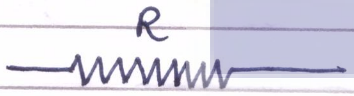
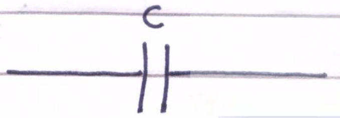
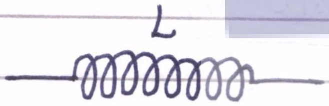
1. 

Resistor → Resistange

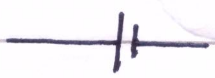
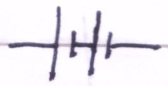
2. 

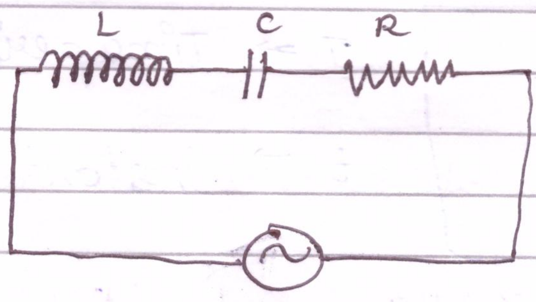
Capacitor → Capacitance

3. 

Inductor → Inductance

4. 
A.C (Sign of Alternating Current)

5. 
Cell
or

Battery
They provide D.C Current



LCR Circuit

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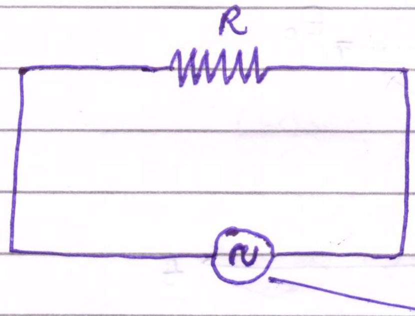
A·C Circuit with Resistance (R)



Applied Voltage

$$E = E_0 \sin \omega t$$

$$I \times R = E_0 \sin \omega t$$

$$I = \left[\frac{E_0}{R}\right] \sin \omega t$$

$$\boxed{I = I_0 \sin \omega t}$$

$I_0 \rightarrow$ max. current

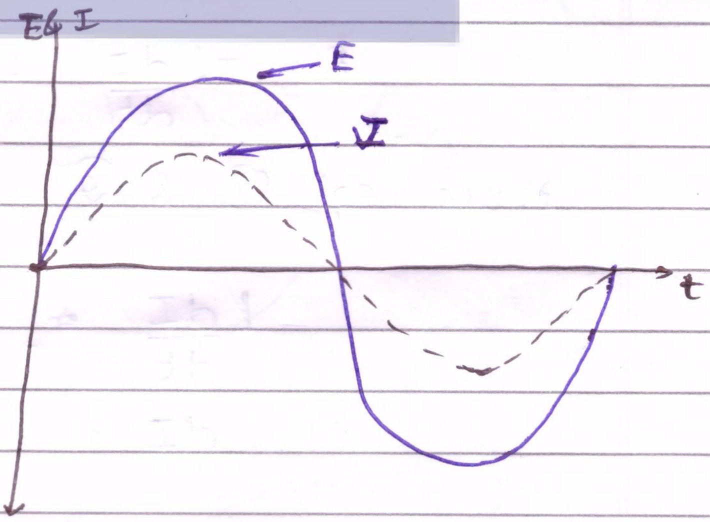
$E_0 \rightarrow$ max. voltage

Note $E = E_0 \sin \omega t$
$I = I_0 \sin \omega t$

Phase angle $[\phi = 0]$

Voltage & Current are in same phase.

graphical / wave diagram



- Amplitude of Current is less than the amp. of the Voltage
- Voltage on currents are impaired phase current each other in pure current.

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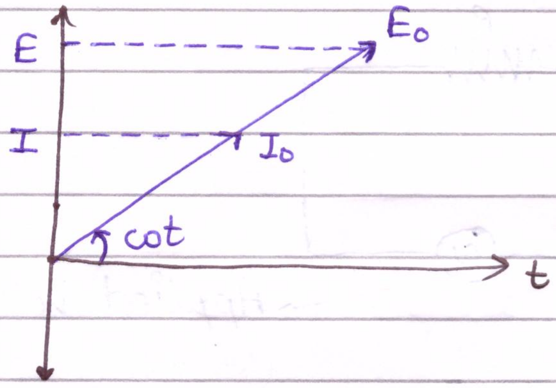
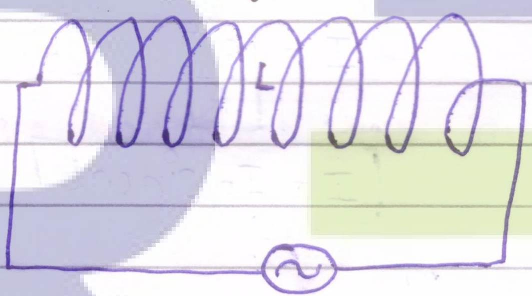
Phasor Diagram



A.C Circuit containing Inductance only



$$\boxed{E = E_0 \sin\omega t} \quad \text{---} (1)$$

Emf in Inductor

$$E = -L\frac{dI}{dt} \quad \text{---} (2)$$

From eq^n (1) & (2)

$$L\frac{dI}{dt} = E_0 \sin\omega t$$

$$dI = \frac{E_0}{L}\sin\omega t \, dt$$

Integrate both side

$$\int dI = \int \frac{E_0}{L}\sin\omega t \, dt$$

$$\int dI = \frac{E_0}{L}\int \sin\omega t \, dt$$

$$I = \frac{E_0}{L}\left(\frac{-\cos\omega t}{\omega}\right)$$

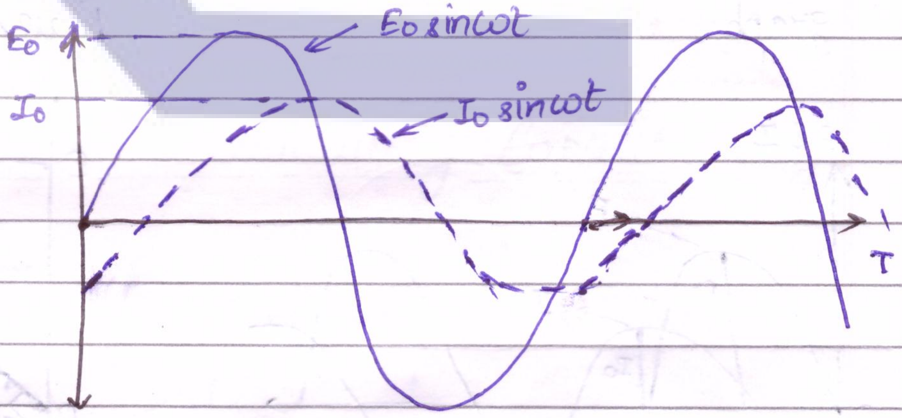
$$I = -\frac{E_0}{L}\left(\frac{\cos\omega t}{\omega}\right)$$

$$I = -\frac{E_0}{L\omega}\cos\omega t$$

Using the identity, $-\cos\omega t = \sin\left[\omega t - \frac{\pi}{2}\right]$

$$I = \frac{E_0}{L\omega}\sin\left[\omega t - \frac{\pi}{2}\right]$$

$$\boxed{I = I_0 \sin\left[\omega t - \frac{\pi}{2}\right]}$$



Inductive Reactance

$I = \frac{E_0}{L\omega}$, As, $E = IR$, $I = \frac{E}{R}$.

