PARISHRAM

2026

Lecture -01

Alternating Current

PHYSICS Lecture - 1

BY - RAKSHAK SIR

Topics *to be covered*

1. Average and RMS Value of AC
2.
3.

Unit-III	**Magnetic Effects of Current and Magnetism**	17
	Chapter–4: Moving Charges and Magnetism	
	Chapter–5: Magnetism and Matter	
Unit-IV	**Electromagnetic Induction and Alternating Currents**	
	Chapter–6: Electromagnetic Induction	
	Chapter–7: Alternating Current	

'Eqn of an SHM'

Chapter–7: Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LCR series circuit (phasors only), resonance, power in AC circuits, power factor, wattless current. AC generator, Transformer.

EMI

Alternating Current (AC)

$\varepsilon = \varepsilon_0 \sin\omega t$

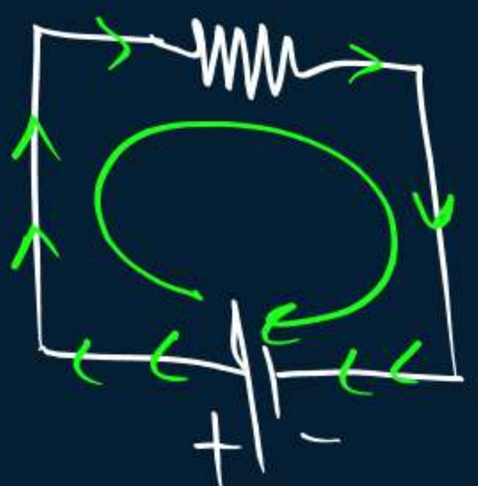
$i = i_0 \sin\omega t \qquad y = A \sin\omega t$

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

The current which changes its direction after a regular interval of time is called alternating current.

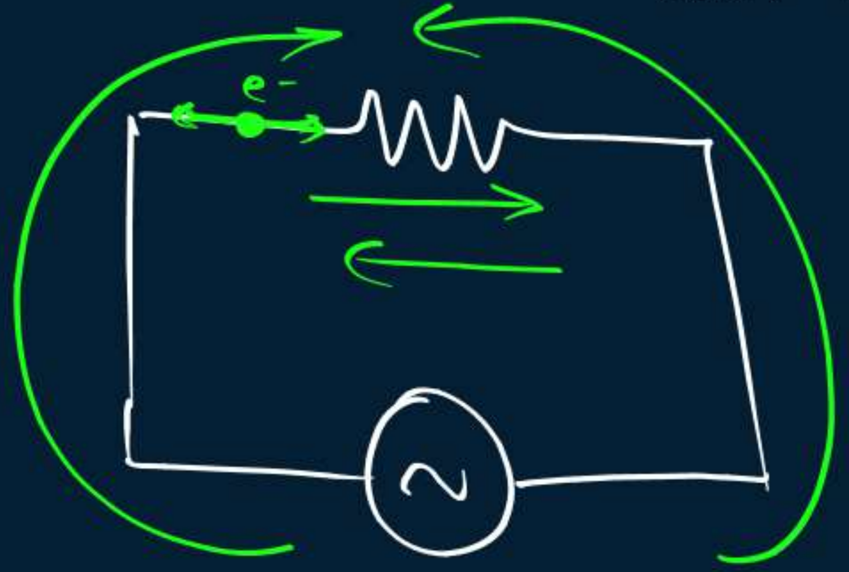
Feel of AC:

D.C. → Battery



Dc supply

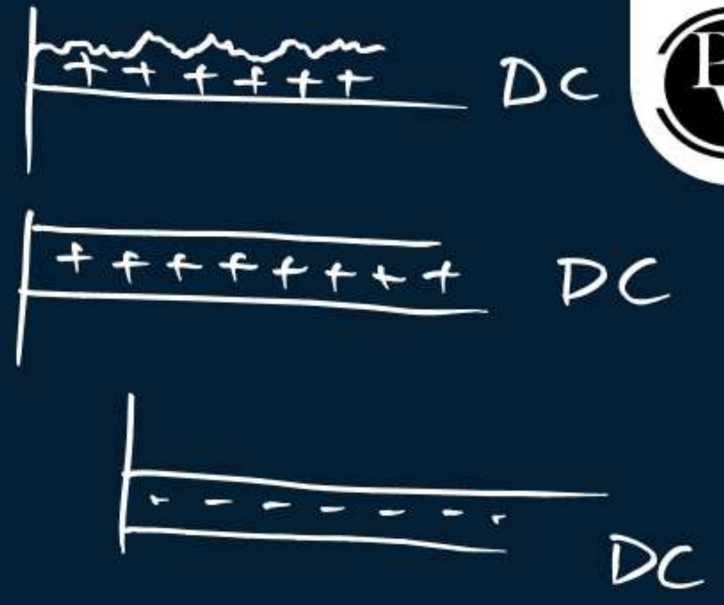
A.C. → A.C. Generator

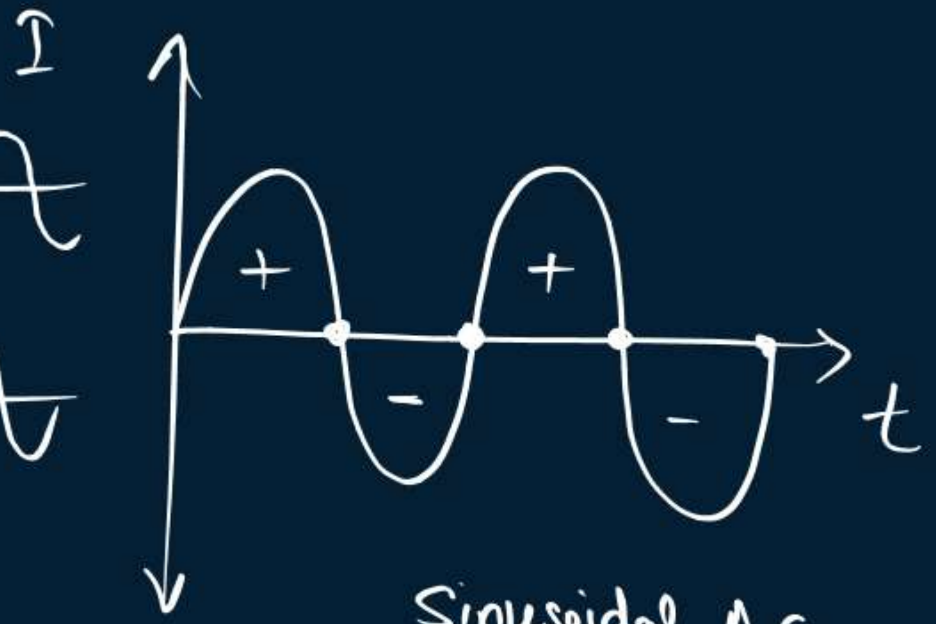


AC Source

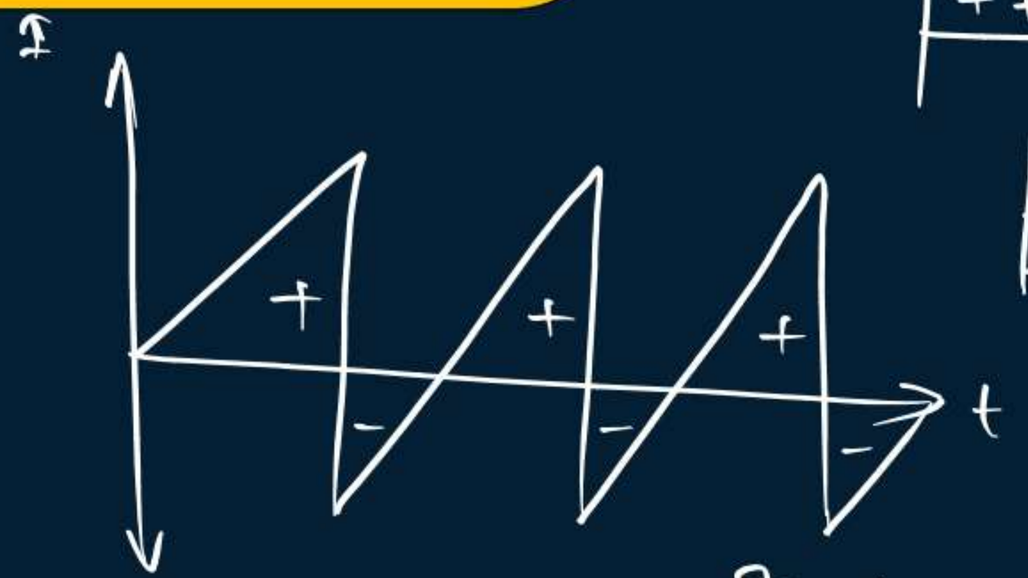
Types of Alternating Currents

DC :-

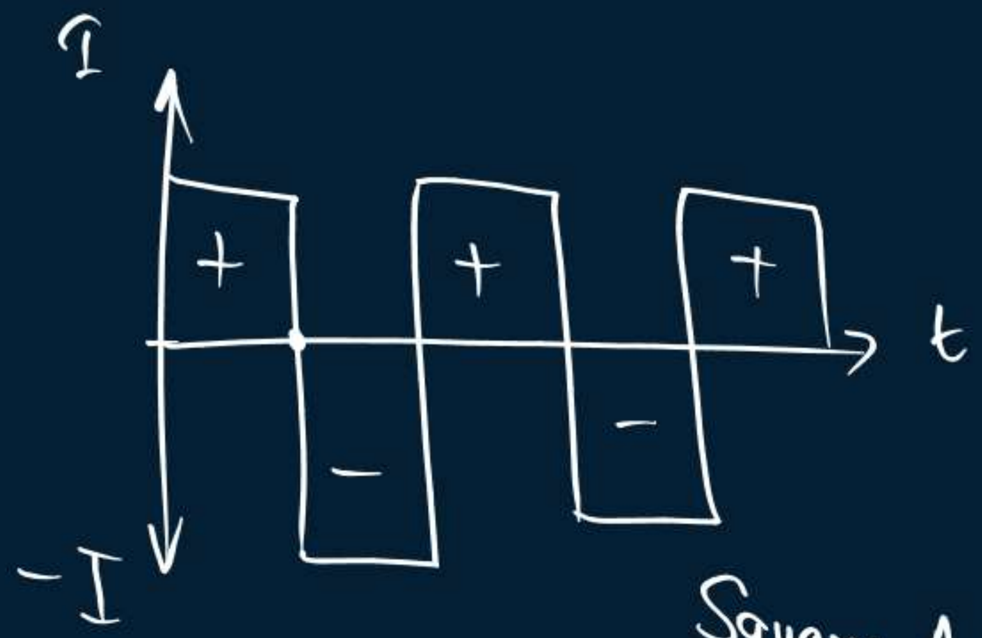




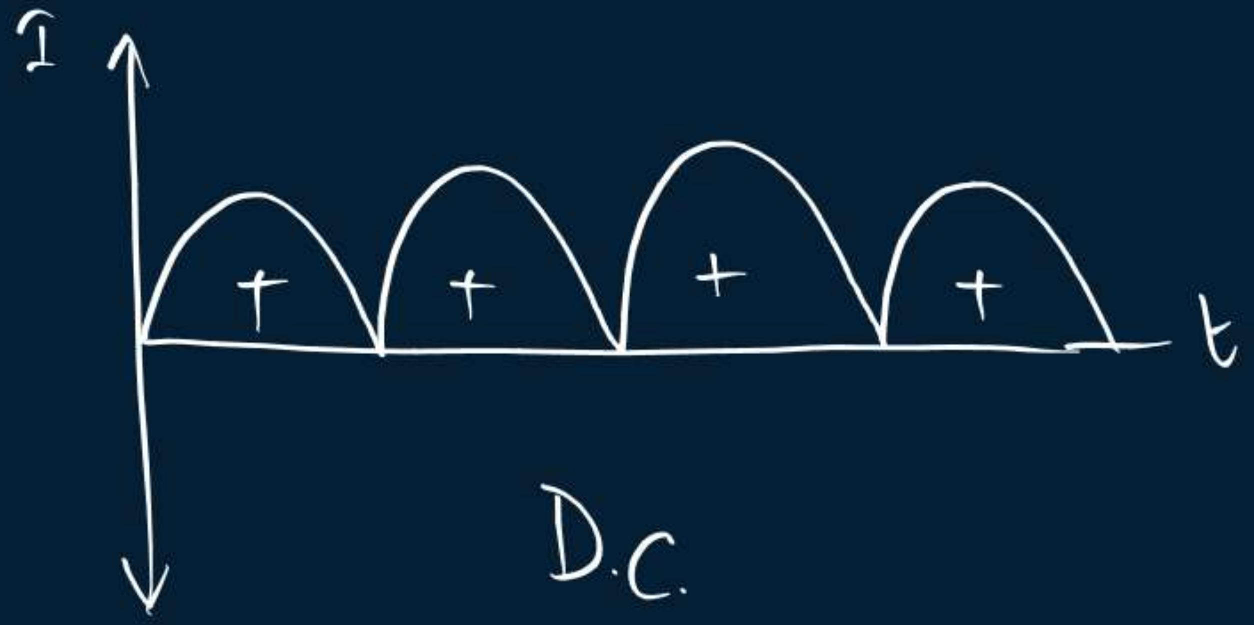
Sinusoidal A.C.



Saw-tooth A.C.



Square A.c.



D.C.