X_L is Inductive Reastance, $\boxed{X_L = \omega L}$

$$\boxed{X_L = 2\pi \nu L}$$

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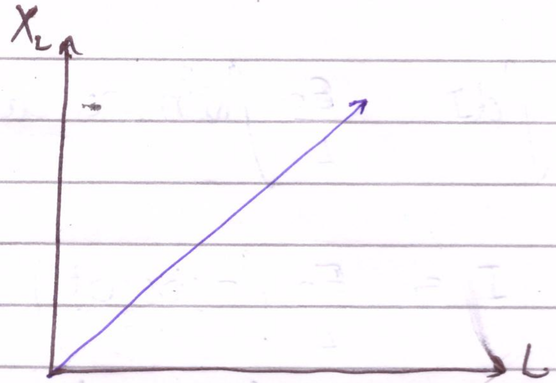


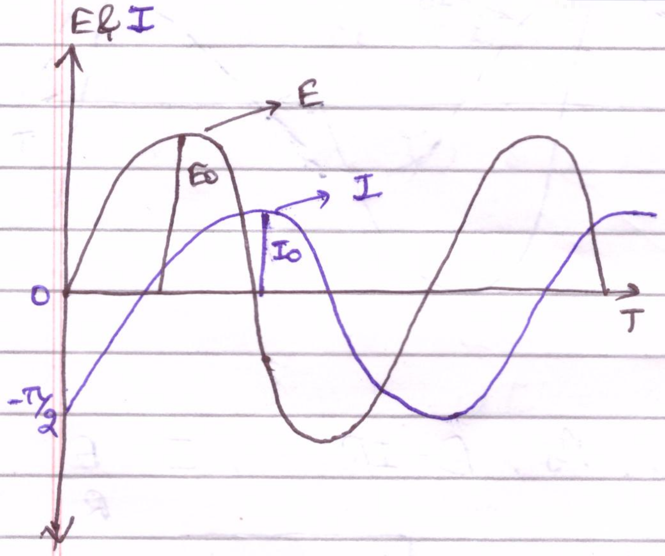
Note:

$$\left.\begin{array}{ll} ① & E = E_0 \sin\omega t \\ ② & I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right) \end{array}\right]$$

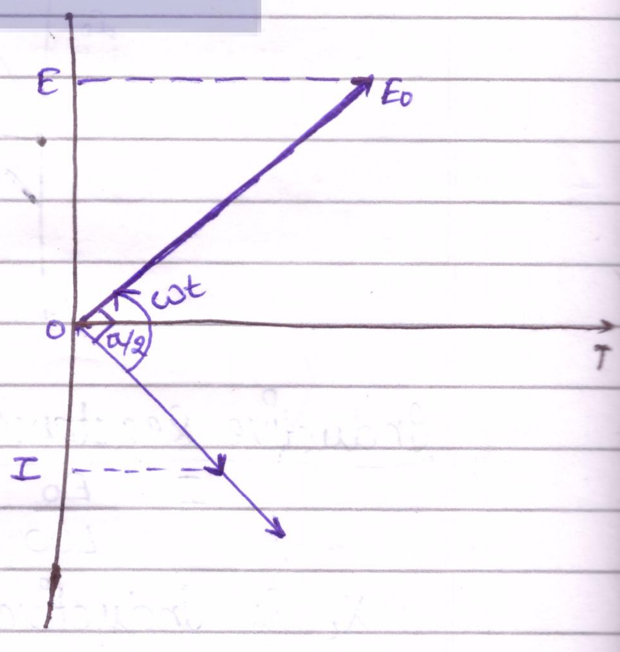
- Current is lag behind by $\frac{\pi}{2}$ from voltage.
- Voltage is lead by $\pi/2$ from current.

$$\boxed{\text{Phase difference} = \pi/2}$$

graph



Phase diagram

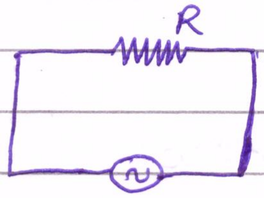


$X_L = \omega L$

Unit = ohm (Ω) = $H\,sec^{-1}$

(1) $E = E_0 \sin \omega t$

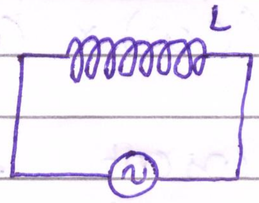
Resistance



$$\boxed{\begin{aligned} E &= E_0 \sin \omega t \\ I &= I_0 \sin \omega t \end{aligned}}$$

ϕ = phase angle $= 0$

Inductor



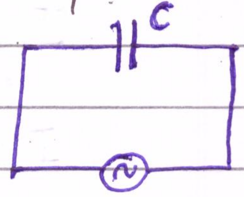
$$\boxed{\begin{aligned} E &= E_0 \sin(\omega t) \\ I &= I_0 \sin\left(\omega t - \frac{\pi}{2}\right) \end{aligned}}$$

phase angle, $\boxed{\phi = \frac{-\pi}{2}}$

$\boxed{X_L = \omega L}$

Inductive Reactance

Capacitor



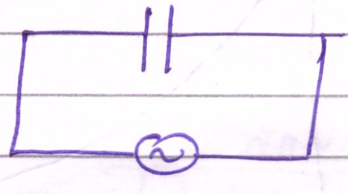
$$\boxed{\begin{aligned} E &= E_0 \sin(\omega t) \\ I &= I_0 \sin\left(\omega t - \frac{\pi}{2}\right) \end{aligned}}$$

phase angle $\rightarrow$ $\boxed{\phi = +\frac{\pi}{2}}$

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

Capacitative Reactance

A.C Circuit Containing Capacitor only.



$\rightarrow$ $Q = CV$

$V = \frac{Q}{C}$

$Q = C \times V = CE$

$Q = C \times E_0 \sin \omega t$

Differentiation both side

$$I = \frac{dQ}{dt} = \frac{d}{dt}(CE_0 \sin \omega t)$$

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$$I = CE_0 \frac{d}{dt}(\sin\omega t)$$

$$I = CE_0 \cos\omega t \times (\omega)$$

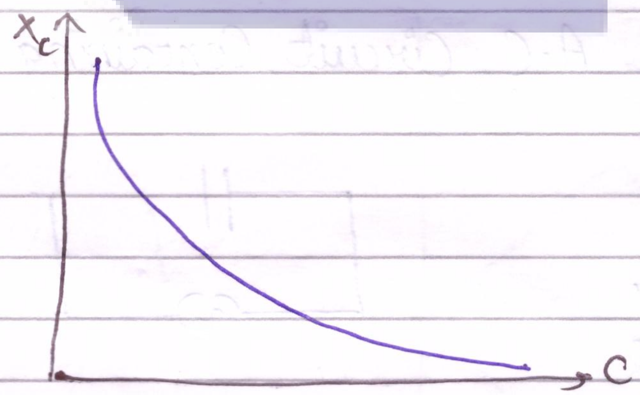
$$I = E_0 (C\omega) \times \cos\omega t$$

$$I = \frac{E_0}{1/C\omega} \cos\omega t \Rightarrow I_0 \cos\omega t$$

$$\boxed{I = I_0 \cos\omega t} \Rightarrow \boxed{I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)}$$

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

$\omega = 2\pi\nu$, $\boxed{X_C = \frac{1}{2\pi\nu \times C}}$



Note $E = E_0 \sin\omega t$

$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ $\boxed{\phi = +\frac{\pi}{2}}$

Current lead by $\pi/2$ for voltage.