Home Supply of Alternating Current

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

- i → Alternating Current (time varying)
- i_0 → Peak Value of A.C. (Current Amplitude)
- ω → Angular frequency (rad/sec)
- t → any time 't'

Angular frequency (ω) :-

$$\boxed{\begin{aligned} \omega &= \frac{2\pi}{T} \\ \omega &= 2\pi\nu \end{aligned}}$$

Angular freq. ← ω ; ν → frequency

→ Alternating Voltage $= 220$ Volts (V_{rms}) @ $\nu = 50\,Hz$

→ In U.S.A. $=$ 110 V @ 60 Hz

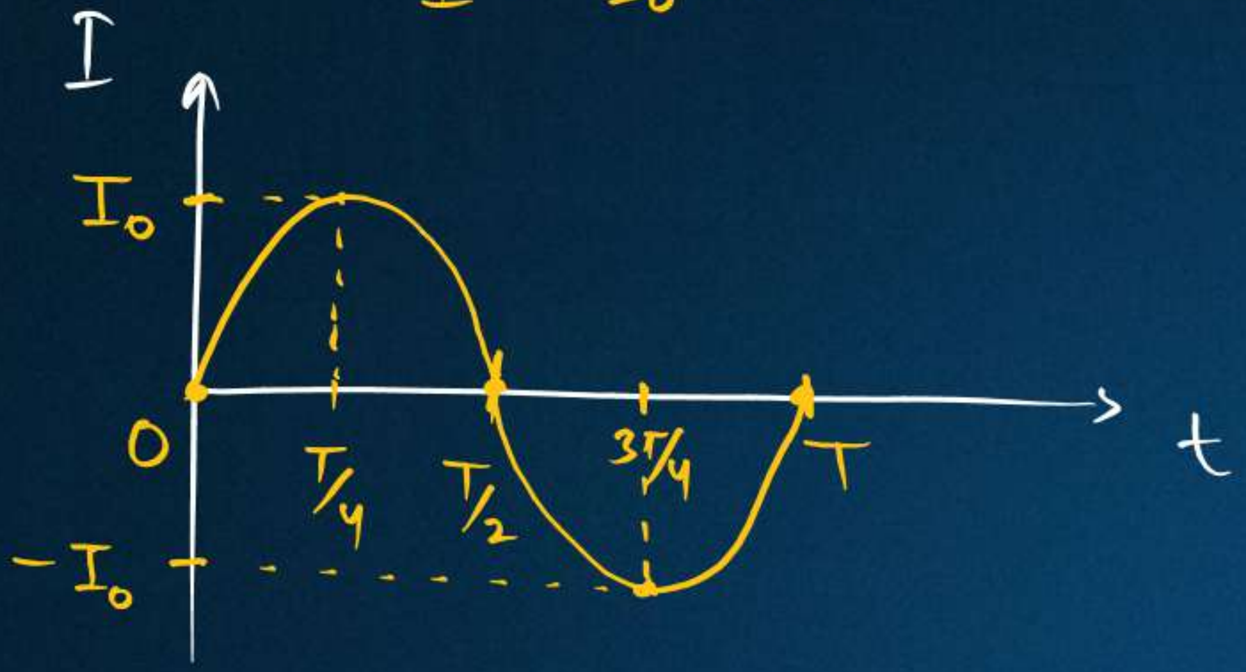
Q
$\nu = 50\,Hz$

$\omega = 2\pi\nu$

$= 2\pi 50$

$= 100\pi$ rad/sec

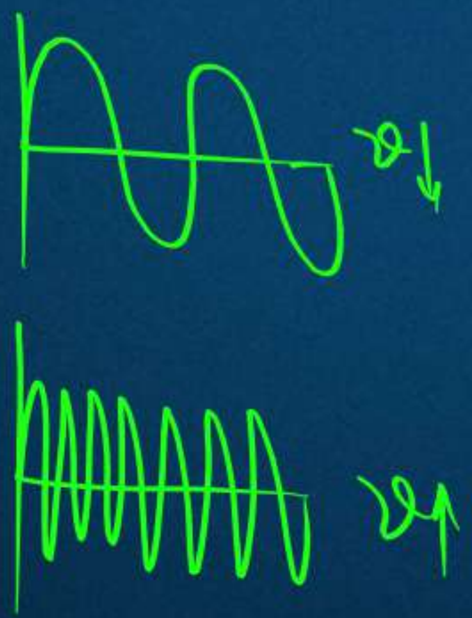
$$I = I_0 \sin\omega t$$



i) One cycle complete $\longrightarrow$ Time Period (T)

ii) half cycle complete $\longrightarrow$ T/2

iii) Amplitude $\rightarrow$ Maximum Value (i_0)



iv) frequency (ν)

$\hookrightarrow$ SI unit $\Rightarrow$ hertz (Hz)

Soch Bhai Soch

How many times in Indian home supply, the current changes its direction in 1 second?

$\nu = 50\,Hz$

1 sec $\longrightarrow$ 50 Baar oscillations

1 oscillation $\longrightarrow$ 2 directions

50 ——— $50 \times 2 = 100$ Baar direction change

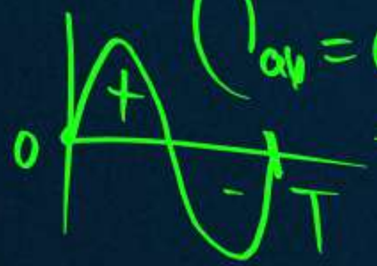
AC

Average Value

full cycle

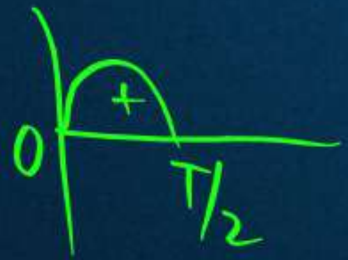
$(0 - T)$

$(i_{av} = 0)$



half cycle

$(0 - T/2)$



Peak Value

$$\boxed{i_0 = \frac{NBA\omega}{R}}$$

RMS Value

Average Current in Sinusoidal AC (RVSN)

It is the constant current which must be flown through equivalent DC circuit, so that same charge flows in both the circuits in a given time.

* For Full Cycle (0 − T)

$$i = \frac{dq}{dt}$$

$$dq = i \cdot dt$$

Int. both sides . . .

$$\int dq = \int_0^T i \cdot dt$$

$$\int dq = \int_0^T i_0 \sin\omega t \cdot dt \qquad [i = i_0 \sin\omega t]$$

$$q = i_0 \int_0^T \sin\omega t \cdot dt$$

$$q = i_0 \left[-\frac{\cos\omega t}{\omega}\right]_0^T$$

$$q = \frac{i_0}{\omega}\left[-\cos\omega t\right]_0^T$$

$$q = \frac{i_0}{\omega}\left[-\cos\frac{2\pi}{\cancel{T}}(\cancel{T}) - \left(-\cos\frac{2\pi}{T}(0)\right)\right]$$

$$q = \frac{i_0}{\omega}\left[-\cos 2\pi - (-\cos 0)\right]$$

$$q = \frac{i_0}{\omega}\left(-1 - (-1)\right)$$

$$q = \frac{i_0}{\omega}(-1+1)$$

$$\boxed{q = 0}$$

$$i_{av} = \frac{\Delta q}{\Delta t}$$

$$\boxed{i_{av} = 0}$$

Imp.

for half cycle $(0 - T/2)$

$$i = \frac{dq}{dt}$$

$$dq = i \cdot dt$$

Int. both sides...

$$\int dq = \int_0^{T/2} i \cdot dt$$

$$q = \int_0^{T/2} i_0 \sin\omega t \cdot dt$$

$$q = i_0 \int_0^{T/2} \sin\omega t \cdot dt$$

$$q = i_0 \left[-\frac{\cos\omega t}{\omega} \right]_0^{T/2}$$

$$q = \frac{i_0}{\omega} \left[-\cos \frac{\cancel{2}\pi}{\cancel{T}} \times \frac{\cancel{T}}{\cancel{2}} - \left(-\cos \frac{2\pi}{T} \times 0 \right) \right]$$

$$q = \frac{i_0}{\omega} \left[-\cos\pi - (-\cos 0) \right]$$

$$q = \frac{i_0}{\omega} \left[-(-1) - (-1) \right]$$

$$q = \frac{i_0}{\omega} [+1+1]$$

$$q = \frac{\cancel{2} i_0}{\frac{\cancel{2}\pi}{T}} = \frac{i_0 T}{\pi}$$

$$i_{av} = \frac{\Delta q}{\Delta T} = \frac{i_0 \cancel{T}}{\pi \cancel{T}/2} = \frac{2}{\pi} i_0$$

414

$$\boxed{i_{av} = \frac{2}{\pi} i_0 = 0.637\, i_0}$$

RMS Value of AC (RVSN)

It is the constant current which produces the same heating effect in a given resistor as it produces by the given AC when passed for same time

- Root Mean Square i_{rms}
- Virtual Value i_v
- Effective Value i_{eff}

Imp

$$H = i^2 R t$$

$$dH = i^2 R\,dt$$

Int. both sides...

$$\int dH = \int_0^T i^2 R\,dt$$

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

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

$$i_{rms}^2 \cancel{R}\cancel{T} = i_0^2 \cancel{R} \int_0^T \sin^2\omega t \cdot dt$$

$$i_{rms}^2 = \frac{i_0^2}{T}\int_0^T \sin^2\omega t \cdot dt$$

$$H = i_{rms}^2 R T$$

$$\boxed{i_{rms} = \sqrt{\frac{i_0^2}{T}\int_0^T \sin^2\omega t \cdot dt}} \quad \text{.... eq (1)}$$

$$\sin^2\theta = \frac{1-\cos 2\theta}{2}$$

$$\int_0^T \sin^2\omega t \cdot dt$$

$$\int_0^T \frac{1-\cos 2\omega t}{2} \cdot dt$$

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

$$\frac{1}{2}\left\{[t]_0^T - \left[\frac{\sin 2\omega t}{2\omega}\right]_0^T\right\}$$

$$\frac{1}{2}\left[(T-0) - \left\{\sin \frac{2\times 2\pi}{2\omega\, \cancel{T}}\cancel{T} - \frac{\sin 2\frac{2\pi}{T}(0)}{2\omega}\right\}\right]$$

$$\frac{1}{2}\left[T - \frac{1}{2\omega}\left\{\sin 4\pi - \sin 0\right\}\right]$$

$$\frac{1}{2}[T-0] = \frac{T}{2}$$

Put this Value in eq (1)..

$$i_{rms} = \sqrt{\frac{i_0^2}{T}\,\frac{\cancel{T}}{2}}$$

याद *

$$\boxed{i_{rms} = \frac{i_0}{\sqrt{2}} = 0.707\, i_0}$$

Form Factor

$$= \frac{i_{rms}}{i_{av}}$$

$i_{rms} \rightarrow$ full cycle $(0-T)$

$i_{av} \rightarrow$ half cycle $(0-T/2)$

NEET/JEE/CUET

$$\frac{i_{rms}}{i_{av}} = \frac{\frac{\cancel{i_0}}{\sqrt{2}}}{\frac{2}{\pi}\cancel{i_0}} = 1.11$$

$$\boxed{\frac{i_{rms}}{i_{av}} = 1.11}$$

Homework

UDAY 2025
- Notes → Uniform cm : SHM
- videos — 1 lec + $\frac{1}{2}$ lec

Derivations × 3
- 1 Fair
- 2 Rough

Oscillations – 1.5–2h

↓

6–7 hr

PARISHRAM

2026

Lecture - 02

Alternating Current

PHYSICS Lecture - 2

BY - RAKSHAK SIR

Topics *to be covered*

1. AC Source Connected to R, L, C.
2. Phasors
3.

* Some Mathematical RDx

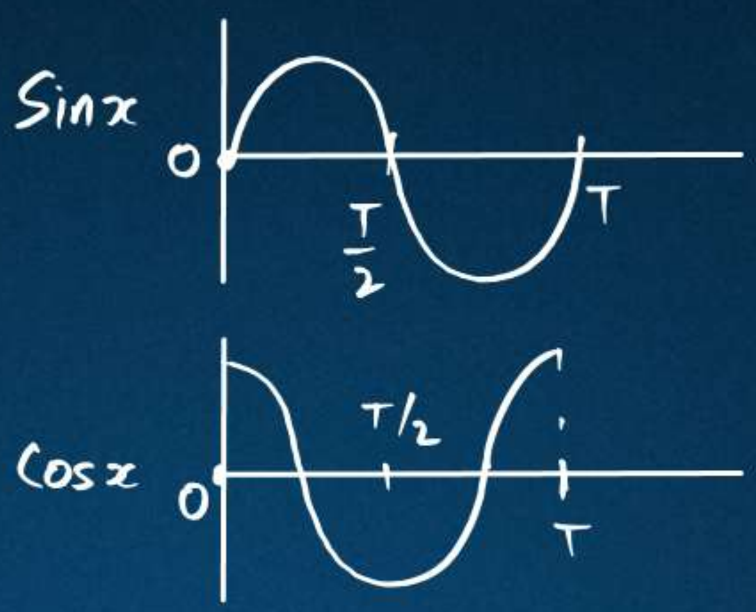
$$\boxed{i_{av} = \frac{\int i \cdot dt}{\int dt} = \frac{\int i \cdot dt}{T}}$$

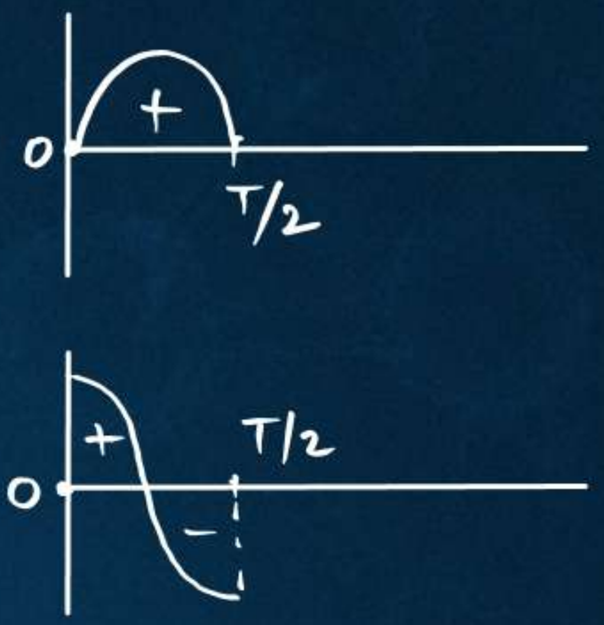
$$\boxed{i_{rms} = \sqrt{\frac{\int i^2 \cdot dt}{\int dt}} = \sqrt{\frac{\int i^2 \cdot dt}{T}}}$$

$$i_{av} = \langle i \rangle$$

$$V_{av} = \langle V \rangle$$

$$P_{av} = \langle P \rangle$$





Full cycle :-

$$\langle \sin \omega t \rangle = 0$$

$$\langle \cos \omega t \rangle = 0$$

$$\langle \sin 2\omega t \rangle = 0$$

$$\langle \cos 2\omega t \rangle = 0$$

$$\langle \sin^2 \omega t \rangle = \frac{1}{2}$$

$$\langle \cos^2 \omega t \rangle = \frac{1}{2}$$

Half Cycle :-

$$\langle \sin \omega t \rangle = \frac{2}{\pi}$$

$$\langle \cos \omega t \rangle = 0$$

QUESTION

$\omega = 2\pi\nu$

The time required for the 50 Hz sinusoidal source alternating current to reach its rms value from zero is

$\xrightarrow{} \nu$

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

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

$$i_{rms} = i_0 \sin\omega t$$

$$\frac{\cancel{i_0}}{\sqrt{2}} = \cancel{i_0} \sin\omega t$$

$$\frac{1}{\sqrt{2}} = \sin\omega t$$

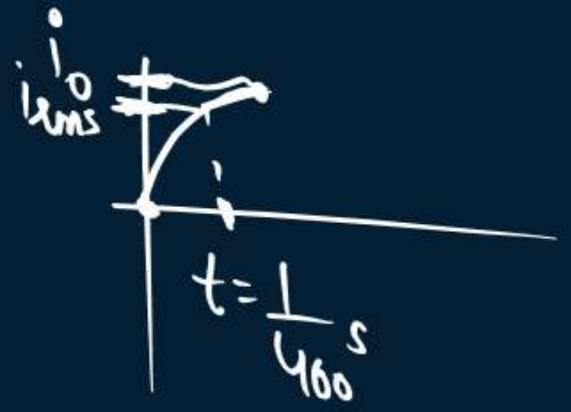
$$\sin\frac{\pi}{4} = \sin\omega t$$

$$\omega t = \frac{\pi}{4}$$

$$2\pi\nu t = \frac{\pi}{4}$$

$$2\cancel{\pi} 50 t = \frac{\cancel{\pi}}{4}$$

$$t = \frac{1}{400}\text{ s}$$



Which is more dangerous? – 220 V DC or 220 V AC

Peak Value of DC Voltage = 220V

RMS Value of A.C. Voltage = 220V

[0 − 311V]

$\varepsilon_{rms} = V_{rms} = 220V$

$\varepsilon_{rms} = \frac{\varepsilon_0}{\sqrt{2}}$

$\varepsilon_0 = \sqrt{2} \times \varepsilon_{rms} = \sqrt{2} \times 220$

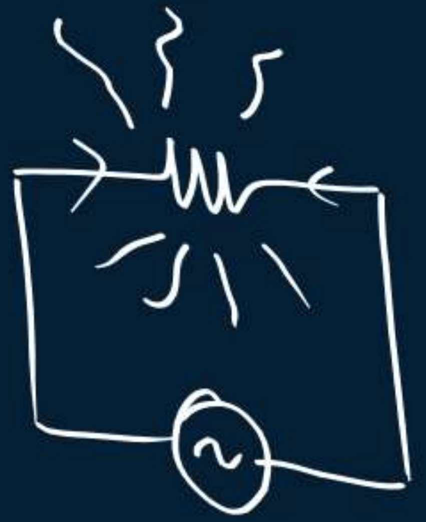
$= 311V$

Measurement of AC

M.C.