Voltage lag behind $\pi/2$ for current.

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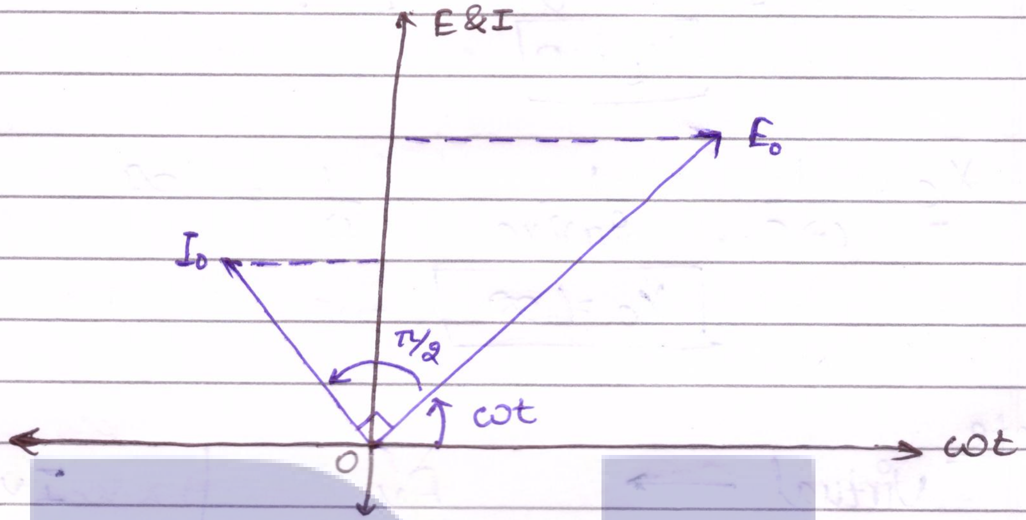
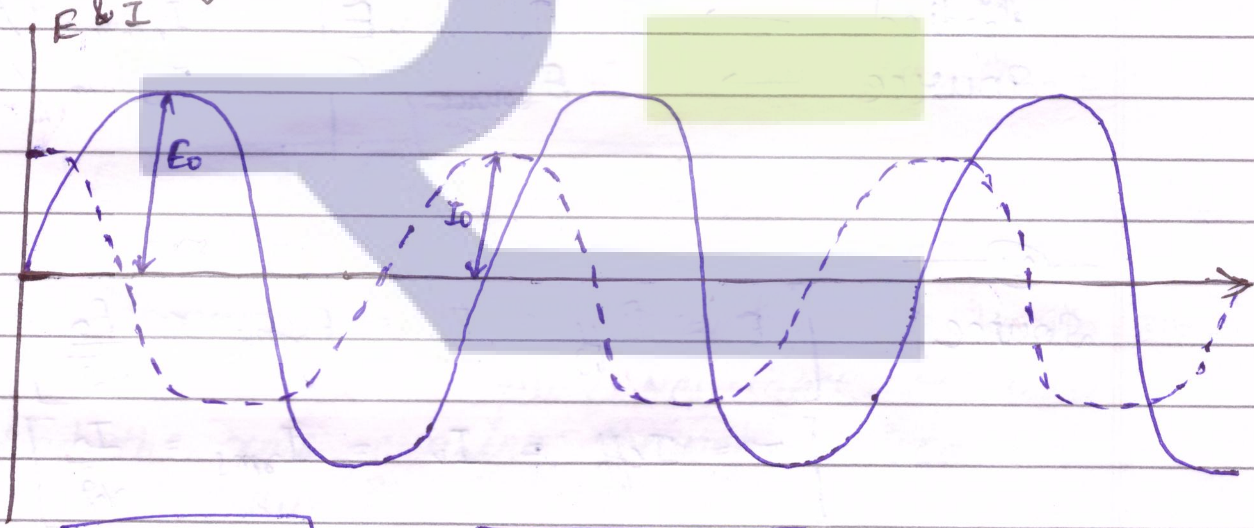
Graphical Representation



Phase Diagram



$$\boxed{X_c = \frac{1}{\omega C}} \qquad \boxed{X_c = \frac{1}{2\pi\nu \times C}}$$

Unit

$$\Omega = \frac{1}{sec^{-1} f} \Rightarrow \boxed{\Omega = sec\, f^{-1}}$$

Unit $\boxed{\Omega = sec\, f^{-1}}$

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DC circuit $\rightarrow$ $\nu = 0$

$X_L = \omega L = 2\pi\nu \times L = 0$

$$\boxed{X_L = 0}$$

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu \times C} = \frac{1}{0} = \infty$

$$\boxed{X_C = \infty}$$

Note

Virtual $\longrightarrow$	E_v	I_v
root mean square $\rightarrow$	E_{rms}	I_{rms}
effecitive $\longrightarrow$	E_{eff}	I_{eff}
Applied $\longrightarrow$	$E_{applied}$, E	$I_{applied}$ / I
Source $\longrightarrow$	E_{source}, E	I_{source} / I

Source

$$\left[E = E_{eff} = E_v = E_{rms} = \frac{E_0}{\sqrt{2}} \right]$$

$$\left[I = I_{eff} = I_v = I_{rms} = \frac{I_0}{\sqrt{2}} \right]$$

Amplitude of Source

★ E_0 = Max. voltage / Potential Emf

★ I_0 = Max. current / current

Amplitude of current

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- Instantaneous voltage $\longrightarrow$ $E = E_0 \sin \omega t$
- Instantaneous current $\longrightarrow$ $I = I_0 \sin \omega t$

Ques What will be the Instantaneous voltage for A.C supply of 220 volt & at 50 heartz ?

Ans $E = 220$ volt , $\nu = 50$ Hz

$$E = \frac{E_0}{\sqrt{2}}$$

$$E_0 = \sqrt{2} \times E$$

$$E_0 = 220 \times \sqrt{2} = 311 \text{ volt}$$

$$E = E_0 \sin \omega t$$

$$E = 311 \sin (2\pi\nu \times t) = 311 \sin (2\pi \times 50 \times t)$$

$$\boxed{E = 311 \sin (100\pi t) \text{ volt}}$$

Ques An alternating voltage given by, $V = 140 \sin (314t)$ connected across a pure Resistance of $50\,\Omega$, find the rms current through Resistance ?

Ans $V = 140 \sin (314t)$

$\omega, 314 \Rightarrow 2\pi\nu = 3.14$

$V = V_0 \sin (314t)$

$\nu = \frac{3.14}{2\pi}$

$E_0 = I_0 \times R$, $E = 140$

$E_0 = IR \longrightarrow I_0 = \frac{E_0}{R} = \frac{14\cancel{0}}{5\cancel{0}} \Rightarrow \Big| \; I = \frac{I_0}{\sqrt{2}} = \frac{14}{\sqrt{2} \times 5}$

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Ques The Instantaneous Current from A.C source is $I = 9 \sin(314t)$ which in frequency of source & vitue value of current.

Ans

$$I = I_0 \sin \omega t$$

$$I = 10 \sin(314t)$$

$$\omega = 3.14$$

$$\boxed{\nu = \frac{1 \times 3.14}{2\pi} \text{ Hz}}$$

$$2\pi\nu = 3.14$$

$$I_0 = 10 \quad , \quad I_V = \frac{I_0}{\sqrt{2}}$$

$$\boxed{I_V = \frac{10}{\sqrt{2}}}$$

Ques $I_1 = 2A$, $I_2 = 3A$, $I_3 = 4A$, $I_4 = 5A$, find the root mean square value of current?

Ans

$$I = \sqrt{\frac{I_1^2 + I_2^2 + I_3^2 + I_4^2}{4}} \Rightarrow \sqrt{\frac{54}{4}} \text{ A}$$

Ques A light Bulb is rated at 100 watt for 220 volt supply five (a) Resistance of Bulb?
(b) Peak voltage of Source?
(c) r.m.s current through the Bulb?

Ans

$$\boxed{P = \frac{V^2}{R} = VI = I^2R}$$

$$\left[\because V = IR, \quad I = \frac{V}{R} \right]$$

(a) $R = \frac{V^2}{P} = \frac{220 \times (2)^2}{100} = 484\,\Omega$

(b) $E_v = \frac{E_0}{\sqrt{2}} \Rightarrow E_0 = E_v \times \sqrt{2} \Rightarrow 220\sqrt{2}$

(c) $P = EI \Rightarrow I = \frac{P}{E} = \frac{100}{220}$

$P = \frac{V^2}{R} \Rightarrow I^2R \Rightarrow VI \Rightarrow \frac{\omega}{t}$

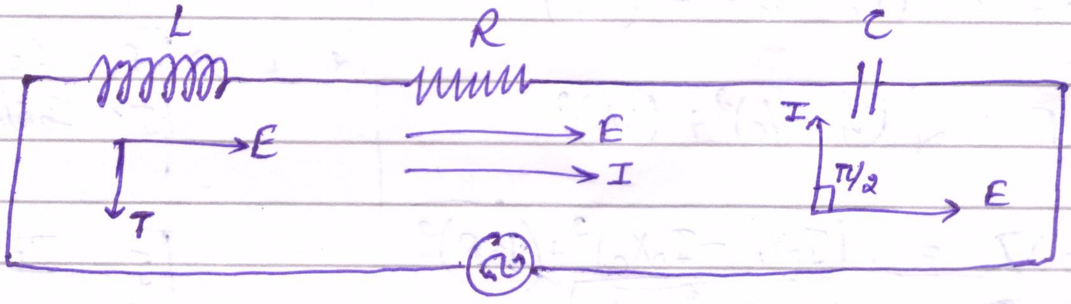
Note

- Resistance : $\longrightarrow$ V, I $\boxed{\begin{array}{l} E = E_0 \sin\omega t \\ I = I_0 \sin\omega t \end{array}}$

- Inductance : $\longrightarrow$ V, I $\boxed{\begin{array}{l} E = E_0 \sin(\omega t) \\ I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right) \end{array}}$

- Capacitor : $\longrightarrow$ V, I $\boxed{\begin{array}{l} E = E_0 \sin \\ I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right) \end{array}}$

AC Circuit containing LCR :



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Let, Applied Current I, $I = I_0 \sin(\omega t)$

max. voltage across Resistance (R)

$$\boxed{V_0 = I_0 R}$$

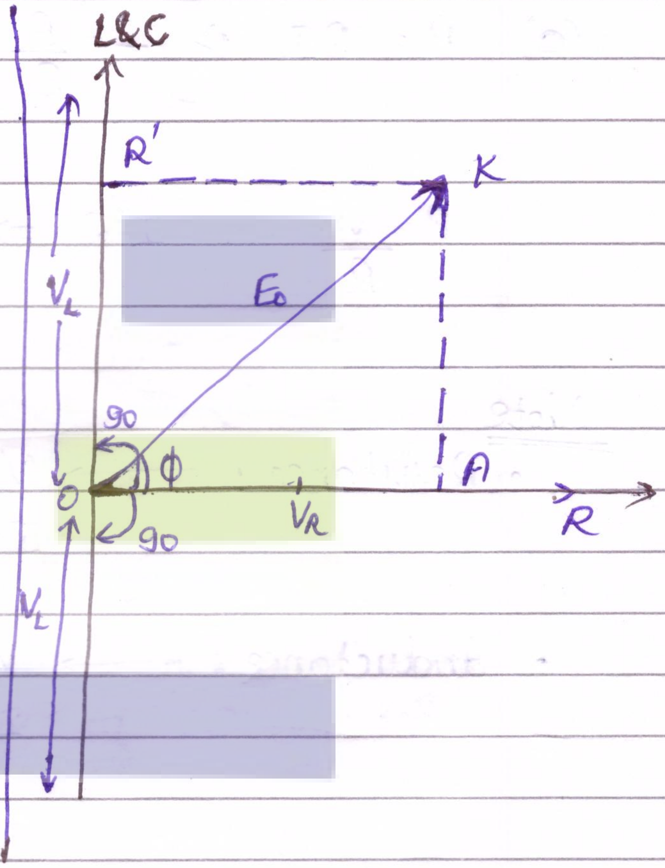
Voltage across Inductor lead current by $90°$

$$\boxed{V_L = I_0 \times L}$$

Voltage across capacitor lag behind by $90°$

$$\boxed{V_C = I_0 \times C}$$

Assume $L > C$



$$(OK)^2 = (KA)^2 + (OA)^2$$

$$E_0^2 = (B'O)^2 + (OA)^2$$

$$E_0^2 = (V_L - V_C)^2 + (V_R)^2$$

$$E = \sqrt{(V_L - V_C)^2 + (V_R)^2}$$

$$I_0 \times Z = \sqrt{(I_0 X_L - I_0 X_C)^2 + (I_0 R)^2}$$

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

Note

① $R \Rightarrow \boxed{\begin{array}{l} I = I_0 \sin \omega t \\ E = E_0 \sin \omega t \end{array}}$

② $L \Rightarrow \boxed{\begin{array}{l} E = E_0 \sin \omega t \\ I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right) \end{array}}$

$\boxed{\begin{array}{l} I = I_0 \sin \omega t \\ E = E_0 \sin\left(\omega t + \frac{\pi}{2}\right) \end{array}}$

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(3) C = $\boxed{\begin{array}{l} E = \underline{E_0 \sin \omega t} \\ I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right) \end{array}}$

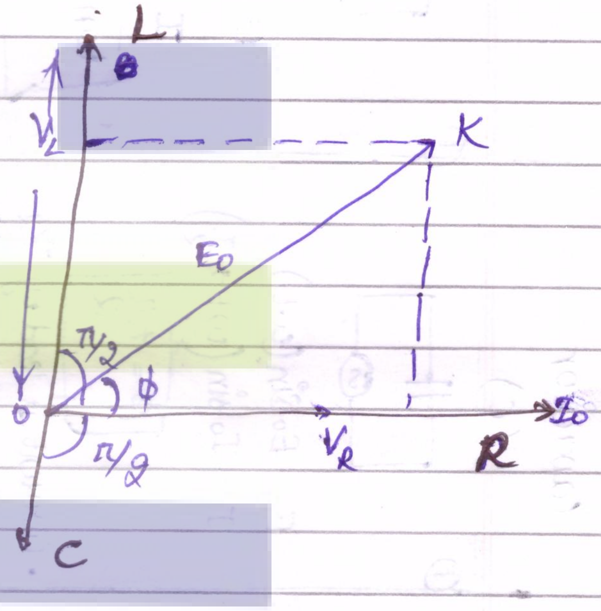
$\boxed{\begin{array}{l} I = \underline{I_0 \sin \omega t} \\ E = E_0 \sin\left(\omega t - \frac{\pi}{2}\right) \end{array}}$