→ Galvanometer is best device to measure D.C. but Not A.C.

→ Hot-wire Galvanometer



I_{rms}

QUESTION

An alternating current is given by $I = I_1 \cos \omega t + I_2 \sin \omega t$. The RMS value of current is given by

A $\dfrac{I_1 + I_2}{\sqrt{2}}$

B $\dfrac{(I_1 + I_2)^2}{2}$

C $\sqrt{\dfrac{I_1^2 + I_2^2}{2}}$

D $\dfrac{\sqrt{I_1^2 + I_2^2}}{2}$

$$I = I_1 \cos\omega t + I_2 \sin\omega t$$

$$I^2 = (I_1 \cos\omega t + I_2 \sin\omega t)^2$$

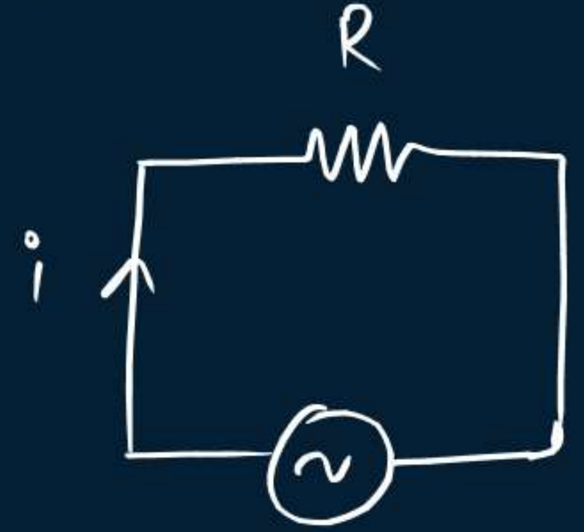
$$I^2 = I_1^2 \cos^2\omega t + I_2^2 \sin^2\omega t + 2 I_1 I_2 \sin\omega t \cos\omega t$$

$$I^2 = I_1^2 \frac{1}{2} + I_2^2 \frac{1}{2} + 0$$

$$I^2 = \frac{I_1^2}{2} + \frac{I_2^2}{2}$$

$$I^2 = \frac{I_1^2 + I_2^2}{2} \longrightarrow I = \sqrt{\frac{I_1^2 + I_2^2}{2}}$$

AC Source connected to Resistor



$V = V_0 \sin\omega t$ ... (1)

$V = iR$ ... (2)

equate (1) and (2)

$iR = V_0 \sin\omega t$

$iR = V_0 \sin\omega t$

$i = \left(\frac{V_0}{R}\right)\sin\omega t$ ... (3)

Comparing eq (3) with General eq of A.C.

$i = i_0 \sin\omega t$

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

$$\boxed{\begin{aligned} V &= V_0 \sin\omega t \\ i &= i_0 \sin\omega t \end{aligned}}$$

both V and i are in same phase

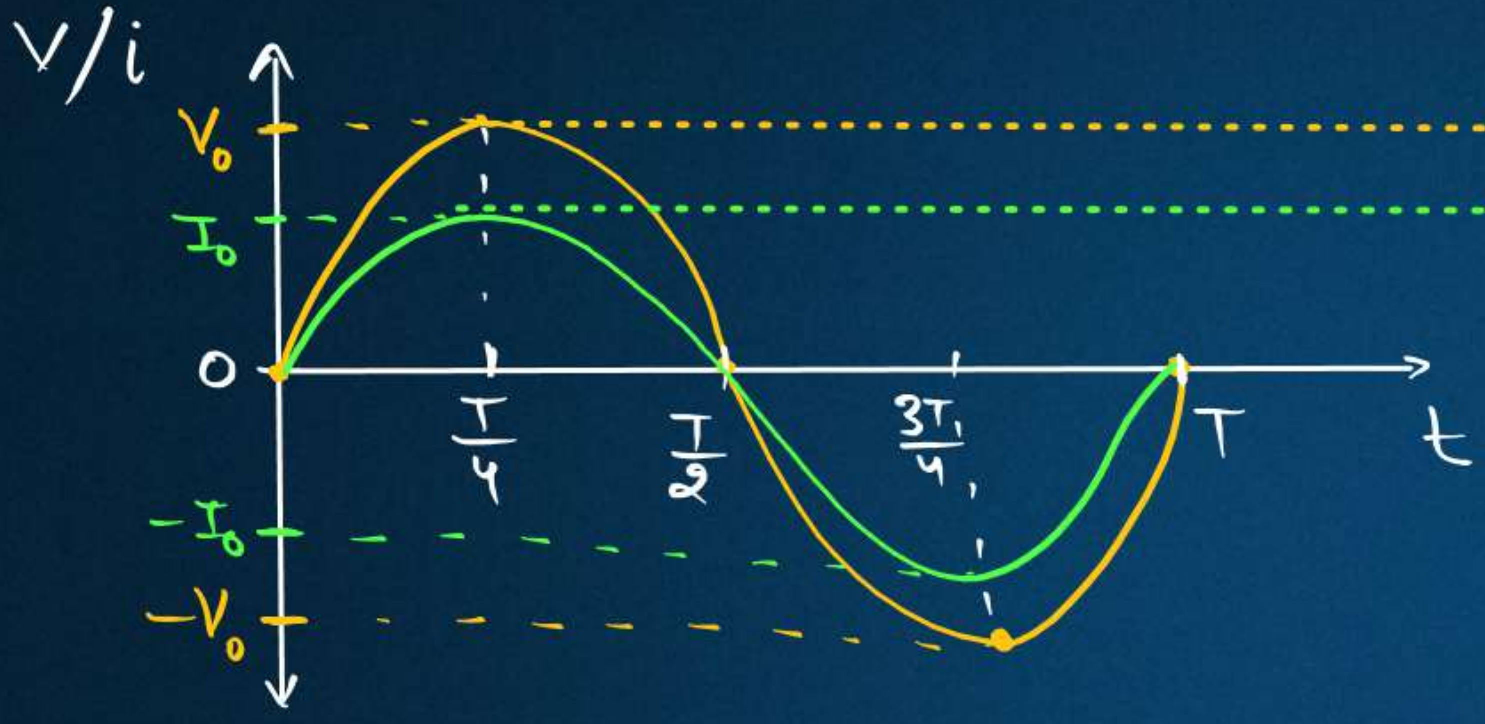
$\Delta\phi = \phi_2 - \phi_1$

$= \omega t - \omega t$

$\Delta\phi = 0$

(No Phase Diff)

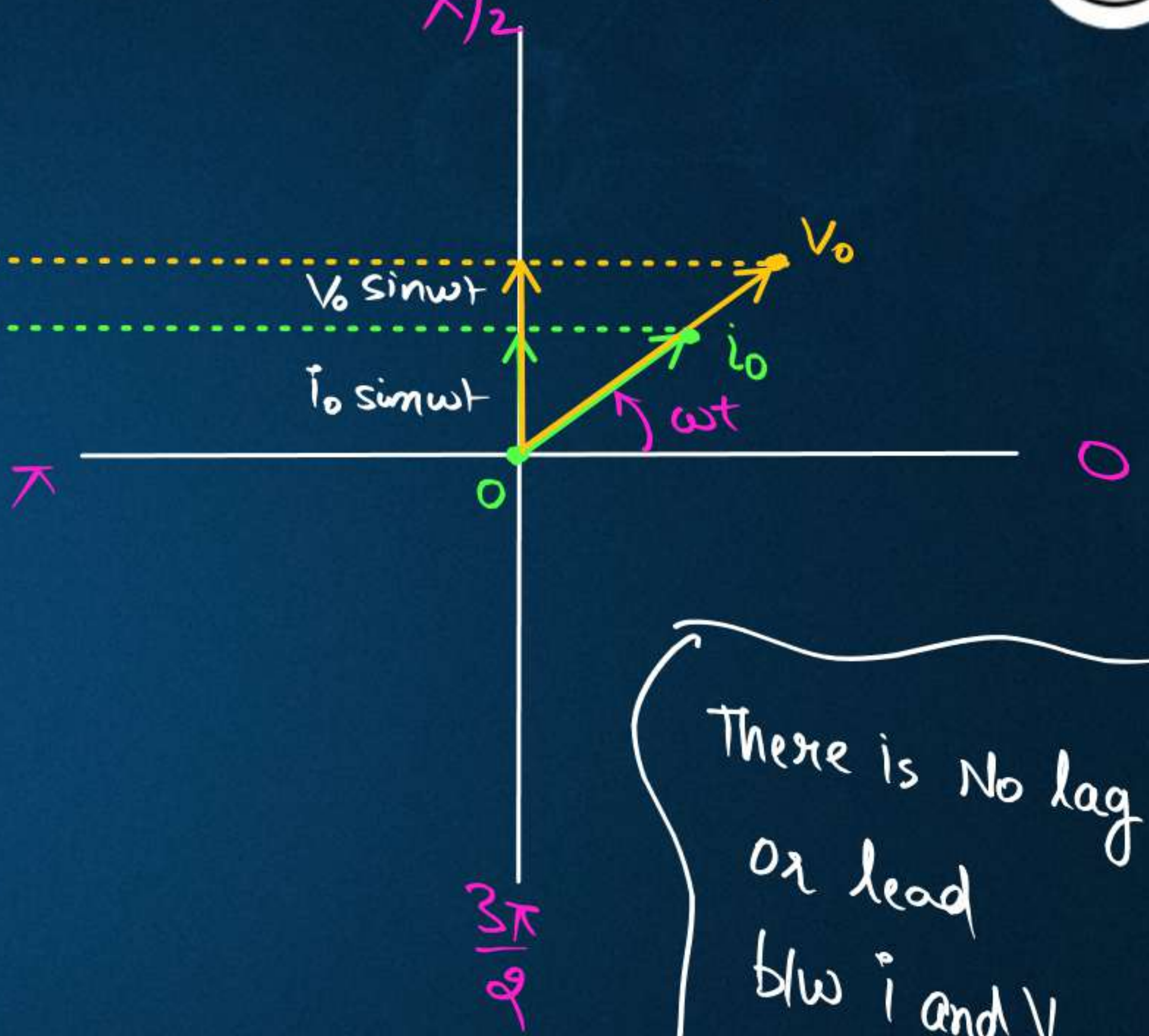
* Graph & Phasor



$$V = V_0 \sin\omega t$$
$$i = i_0 \sin\omega t$$

$$\left(\begin{aligned} \omega t &= \theta \\ \omega &= \frac{\theta}{t} \end{aligned} \right)$$

Phasor Diagram



There is No lag or lead b/w i and V in a pure resistive Ckt.

* Power consumed

R

$V = V_0 \sin\omega t$

$i = i_0 \sin\omega t$

$P = Vi$

$$P = Vi$$
$$= V_0 \sin\omega t \; i_0 \sin\omega t$$
$$P = V_0 i_0 \sin^2\omega t$$

$$P_{av} = \frac{\int P \cdot dt}{\int dt}$$

$$= \frac{\int V_0 i_0 \sin^2\omega t \cdot dt}{\int dt}$$

$$P_{av} = V_0 i_0 \times \frac{1}{2}$$

$$P_{av} = \frac{V_0}{\sqrt{2}} \frac{i_0}{\sqrt{2}}$$

$$\boxed{P_{av} = V_{rms} \, i_{rms}}$$

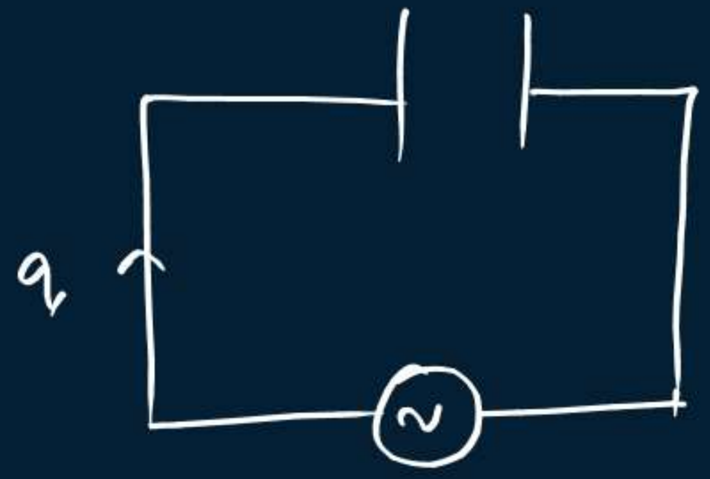
Pure Resistive

$$\frac{\int \sin^2\omega t \cdot dt}{\int dt} = \frac{1}{2}$$

$\sin(90+\theta) = \cos\theta$

AC Source connected to Capacitor

→ Pure capacitive ckt.



$$\boxed{V = V_0 \sin\omega t} \quad \ldots (1)$$

$$q = CV$$

$$V = \frac{q}{C} \quad \ldots (2)$$

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

$$\frac{q}{C} = V_0 \sin\omega t$$

$$q = CV_0 \sin\omega t$$

diff. both sides....

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

$$i = C.V_0.\cos\omega t.\omega$$

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

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

$$i = CV_0\omega \sin\left(\omega t + \frac{\pi}{2}\right)$$

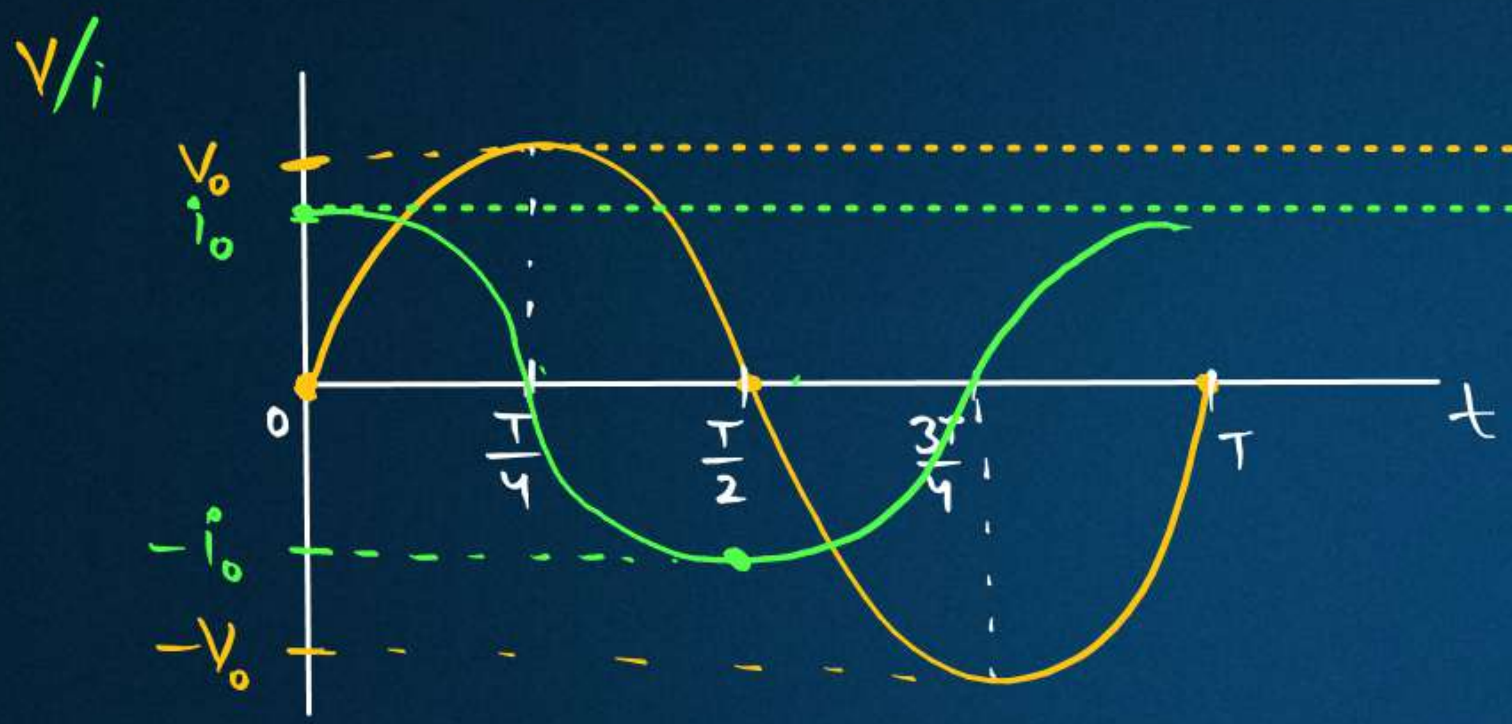
$$\boxed{i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)}$$

i has "$\frac{\pi}{2}$" phase diff ($\Delta\phi$) than V

here, i leads V by $\frac{\pi}{2}$

V lags i by $\frac{\pi}{2}$

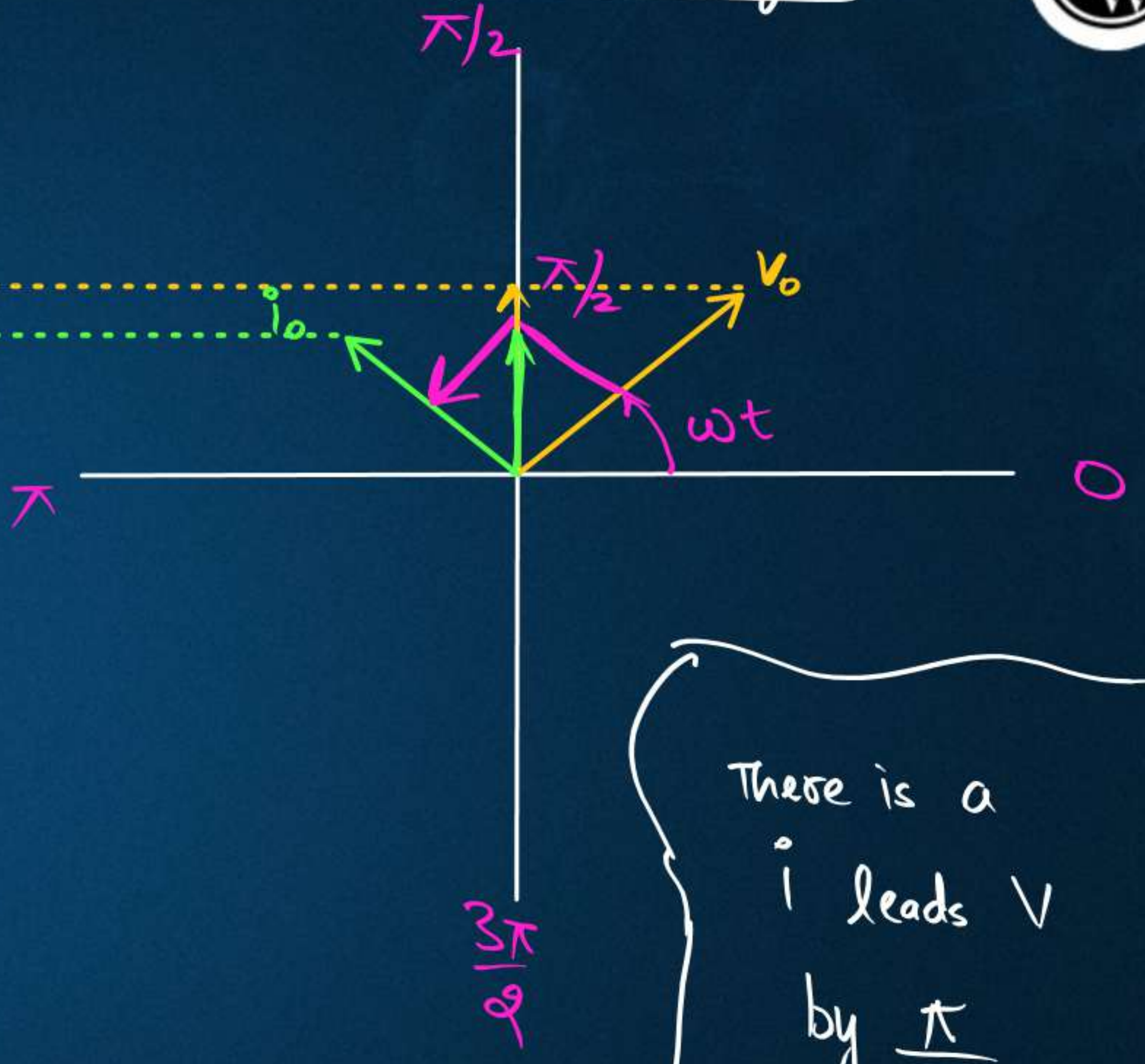
* Graph & Phasor



$$V = V_0 \sin \omega t$$
$$i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$\left(\begin{aligned} \omega t &= \theta \\ \omega &= \frac{\theta}{t} \end{aligned}\right)$$

Phasor Diagram



There is a i leads V by $\frac{\pi}{2}$

Power

$$P = Vi$$

$$P = V_0 \sin(\omega t) \times i_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$= V_0 i_0 \sin\omega t \cdot \cos\omega t$$

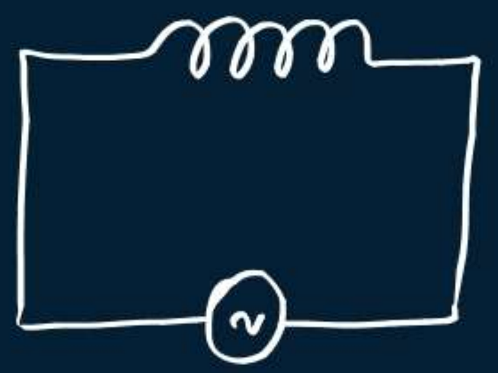
$$P_{av} = V_0 i_0 \langle \sin\omega t \rangle \langle \cos\omega t \rangle$$

$$P_{av} = V_0 i_0 \times 0$$

$$\boxed{P_{av} = 0}$$

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

AC Source connected to Inductor



$\boxed{V = V_0 \sin\omega t}$ ---- ①

$\mathcal{E}_e = -L\dfrac{di}{dt}$ ---- ②

$V = \mathcal{E}_e$

$V_0 \sin\omega t = -L\dfrac{di}{dt}$

$L\dfrac{di}{dt} = V_0 \sin\omega t$

$di = \dfrac{V_0}{L}\sin\omega t \cdot dt$

Int. both sides . . .

$\int di = \int \dfrac{V_0}{L}\sin\omega t \cdot dt$

$i = \dfrac{V_0}{L}\int \sin\omega t \cdot dt$

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

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

$i = \dfrac{V_0}{\omega L}\left(-\sin\left(\dfrac{\pi}{2}-\omega t\right)\right)$

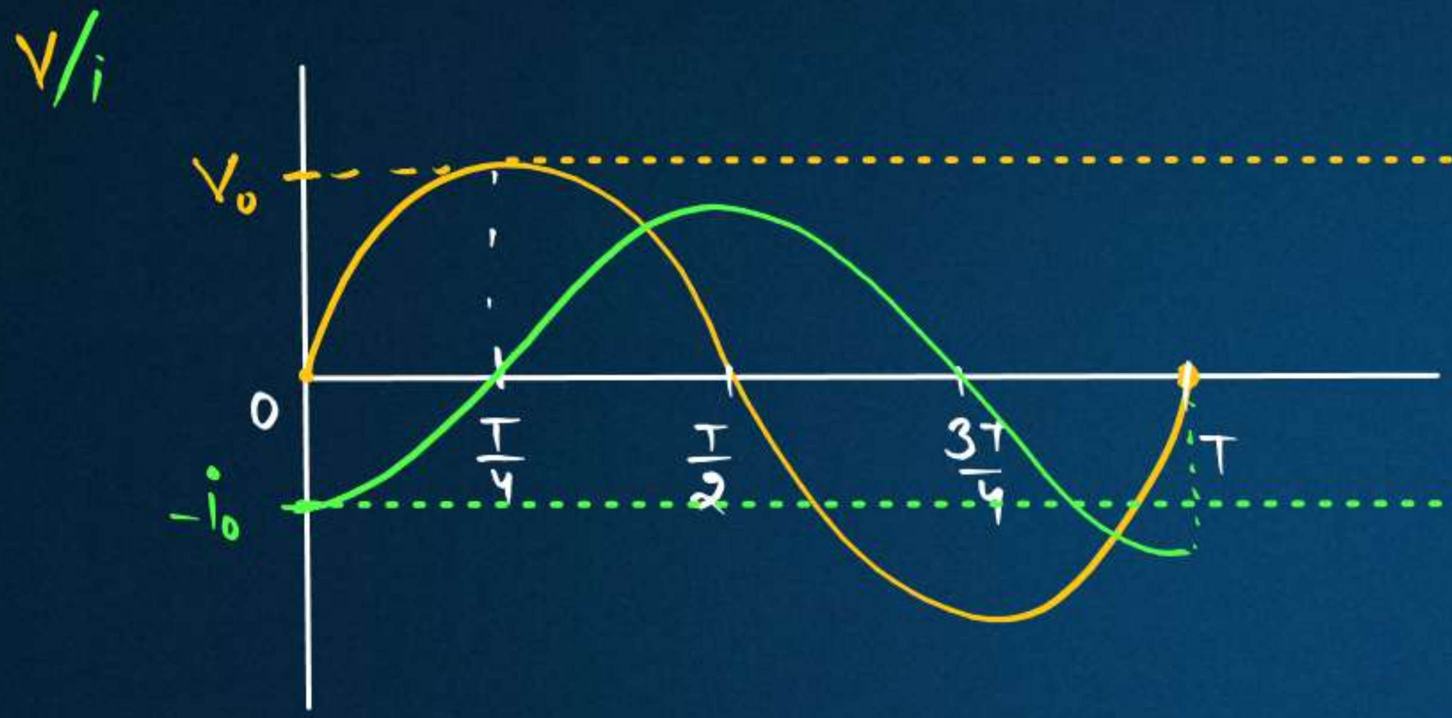
$i = \left(\dfrac{V_0}{\omega L}\right)\sin\left(\dfrac{-\pi}{2}+\omega t\right)$