$\tan\phi = \frac{KA}{OA}$

$\tan\phi = \frac{V_L - V_C}{V_R}$

$\tan\phi = \frac{I_0 X_L - I_0 X_C}{I_0 \times R}$

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



Resistance (R)

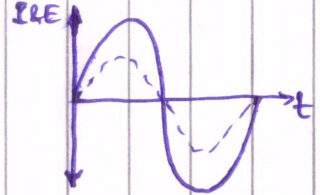
① 

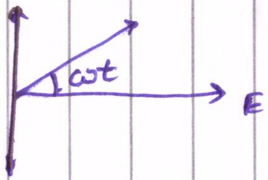
$E = E_0 \sin(\omega t)$

$I = I_0 \sin(\omega t)$

ϕ = phase angle = 0

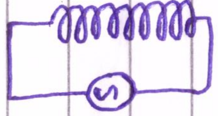
- Current & Voltage are in same phase





$V_R = IR$,

Inductance (L)

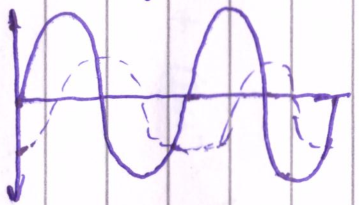
① 

$E = E_0 \sin(\omega t)$

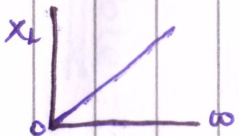
$I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

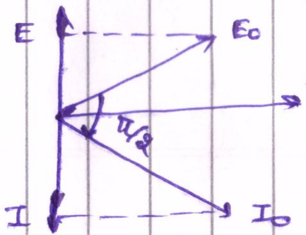
$\boxed{\phi = -\pi/2}$

- Current is lag behind by $\frac{\pi}{2}$ voltage is lead by $\frac{\pi}{2}$.

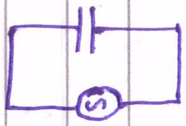


$\boxed{V_L = IX_L}$, $\boxed{X_\omega = \omega L}$





Capacitor (C)

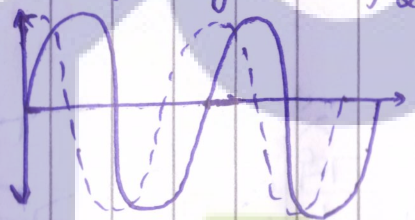
① 

$E = E_0 \sin(\omega t)$

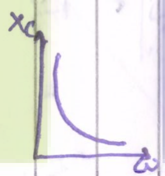
$I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

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

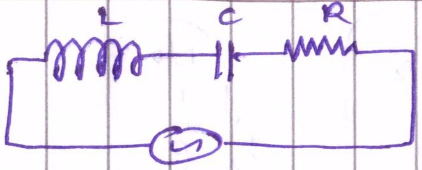
- Current is lead by $\pi/2$ voltage is lag behind by $\frac{\pi}{2}$



$\boxed{V_C = IX_C}$ $\boxed{X_C = \frac{1}{\omega C}}$



(LCR)

① 

$E = E_0 \sin(\omega t)$

$I = I_0 \sin(\omega t - \phi)$

$$\boxed{\tan\phi = \frac{X_L - X_C}{R} = \frac{V_L - V_C}{V_R}}$$

$V_{LCR} = IZ$, $\boxed{Z = \sqrt{R^2 + (X_L - X_C)^2}}$ $\boxed{Z = \text{Impedence}}$

$$\boxed{V_{LCR} = \sqrt{V_R^2 + (V_L - V_C)^2}}$$

Note

$V_{Eff} = E_V = E_{rms} = E_{Applied} = E_{source} = \frac{E_0}{\sqrt{2}}$ → Amplitude of volt/emf → Max volt./emf

$I_{Eff} = I_V = I_{rms} = I_{Applied} = I_{source} = \frac{I_0}{\sqrt{2}}$ → Max current → Amplitude of current

$P = E_v I_v \cos\phi$

$= E_v I_v (1)$

$\boxed{P = E_v I_v}$

Power factor $= \cos\phi$

$= \cos(0) = 1$

- $P = E_v I_v \cos\phi$

$= E_v I_v \cos 90 = 0$

$\boxed{P = 0}$

Power factor $= \cos(-90)$

$= 0$

- $P = E_v I_v \cos 90$

$= E_v I \cos 90 = 0$

$\boxed{P = 0}$

Power factor $= \cos(90)$

$= 0$

$\boxed{\text{Power}}$ * $P = E_v I_v \cos\phi$.

① $\cos\phi$ = Power factor $= \frac{R}{Z}$

$$\boxed{\cos\phi = \frac{R}{\sqrt{R^2 + (X_L - X_C)^2}}}$$

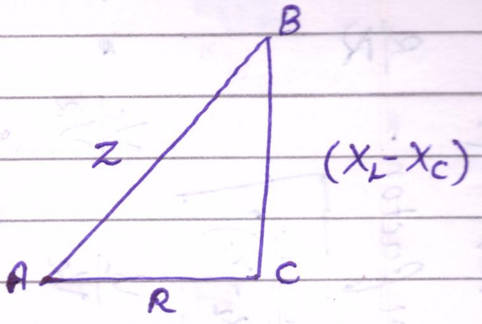
② Quality-factor $= \frac{V_L}{V_R} = \frac{V_C}{V_R} = \frac{1}{R}\sqrt{\frac{L}{C}}$

③ Resonance $= X_L = X_C$, $\boxed{\nu = \frac{1}{2\pi\sqrt{LC}}}$

Resonace frequency

Note : Impedence Triangle

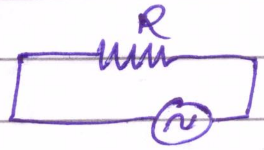
(i) $Z = \sqrt{R^2 + (X_L - X_C)^2}$, $\tan\phi = \frac{X_L - X_C}{R}$



Note :

(i) Resistance (Non-Inductive ckt)

$X_L = X_C = 0$



(ii) If $\boxed{X_L > X_C}$ ⟶ Inductance Dominating ckt

If $\boxed{X_L < X_C}$ ⟶ Capacitance Dominating ckt

Note :