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

i lags behind V by $\pi/2$

V leads i by $\dfrac{\pi}{2}$

* Graph & Phasor

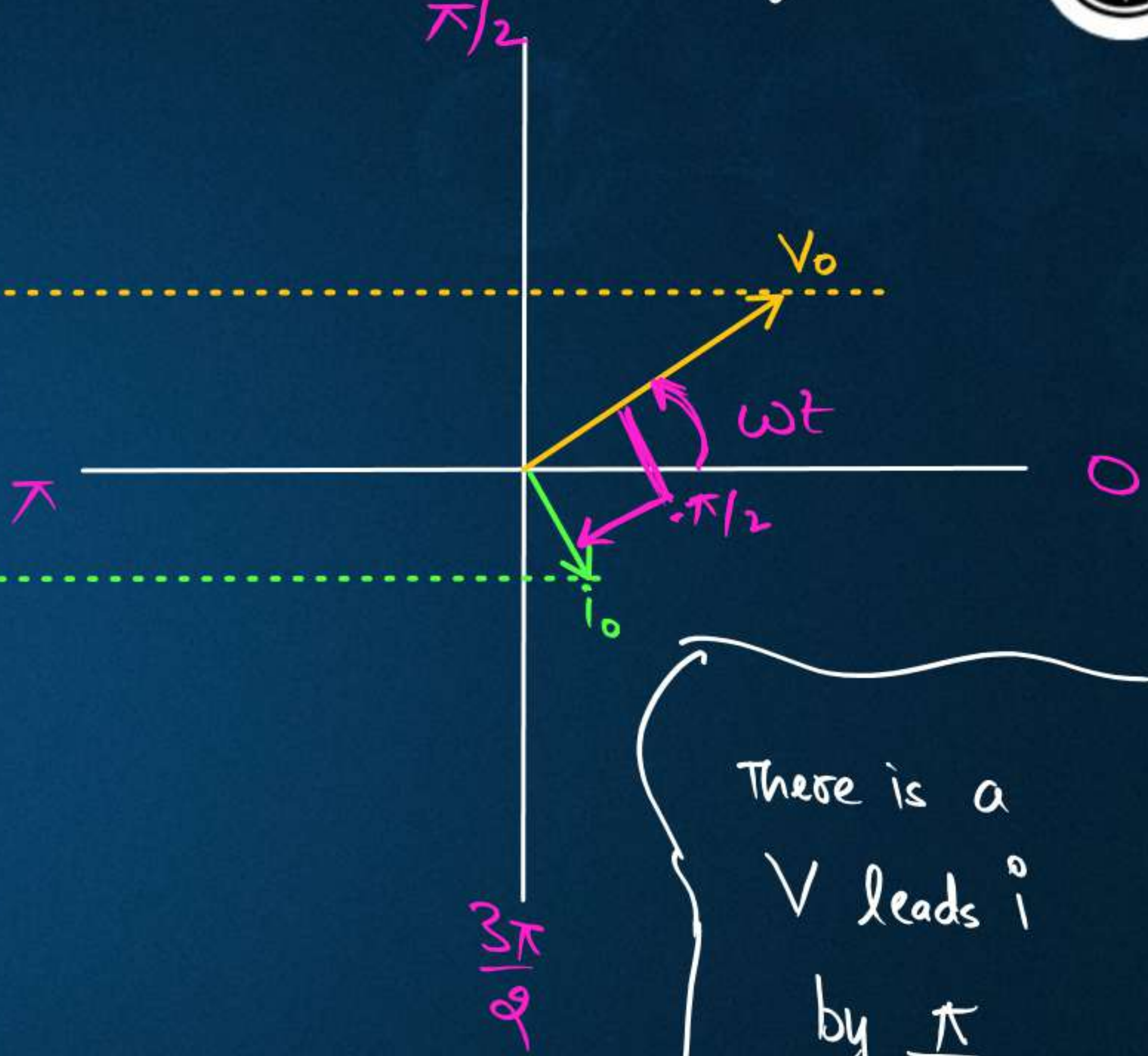


$$V = V_0 \sin\omega t$$

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

$$\left(\begin{aligned} \omega t &= \theta \\ \omega &= \frac{\theta}{t} \end{aligned}\right)$$

Phasor Diagram



There is a V leads i by $\frac{\pi}{2}$

Power in pure inductive ckt.

$$P = Vi$$

$$= V_0 \sin\omega t \; i_0 \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$= V_0 \sin\omega t \left(-i_0 \cos\omega t\right)$$

$$P_{av} = -V_0 i_0 \langle \sin\omega t \times \cos\omega t \rangle$$

$$\boxed{P_{av} = 0}$$

Watt-less Currents

Currents in purely inductive as well as capacitive circuits, do not dissipate Power Averagely

$P_{av} = 0$

$i \rightarrow$ Watt-less Current

Homework

Notes

Likh ke Practice × 1

DPP Try

PARISHRAM

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Lecture-03

Alternating Current

PHYSICS Lecture - 3

BY - RAKSHAK SIR

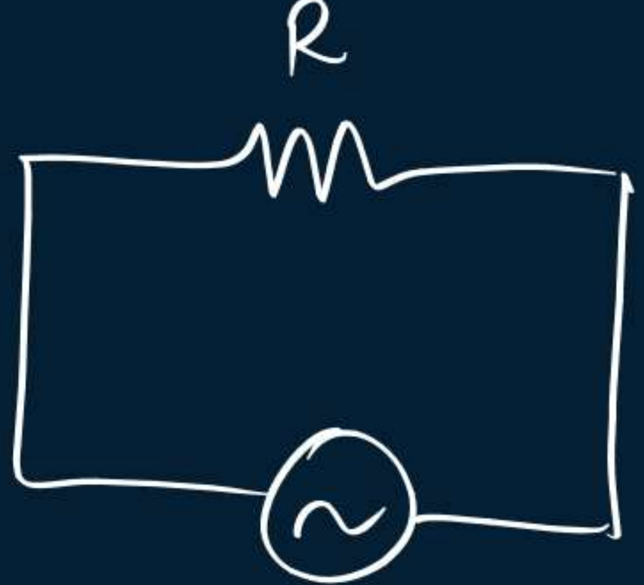
Topics *to be covered*

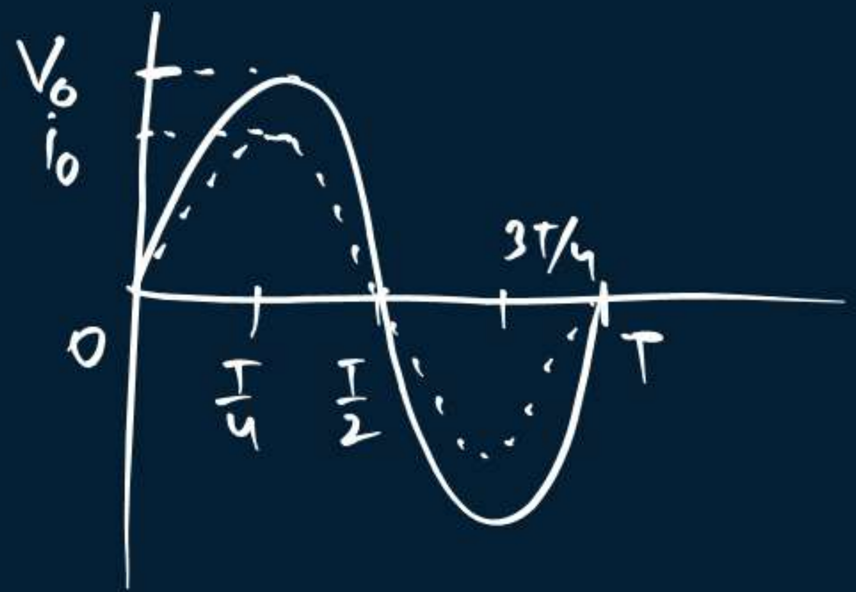
1 Series L,C,R Circuit

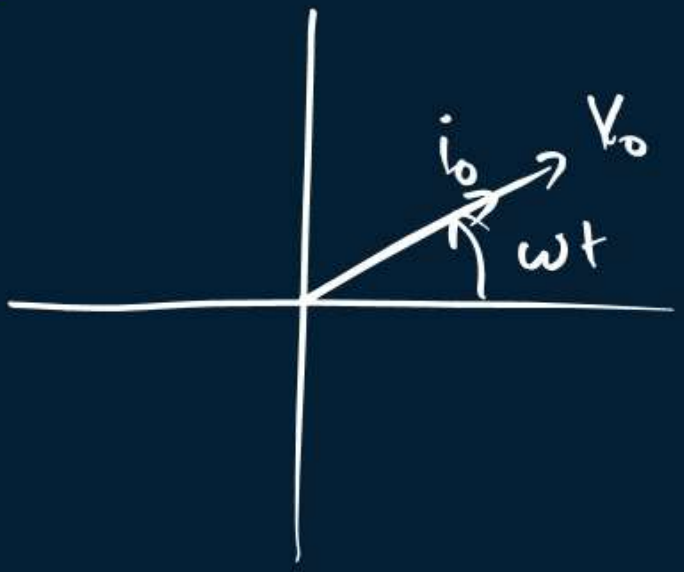
2 Resonance

3

AC Source connected to Resistor







$$\boxed{V = V_0 \sin\omega t}$$

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

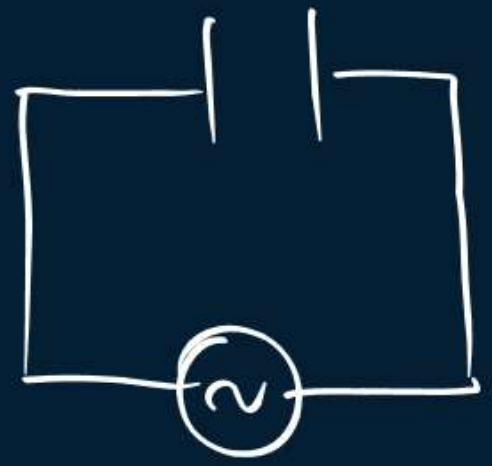
$$\boxed{i = i_0 \sin\omega t}$$

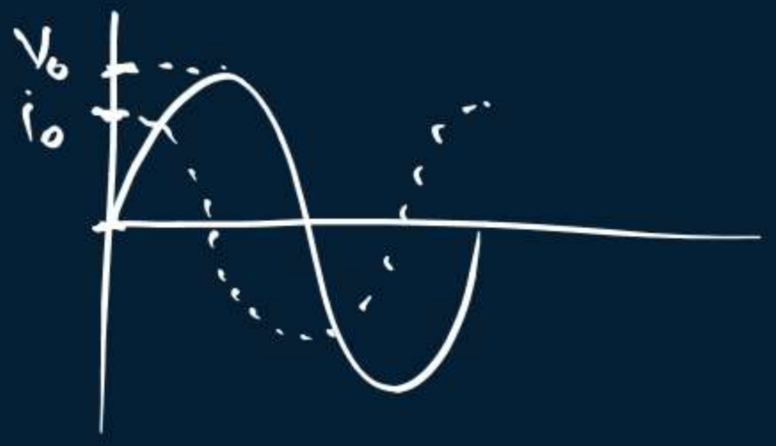
Same Phase

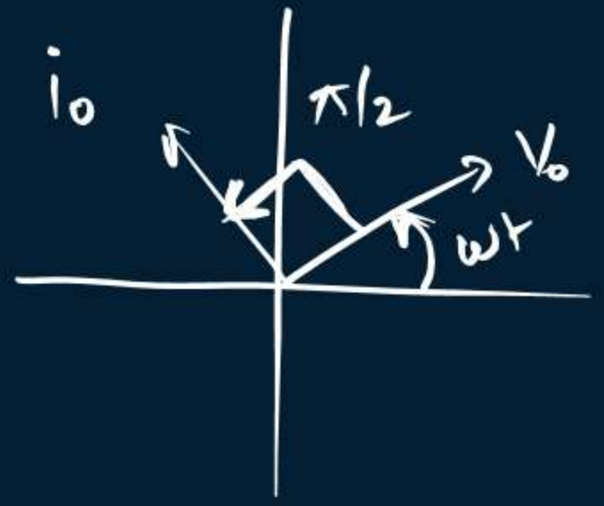
$$* \boxed{i_0 = \frac{V_0}{R}}$$

$$\boxed{P_{av} = V_{rms} \cdot i_{rms}}$$

AC Source connected to Capacitor







$$\boxed{V = V_0 \sin\omega t}$$

$$i = \omega C V_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

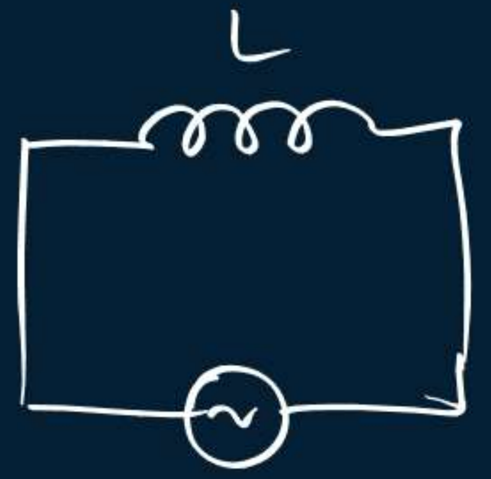
$$\boxed{i_0 = \omega C V_0}$$

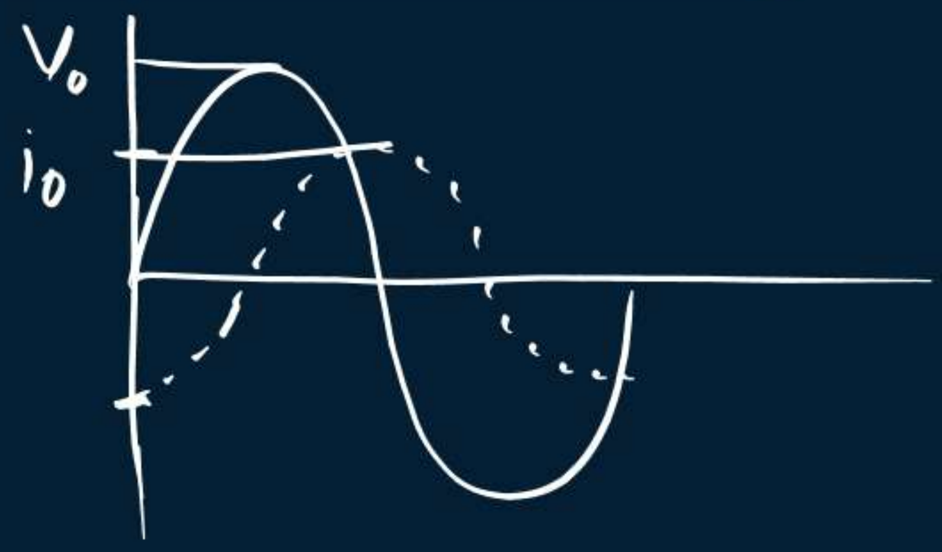
$$\boxed{i = i_0 \sin\left(\omega t + \frac{\pi}{2}\right)}$$

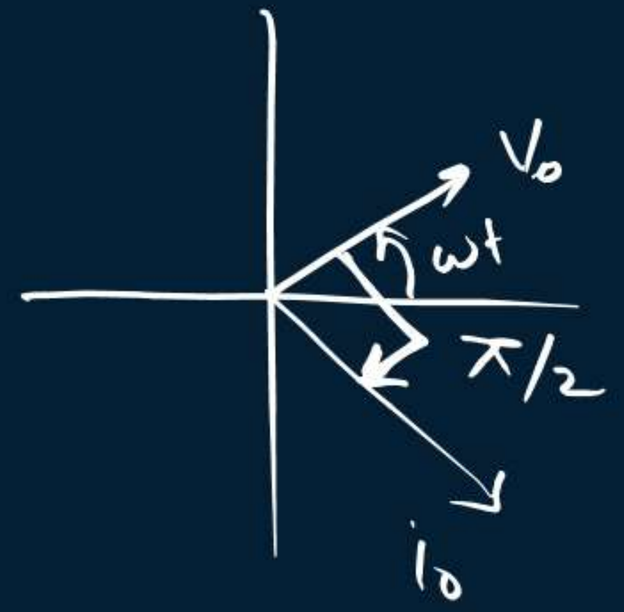
i leads V by $\frac{\pi}{2}$

$$P_{av} = 0$$

AC Source connected to Inductor







V leads i by $\left(\frac{\pi}{2}\right)$

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

$$i = \left[\frac{V_0}{\omega L}\right]\sin\left(\omega t - \frac{\pi}{2}\right)$$

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

$$\boxed{i_0 = \frac{V_0}{\omega L}}$$

$$P_{av} = 0$$

Variation of Reactance with frequency

X

Inductive reactance

→ The opposition offered by an inductor connected to an AC ckt.

→ $\boxed{X_L = \omega L}$

→ ohm(Ω)

Capacitive reactance

→ The opposition offered by a capacitor connected to an A.C. source

→ $\boxed{X_C = \frac{1}{\omega C}}$

→ ohm(Ω)

$$i_0 = \frac{V_0}{\omega L}$$

$$V_0 = i_0(\omega L)$$

$$V_0 = i_0(X_L)$$

$$V = IR$$

$$i_0 = \omega C V_0$$

$$V_0 = \left(\frac{1}{\omega C}\right) i_0$$

$$V_0 = i_0 X_C$$

$$V = IR$$

* $X_L = \omega L$

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

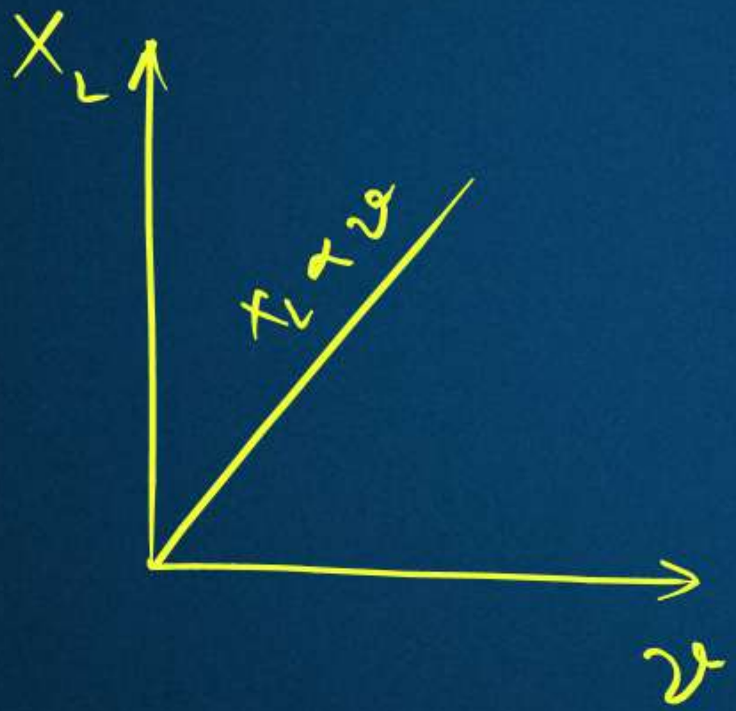
$$\omega = \frac{2\pi}{T}$$

$$\omega = 2\pi\nu$$

$X_L \propto \nu$

OR

$X_L \propto \omega$



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

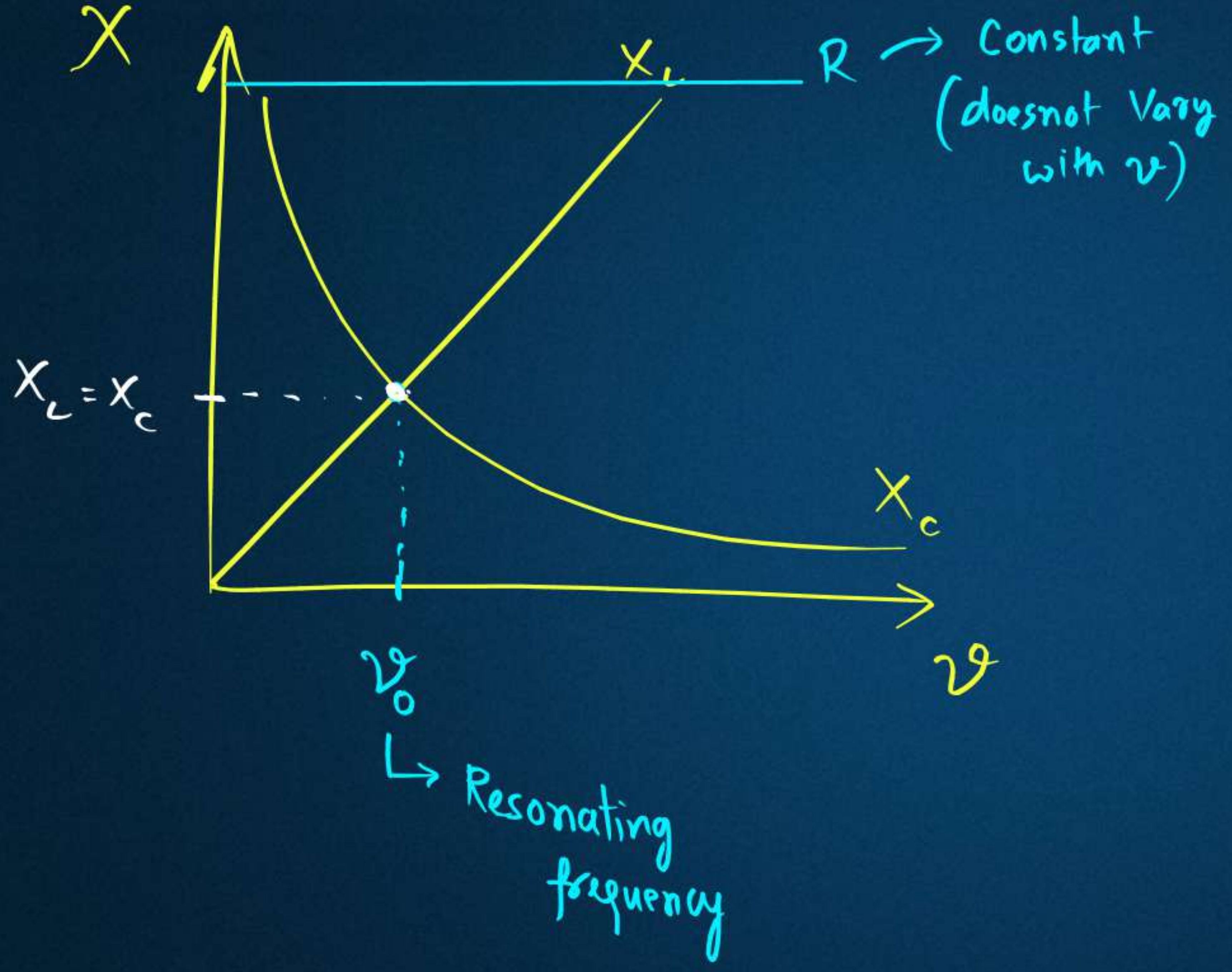
$$\boxed{X_C = \frac{1}{2\pi\nu C}}$$

$X_C \propto \frac{1}{\nu}$

OR

$X_C \propto \frac{1}{\omega}$

Combined Graph



QUESTION

The reactance of a capacitor of capacitance C is X. If both the frequency and capacitance be doubled, then new reactance will be [CBSE AIPMT 2001]

(A) X

(B) 2X

(C) 4X

(D) X/4

$$X_c = X$$

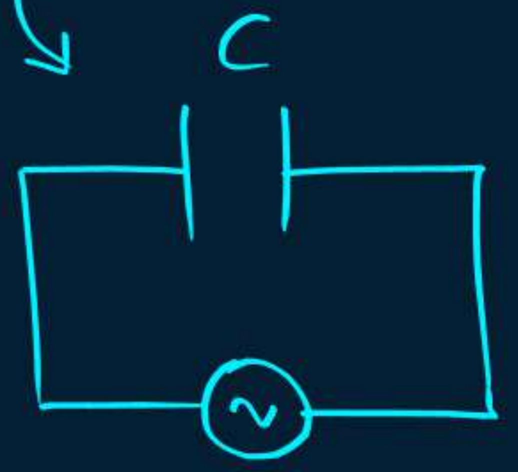
$$X_c = \frac{1}{\omega C}$$

$$X_c = \frac{1}{2\pi \nu C}$$

$$X_c' = \frac{1}{2\pi 2\nu 2C} = \frac{1}{4}\left(\frac{1}{2\pi \nu C}\right)$$

$$X_c' = X/4$$

High pass and Low pass filter



DC : $\nu = 0$

$\omega = 0$

$X_C = \frac{1}{\omega L} = \frac{1}{0}$

$X_C = \infty$

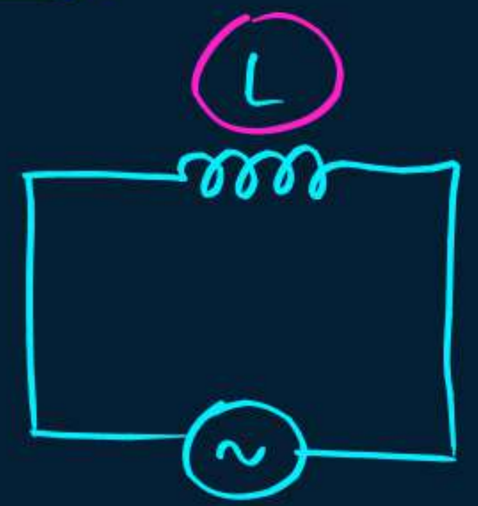
$\boxed{i = 0}$

AC : $\nu \rightarrow$ Very high $\approx \infty$

$\omega \rightarrow \infty$

$X_c = \frac{1}{\omega C} = \frac{1}{\infty} = 0$

$X_c = 0$, $\boxed{i \rightarrow \infty \text{ (Very high)}}$



D.C. : $\nu = 0$

$\omega = 0$

$X_L = \omega L$

$X_L = 0$

$i \rightarrow \infty$

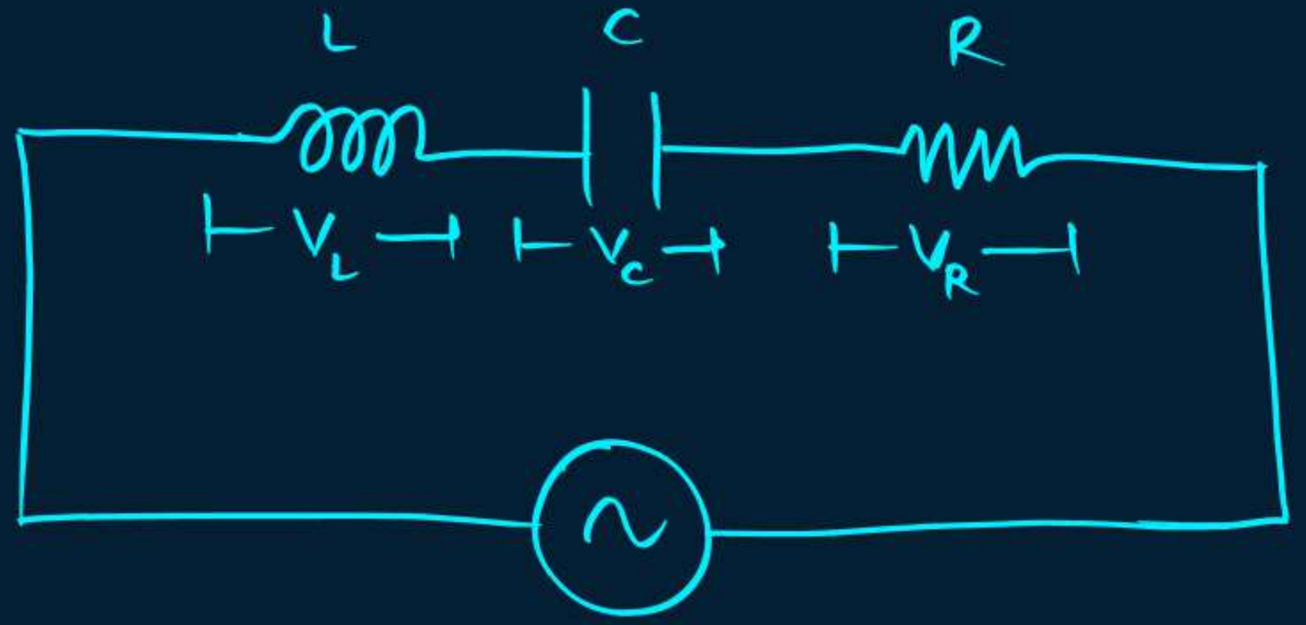
A.C. : $\nu \rightarrow$ Very high $\approx \infty$

$\omega \rightarrow \infty$

$X_L = \omega L = \infty$

$i = 0$

Series LCR Circuit with AC



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

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

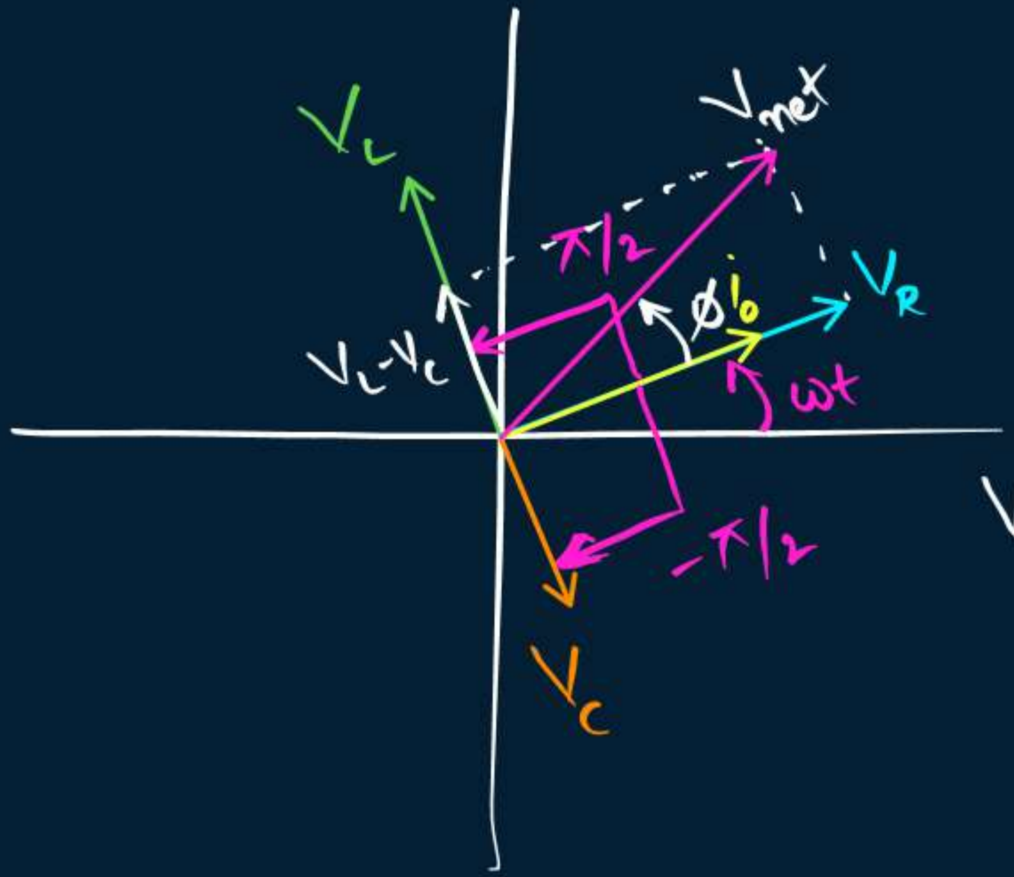
Same phase with i ← $V_R = V_0 \sin\omega t$