$Z = \sqrt{R^2 + (X_L - X_C)^2}$, $P = E_v I_v \cos\phi$

$V = \sqrt{V_R^2 + (V_L - V_C)^2}$, $\cos\phi = \frac{R}{Z}$

LR : ⟶ C = 0

$Z = \sqrt{R^2 + X_L^2}$, $V = \sqrt{V_R^2 + V_L^2}$

RC : ⟶ L = 0

$Z = \sqrt{R^2 + X_C^2}$, $V = \sqrt{V_R^2 + V_C^2}$

LC : ⟶ R = 0

$Z = \sqrt{(X_L - X_C)^2}$, $V = \sqrt{(V_L - V_C)^2}$

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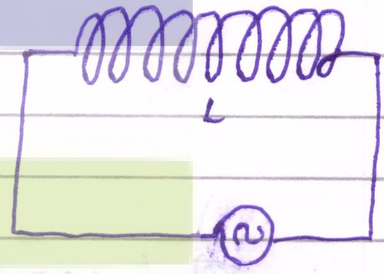
- **Note:**

$$P = \frac{dw}{dt} = EI$$

Energy stored in Capacitor

$$\boxed{E = \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C}}$$

Energy Stored in Inductor



Let emf (e) induced in Inductance.

$$E = -L\frac{dI}{dt}$$

Power : $P = \frac{dw}{dt} = EI$

Let 'dw' is small workdone

$$\frac{dw}{dt} = EI$$

$$dw = EI \cdot dt$$

$$dw = \left(-L\frac{dI}{\cancel{dt}}\right) I \cdot \cancel{dt}$$

$$dw = -LIdI$$

Integration both side

$$\int dw = -L\int IdI$$

$$w = L\left[\frac{I^2}{2}\right] \Rightarrow \boxed{w = \frac{1}{2}LI^2}$$

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Ques 1.5 mH Inductor in Circuit stores a maximum energy of 14 μJ. What is peak current?

Soln Given, $L = 1.5\,mH$
$= 1.5 \times 10^{-3} H$

$E = 14\,\mu J \Rightarrow 14 \times 10^{-6} J$

As we, know,

$$\boxed{W = \frac{1}{2} L I^2}$$

$$14 \times 10^{-6} = \frac{1}{2} \times 1.5 \times 10^{-3} \times I^2$$

$$I^2 = \frac{14 \times 10^{-6} \times 2 \times 10}{15 \times 10^{-3}}$$

$$I = \sqrt{\frac{28 \times 10^{-2}}{15}}$$

And we know, $I = \frac{I_0}{\sqrt{2}}$

$$I_0 = I \times \sqrt{2}$$

$$= \sqrt{\frac{28 \times 2 \times 10^{-2}}{15}} \quad \text{Ans}$$

Ques 1.5 mH Inductor in Circuit stores energy of 14 μJ.

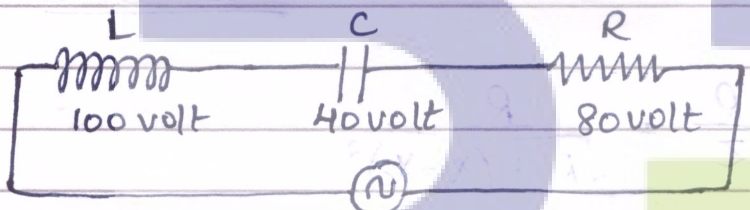
Power Factor ($\cos\phi$) of an A.C

Power Factor is ratio of True power to apperent power.

$$\boxed{\cos\phi = \frac{\text{True Power}}{\text{Apparent Power}} = \frac{P}{E_v I_v}}$$

$$\boxed{\cos\phi = \frac{R}{Z} = \frac{R \times I}{Z \times I} = \frac{V_R}{V_Z}}$$

Ques



Find the Power factor?

Solu $V_R = 80$ volt , $V_L = 100$ volt , $V_C = 40$ volt

$$V_Z = \sqrt{V_R^2 + (V_L - V_C)^2} = \sqrt{(80)^2 + (100-40)^2}$$

$$\cos\phi = \frac{V_R}{V_Z} = \frac{80}{\sqrt{(80)^2 + (60)^2}} \Rightarrow \frac{8\cancel{0}}{10\cancel{0}} = \boxed{\frac{4}{5}} \text{ Ans}$$

Ques In RL circuit Potential difference across Inductor (L) is 120 volt & potential difference across Resistance (R) is 90 volt. If rms value of current is 3A. What is Impedence of circuit & what is phase angle b/w voltage & Current?

Solu $V_L = 120$ volt , $V_R = 90$ volt

$I = 3A$

As we know,

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

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In RL circuit, $V_c = 0$

$$V = \sqrt{V_R^2 + V_L^2}$$

$$V = \sqrt{(120)^2 + (90)^2} = \underline{150 \text{ volt}}$$

and $\boxed{V = IZ}$

$$Z = \frac{V}{I} = \frac{\cancel{150}^{37.5}}{\cancel{4}} \Rightarrow \boxed{37.5} \text{ Ans}$$

$$\underline{Z = 37.5}$$

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

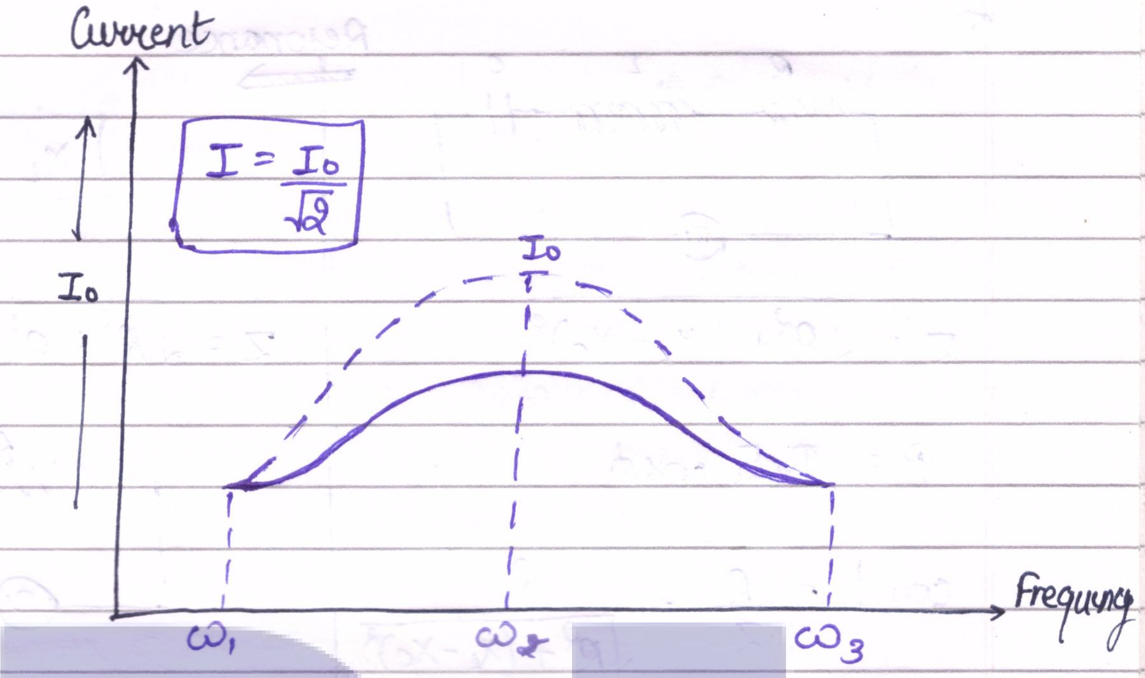
$$\boxed{\tan\phi = \frac{V_R}{V}}$$

Resonance

- It is phenomenon of Resonance is common among a system that have tendency to oscillate at particular frequency called "Natural frequency of oscillation of system."
- If such a system in which a frequency is equal to natural frequency, the amplitude of oscillating become large called Resonance.

at Resonance,

$$\boxed{\text{Applied Frequency} = \text{Natural frequency}}$$



at Resonance

$$X_L = X_C$$

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

$$\omega^2 = \frac{1}{LC}$$

$$(2\pi\nu)^2 = \frac{1}{LC}$$

$$\nu^2 = \frac{1}{4\pi^2 LC}$$

$$\nu = \sqrt{\frac{1}{4\pi^2 LC}}$$

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

Resonance frequency

Note

1) $X_L = X_C$

$X_L = \omega L$, Resonance frequency is

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

$$\boxed{\nu = \frac{1}{2\pi} \times \frac{1}{\sqrt{LC}}}$$

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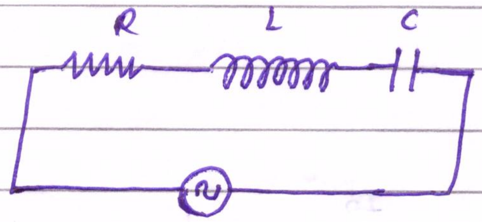
(1)

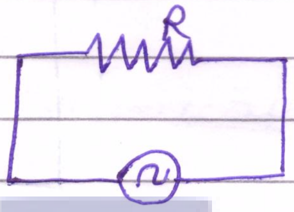
AT Resonance



$$\boxed{X_L = X_C}$$

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

$$Z = \sqrt{R^2 + 0^2}\ ,\quad \underline{Z = R}$$



$$P = I_v E_v \cos\phi$$

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

$\rightarrow \cos\phi = 1$

$$\boxed{\phi = 0}$$

$\longrightarrow P = E_v I_v$

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

$$\boxed{P = \frac{E_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}} = \frac{E_0 I_0}{2}}$$

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

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

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$\boxed{V = V_R}$$

Quality factor [sharpness of resonance]

→ It is ratio of voltage dress Inductor or capacitor to applied voltage across R.

$$Q\cdot F = \frac{V_L \text{ or } V_C}{V_R}$$

$$Q\cdot F = \frac{V_L}{V_R} \qquad\qquad Q\cdot F = \frac{V_C}{V_R}$$

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$$Q\cdot F = \frac{V_L}{V_R}$$

$$Q\cdot F = \frac{\cancel{I}X_L}{\cancel{I}R} = \frac{\omega L}{R}$$

$$Q\cdot F = \frac{1}{\sqrt{LC}} \times \frac{L}{R} \Rightarrow \frac{1}{R}\sqrt{\frac{L^2}{LC}}$$

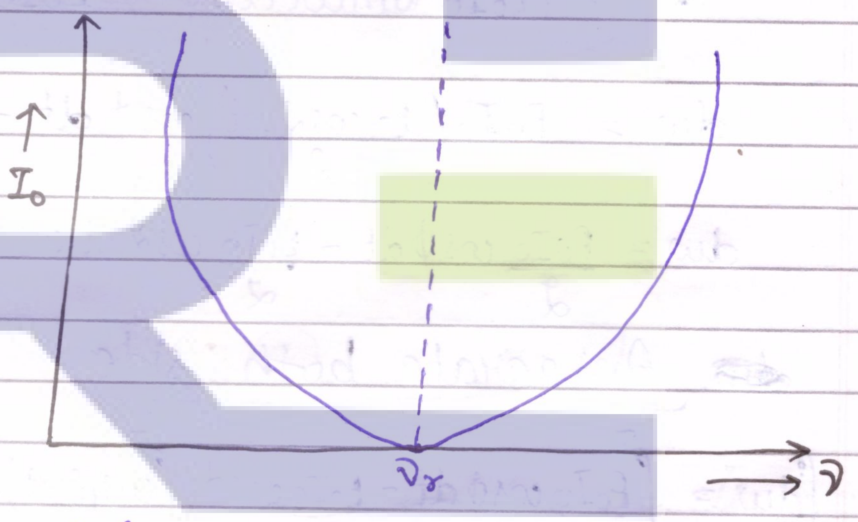
$$\boxed{Q\cdot F = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

$$Q\cdot F = \frac{V_C}{V_R}$$

$$Q\cdot F = \frac{\cancel{I}X_C}{\cancel{I}R} = \frac{1}{\omega C} \times \frac{1}{R}$$

$$\boxed{Q\cdot F = \frac{1}{\frac{1}{\sqrt{LC}} \times C \times R} = \frac{1}{R}\sqrt{\frac{L}{C}}}$$

graph



ν_r = Resonant frequency,

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

Average Power in LCR circuit (Inductive circuit)

Let, Applied emf to LCR circuit is E & $E = E_0 \sin(\omega t)$ & current in long behind the applied emf by phase angle (ϕ) $\boxed{E = E_0 \sin(\omega t)}$

$$\boxed{I = I_0 \sin(\omega t - \phi)}$$

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$$P = \frac{dw}{dt} = EI$$

$\rightarrow$ dw = small workdone

$$dw = EI\,dt$$
$$dw = (E_o \sin\omega t)(I_o \sin(\omega t - \phi))\,dt$$
$$dw = E_o I_o (\sin\omega t)(\sin(\omega t - \phi))\,dt$$
$$dw = E_o I_o (\sin\omega t)(\sin\omega t \cos\phi - \cos\omega t \sin\phi)\,dt$$

$$dw = (E_o I_o \sin^2\omega t \cos\phi - E_o I_o \sin\omega t \cos\omega t \sin\phi)\,dt$$

$$dw = E_o I_o \left(\frac{1-\cos 2\omega t}{2}\right)\cos\phi\,dt - E_o I_o \left(\frac{2 \times \sin\omega t \cos\omega t}{2}\right)\sin\phi\,dt$$

$$dw = \frac{E_o I_o}{2}\cos\phi\,dt - \frac{E_o I_o}{2}\cos 2\omega t \cos\phi\,dt - E_o I_o\left(\frac{\sin 2\omega t}{2}\right)\sin\phi\,dt$$

Integrate both side

$$\int dw = \int_0^T \frac{E_o I_o}{2}\cos\phi\,dt - \frac{E_o I_o \cos\phi}{2}\int_0^T \cos(2\omega t)\,dt - \frac{E_o I_o}{2}\sin\phi \int_0^T \sin 2\omega t\,dt$$

$$w = \frac{E_o I_o}{2}\cos\phi\,[T]_0^T - \frac{E_o I_o}{2}\cos\phi\left[\frac{\sin 2\omega t}{2\omega}\right]_0^T - \frac{E_o I_o}{2}\sin\phi\left[-\frac{\cos 2\omega t}{2\omega}\right]_0^T$$

$$w = \frac{E_o I_o}{2}\cos\phi\,[T-0] - \frac{E_o I_o \cos\phi}{2 \times 2\omega}[\sin 2\omega T - \sin 2\omega(0)] - \frac{E_o I_o \sin\phi}{2\;2\omega}[-\cos 2\omega T + \cos 2\omega(0)]$$

$$w = \frac{E_o I_o}{2}\left[\cos\phi \cdot T - \frac{\cos\phi}{2\omega}[\sin 4\pi] + \frac{\sin\phi}{2\omega}[\cos 4\pi - 1]\right]$$

$$w = \frac{E_o I_o}{2}\left[T\cos\phi - \frac{\cos\phi}{2\omega}(0) + \frac{\sin\phi}{2\omega}[1-1]\right]$$

$\rightarrow \boxed{W = \frac{E_0 I_0}{2} T\cos\phi}$

Here $P = \frac{W}{T} \Rightarrow \frac{E_0 I_0 \times \cancel{T}\cos\phi}{2\times\cancel{T}}$

$\boxed{P = \frac{E_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}} \cos\phi} \Rightarrow \boxed{P = E_v I_v \cos\phi}$

In, $\boxed{P = E_v I_v \cos\phi}$

If, $\phi = 0 \longrightarrow$ R $\quad \boxed{P = E_v I_v}$

$\phi = -90^\circ \longrightarrow$ L $\quad \boxed{P = 0}$

$\phi = +90^\circ \longrightarrow$ C $\quad \boxed{P = 0}$

Ques The Instanteneous emf of A.C source is $\mathcal{E} = 300 \sin 314 t$. What is rms value of emf?