lag ← $V_C = V_0 \sin\left(\omega t - \frac{\pi}{2}\right)$

lead ← $V_L = V_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

$$\vec{V}_{net} = \vec{V}_L + \vec{V}_C + \vec{V}_R$$

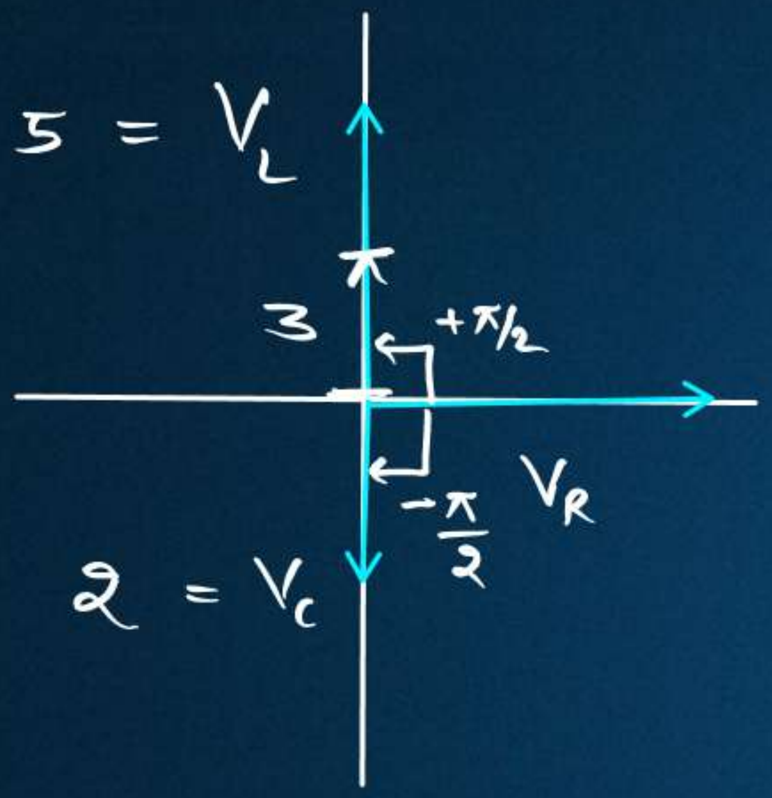
↳ We will use Phasors

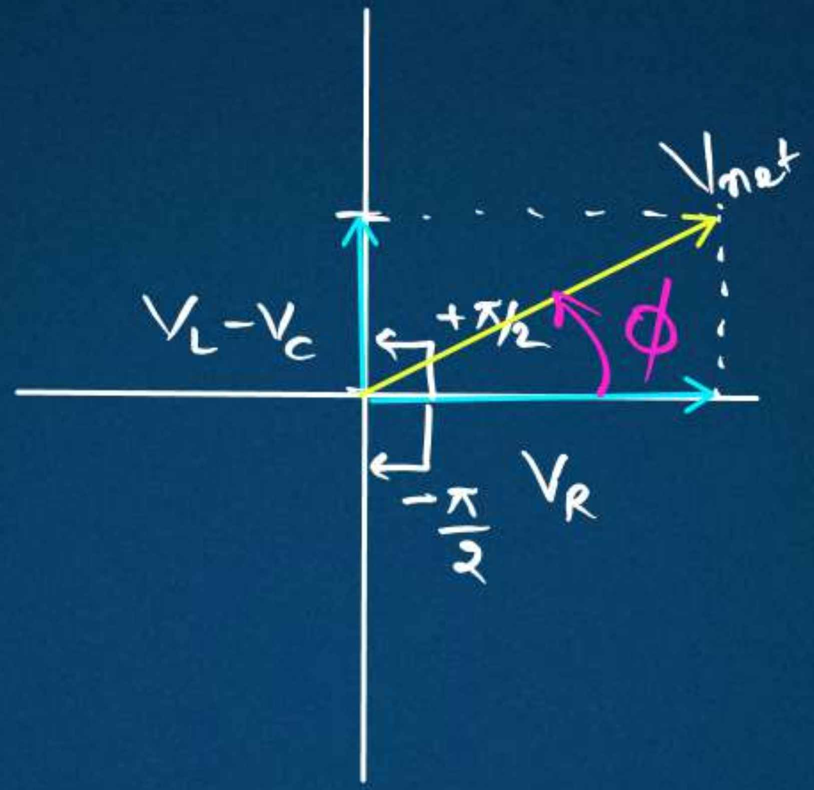


Suppose $V_L > V_C$

$V_L - V_C$

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





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

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

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

$$V_{net} = V_0 \sin(\omega t + \phi)$$

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

$$\boxed{\cos\phi = \frac{V_R}{V_{net}}}$$

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

$$V_{net}^2 = V_R^2 + (V_L - V_C)^2$$

$$(I.Z)^2 = (IR)^2 + (IX_L - IX_C)^2$$

$$\cancel{I^2} Z^2 = \cancel{I^2}\left(R^2 + (X_L - X_C)^2\right)$$

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

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

Impedence is the total opposition offered by Series L-C-R circuit Connected to An A.C. Source

→ Z

→ SI unit → ohm (Ω)

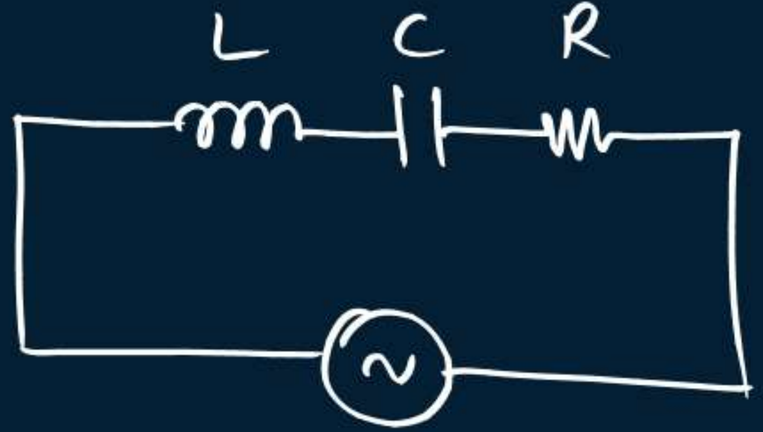
$$\boxed{Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}}$$

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

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

Power factor

Power consumed in series LCR circuit



$$\sin 2\theta = 2\sin\theta\cos\theta$$

$$\sin(A+B) = \sin A\cos B + \cos A\sin B$$

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

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

$$P = Vi$$

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

$$P = V_0 i_0 \sin\omega t\,\underbrace{\sin(\omega t+\phi)}$$

$$P = V_0 i_0 \sin\omega t\left[\sin\omega t\cos\phi + \cos\omega t\sin\phi\right]$$

$$P = V_0 i_0\left[\sin^2\omega t\cos\phi + \sin\omega t\cos\omega t\sin\phi\right]$$

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

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

$$P_{av} = V_0 i_0\left[\langle\sin^2\omega t\rangle\cos\phi + \frac{\langle\sin 2\omega t\rangle\sin\phi}{2}\right]$$

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

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

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

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

P_{av} → True Power

$V_{rms}\, i_{rms}$ → Apparant Power

$\cos\phi$ → Power factor

$\cos\phi$

$\phi = 0^\circ$

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

$\cos 0^\circ = \frac{R}{Z}$

$1 = \frac{R}{Z}$

$\boxed{Z = R}$ → Purely resistive or resonance

$P_{av} = V_{rms}\, i_{rms} \cos\phi$

$\boxed{P_{av} = V_{rms}\, i_{rms}}$ → Purely resistive

$\phi = 90^\circ$

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

$\cos 90 = \frac{R}{Z}$

$0 = \frac{R}{Z}$

$\boxed{R = 0}$

$P_{av} = V_{rms}\, i_{rms} \cos\phi$

$P_{av} = 0$ → Purely capacitive or Purely inductive

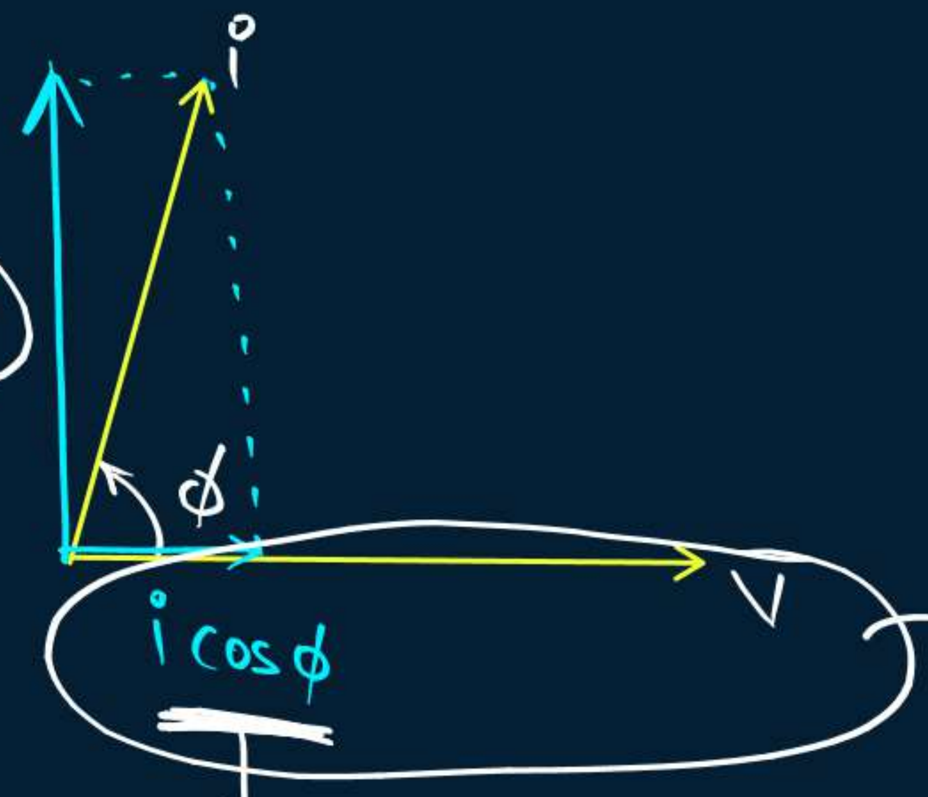
Power

Watt-less current in series LCR circuit

$V = V_0 \sin\omega t$

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

$i\sin\phi$



Power $= Vi\cos\phi$

Watt-less Current

It is the current Which do not contribute in Power of an AC ckt.

$(i\sin\theta \perp V)$

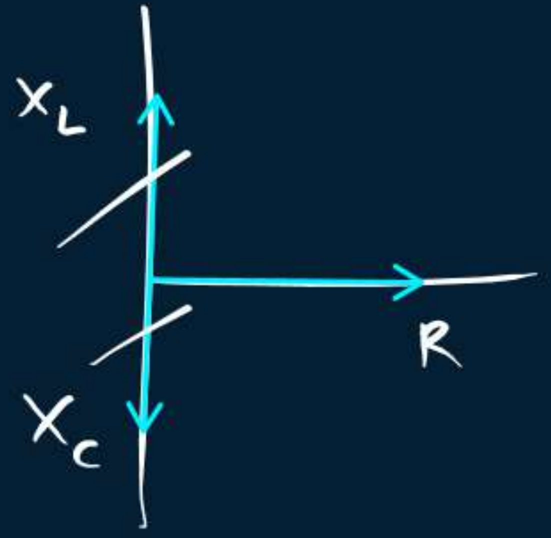
$P = 0$

Watt-full Current

Resonance in LCR series circuit

ir on LCR ckt.

$$\left\{\begin{matrix} X_L = X_C \\ V_L = V_C \end{matrix}\right\}$$



$$X_L = X_C$$

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

$$\omega^2 = \frac{1}{LC} \longrightarrow \boxed{\omega_0 = \frac{1}{\sqrt{LC}}}$$

resonating Ang. freq.

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

$$2\pi\nu_0 = \frac{1}{\sqrt{LC}}$$

$$\boxed{\nu_0 = \frac{1}{2\pi\sqrt{LC}}}$$

resonating frequency

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

$$X_L = X_C$$

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

$$Z = \sqrt{R^2}$$

$$\boxed{Z = R}$$

$$V_{net} = V_R$$

Homework

Likh Kar Practice x 4

DPP Try


PARISHRAM
2026
Lecture-04
Alternating Currents
PHYSICS
Lecture 04
BY - RAKSHAK SIR
Physics Wallah