Ans $E = 300 \sin 314 t$

comparing with, eqn $E = E_0 \sin \omega t$

then, $E_0 = 300$

$\omega = 314$

As we know, $\omega = 2\pi\nu$

$314 = 2\pi\nu$

$\nu = \frac{314}{2\pi}$

and, $E = \frac{E_0}{\sqrt{2}} \Rightarrow \frac{300}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}}$

$E_{rms} = 150\sqrt{2}$

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Ques In Instanteneous current of AC, $I = 5\sin(3/4)t$. What is rms value of current?

Ans $I = 5\sin(3/4)t$

comparing by eqⁿ, $I = I_0 \sin\omega t$

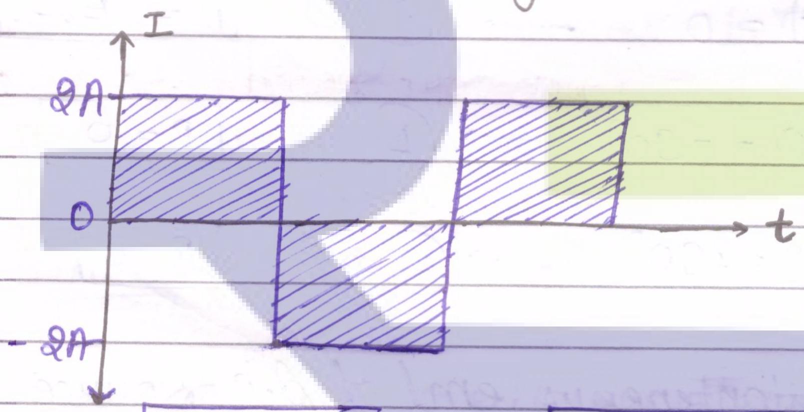
we get,

$\underline{I_0 = 5}$, $\underline{\omega = 3/4}$

As we know,

$I_{rms} = \frac{I_0}{\sqrt{2}} \Rightarrow \underline{\frac{5}{\sqrt{2}} \text{ Ampere}}$

Ques Calculate the Alternating Current;



Ans $I_{rms} = \sqrt{\frac{I_1^2 + I_2^2 + I_3^2}{3}} = \sqrt{\frac{(2)^2 + (-2)^2 + (2)^2}{3}} = \sqrt{\frac{4+4+4}{3}}$

$= \sqrt{\frac{12}{3}} = \sqrt{4} = \underline{2 \text{ Ampere}}$

Ques A pure Inductor of 25mH is connected to a source of 270 volt, find the Inductive reactance and rms current in circuit if frequency of source is 50Hz?

Ans $L = 25mH \Rightarrow 25 \times 10^{-3} H$,

$E_{rms} = 220$ volt , $\nu = 50Hz$

(i) → $X_L = \omega L$

→ $X_L = (2\pi\nu)L$

$= 2 \times \frac{22}{7} \times 50 \times 25 \times 10^{-3} \Rightarrow \frac{\cancel{2} \times \cancel{22}^{11}}{7} \times \frac{\cancel{50} \times \cancel{25}}{\cancel{1000}_{4\ 2}} = \frac{55}{7}$

$= \frac{55}{7} \Rightarrow \underline{7.8571}$

(ii) $E_{rms} = I_{rms}(X_L)$

$\frac{E_{rms}}{X_L} = I_{rms}$

$\boxed{\frac{220}{X_L} = I_{rms}} \Rightarrow \frac{\cancel{220}^{20}}{\cancel{55}_{11}} \times 7 \Rightarrow \underline{12.7272}$

Ques Find the maximum value of current when: an Inductance of one henry is connected to an A.C source of 200 volt, 50Hz.

Ans $\nu = 50Hz$, $E = 200$ volt, $L = 1H$

$E_{rms} = IX_L$

$I = \frac{E_{rms}}{X_L} = \frac{200}{\omega L} \Rightarrow \frac{200}{2\pi\nu L}$

$= \frac{\cancel{200}^{\cancel{100}\,2} \times 7}{\cancel{2} \times \cancel{22}_{11} \times \cancel{50}} = \underline{0.6363}$

$I_0 = I \times \sqrt{2} \Rightarrow \frac{7\sqrt{2}}{11} \Rightarrow \boxed{\frac{7\sqrt{2}}{11} A}$

$I_0 = \frac{7}{11} \times 1.41 \Rightarrow \frac{9.87}{11} \Rightarrow \boxed{0.8972\ A}$

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Ques A coil has an Inductance of 1H
(i) At what frequency will it have a reactance of 3124Ω
(ii) what should be capacity of a capacitor which has the same reactance at that frequency?

Ans (i) $L = 1H$

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

$3124 = 2\pi\nu(1)$

$\nu = \frac{3124 \times 7}{2 \times 22} = \frac{21,868}{44} \Rightarrow 497\ Hz$

(ii) $X_L = X_C$ (same reactance), $C = ?$

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

$C = \frac{1}{2\pi\nu \times X_C} \Rightarrow \frac{7}{2 \times 22 \times 497 \times 3124} = \frac{7}{68315632}$

$= \frac{7}{6.9 \times 10^7} \Rightarrow 1.01 \times 10^{-7} f$

Ques A 1.50 uf capacitor is connected to a 22volt, 50Hz source, find the capacitive reactance & current (rms & peak) in circuit. If the frequency is doubled what happens to capacitive reactance and current?

Ans Given, $C = 1.50\ uf$, $E = 22 volt$, $\nu = 50\ Hz$

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

$X_C = \frac{7}{2 \times 22 \times 50 \times 1.50} \Rightarrow \frac{7}{3300} = 0.00212$

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As we know, $E = IX_c$

$$22 = I \times X_c$$

$$I_{rms} = \frac{22}{X_c} \Rightarrow \frac{22}{\cancel{7}} \times \frac{\cancel{3300} \times 7}{3300}$$

$$= \cancel{10.3711/4.2816\ A} \Rightarrow \underline{0.0466\ A}$$

$$I_0 = I_{rms} \times \sqrt{2}$$

$$= 0.466 \times \sqrt{2}$$

$$= \underline{0.6505}$$

If frequency is doubled then, $\nu' = 2\nu$

$$X_c' = \frac{1}{2\pi\nu' \times C} \Rightarrow \frac{1}{2\pi(2\nu) \times C}$$

$$\boxed{X_c' = \frac{1}{2} X_c}$$

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