Topics *to be covered*

1. Resonance Contd. ✓
2. Transformer ✓
3. Practice Questions ✓

Resonance in LCR series circuit

I rise

Z Low

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

$$Z = \sqrt{R^2 + (0)^2}$$

$$Z = \sqrt{R^2}$$

$$Z = R$$

$$V = iZ$$

$$\boxed{V = iR}$$

To create resonance :-

$$X_L - X_C = 0$$

$$X_L = X_C$$

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

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

resonating Ang. frequency

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

→ ckt. ki frequency = Natural frequency

↓

i → Amplitude Rise ↑

Impedence Low ↓

$$V = iZ$$

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

$$V = iZ$$

$$\frac{V}{Z\downarrow} = i\uparrow$$

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

$$2\pi\nu_0 = \frac{1}{\sqrt{LC}}$$

$$\boxed{\nu_0 = \frac{1}{2\pi\sqrt{LC}}}$$

resonating frequency

$$\text{Power} = V_{rms}\, i_{rms} \cos\phi$$

$$P_{av} = V_{rms}\, i_{rms}\,(1)$$

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

$$= \frac{V_0}{\sqrt{2}}\,\frac{i_0}{\sqrt{2}}$$

$$\boxed{P_{av} = \frac{V_0 i_0}{2}}$$

<u>Power factor</u>

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

At resonance,

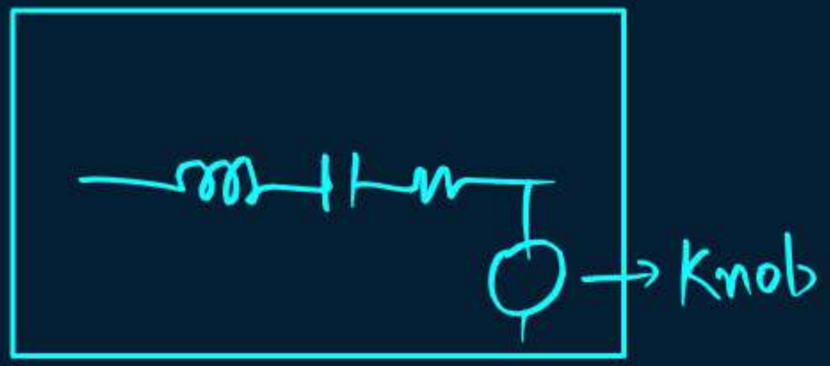
$$Z = R$$

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

$$\cos\phi = 1$$

$$\phi = 0^\circ$$

Example of Radio Tuning



$X_L = X_C$

$\downarrow$

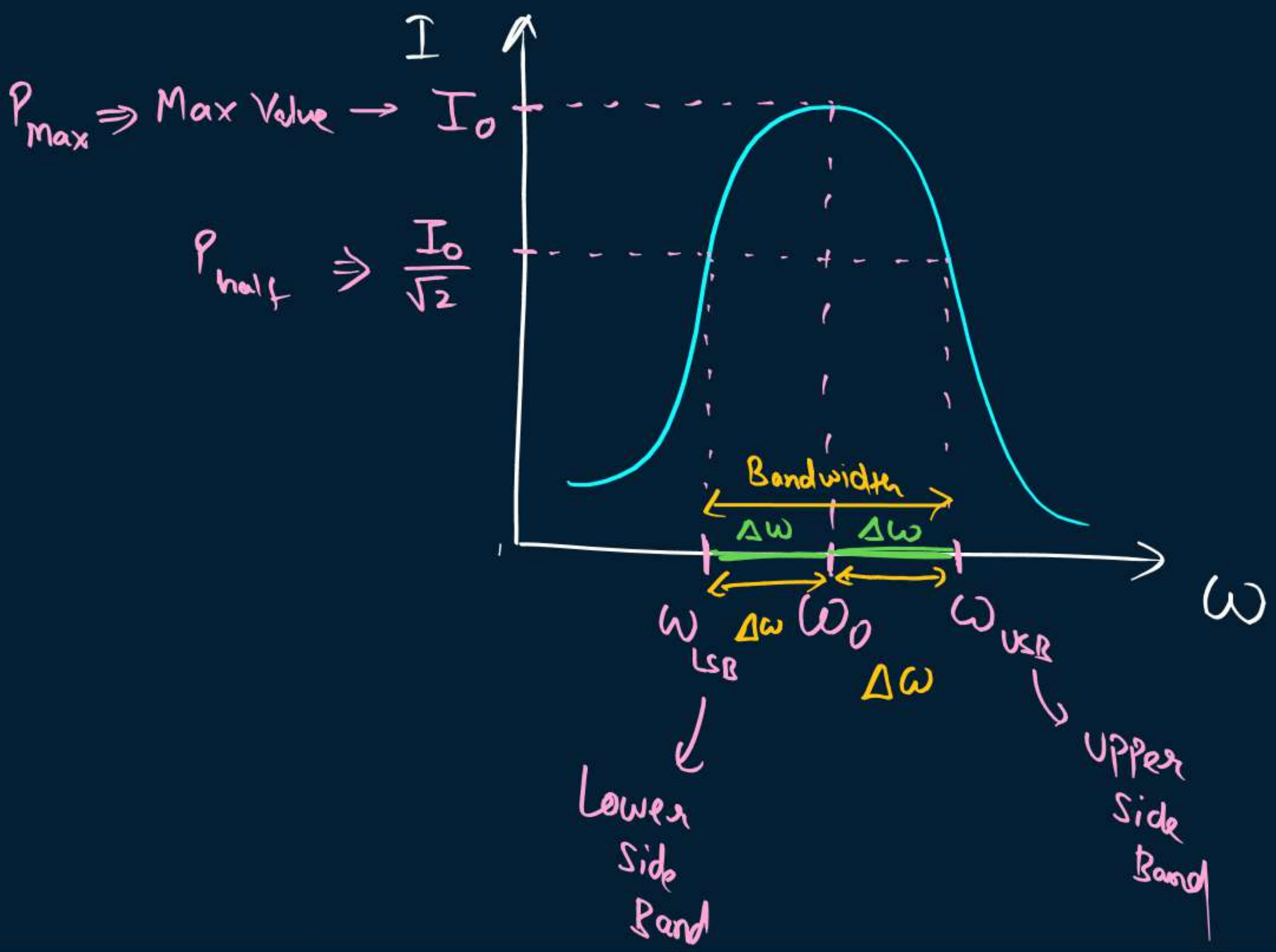
Resonance

$i \uparrow$

$C \rightarrow$ change

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

Graph

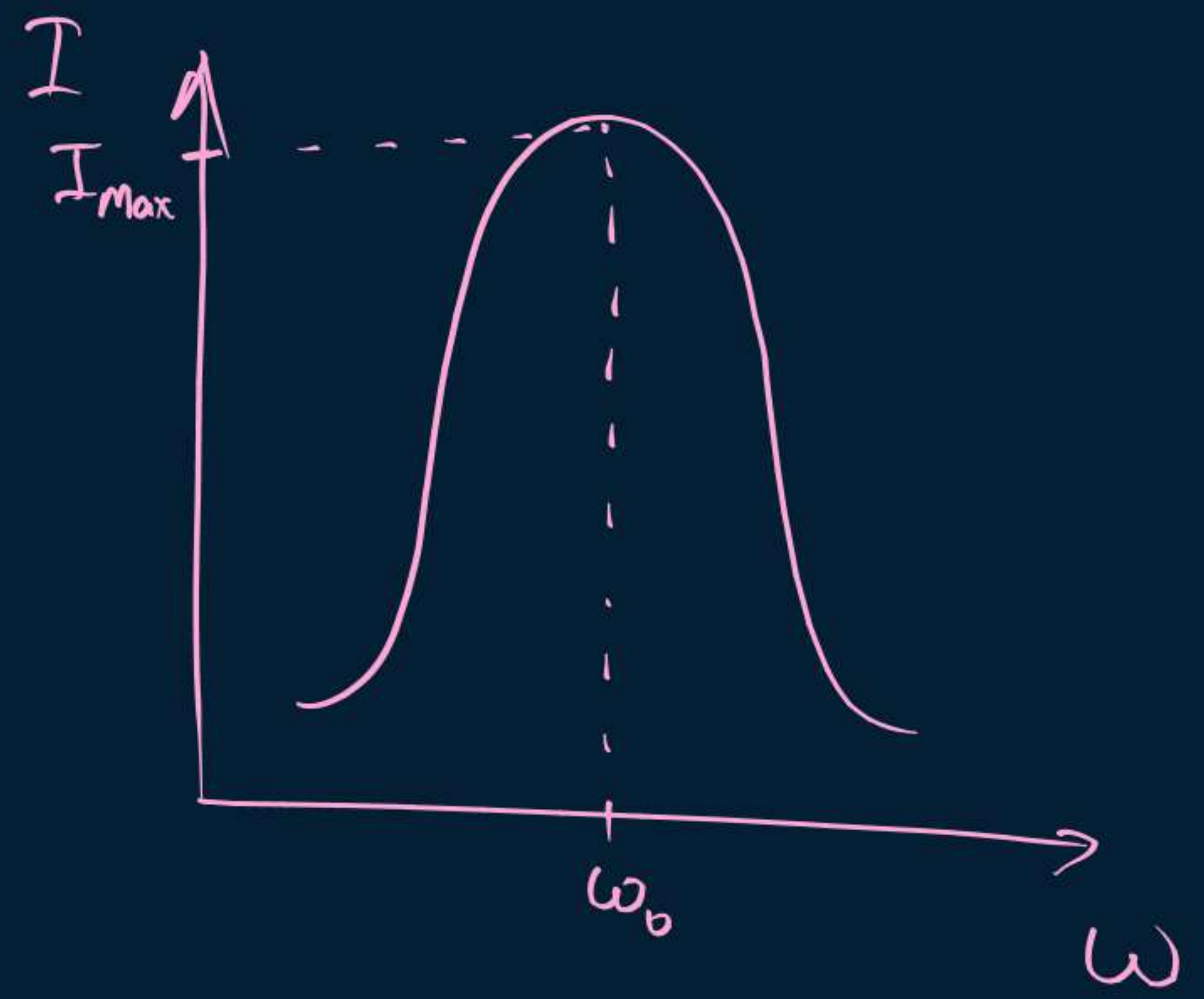


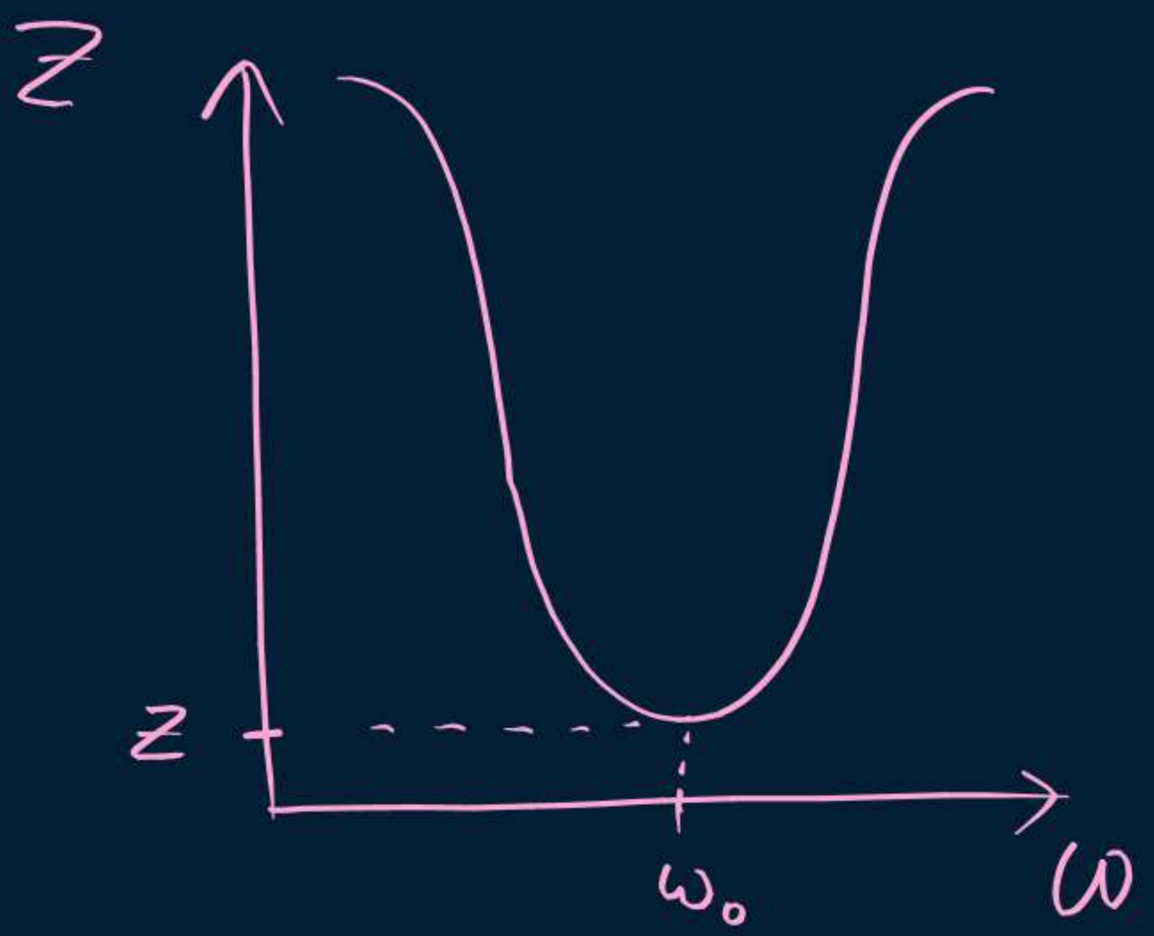
92.6
92.7 MHz
92.8

$$\boxed{\text{Bandwidth} = 2\Delta\omega = \frac{R}{L}}$$

$$\Delta\omega = \omega_{USB} - \omega_0$$

$$\Delta\omega = \omega_0 - \omega_{LSB}$$


I
I_max
ω₀
ω


Z
Z
ω₀
ω

Quality factor / Sharpness of a Circuit (Q)

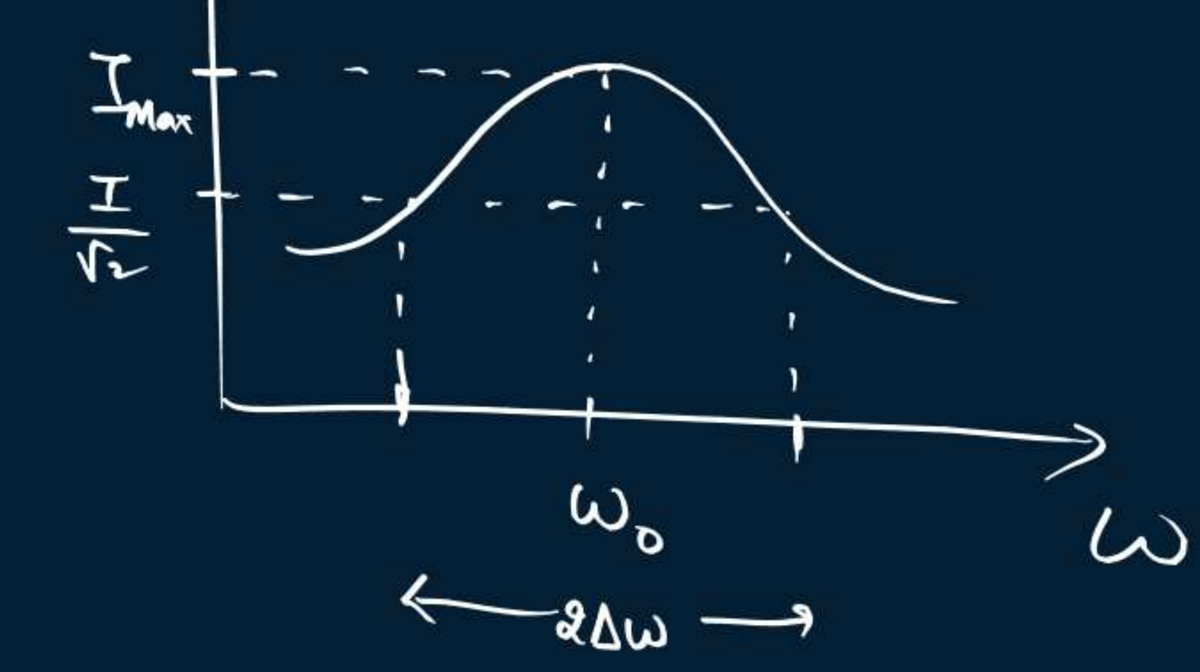
Q- factor

$$\boxed{Q = \frac{\omega_0}{2\Delta\omega}}$$

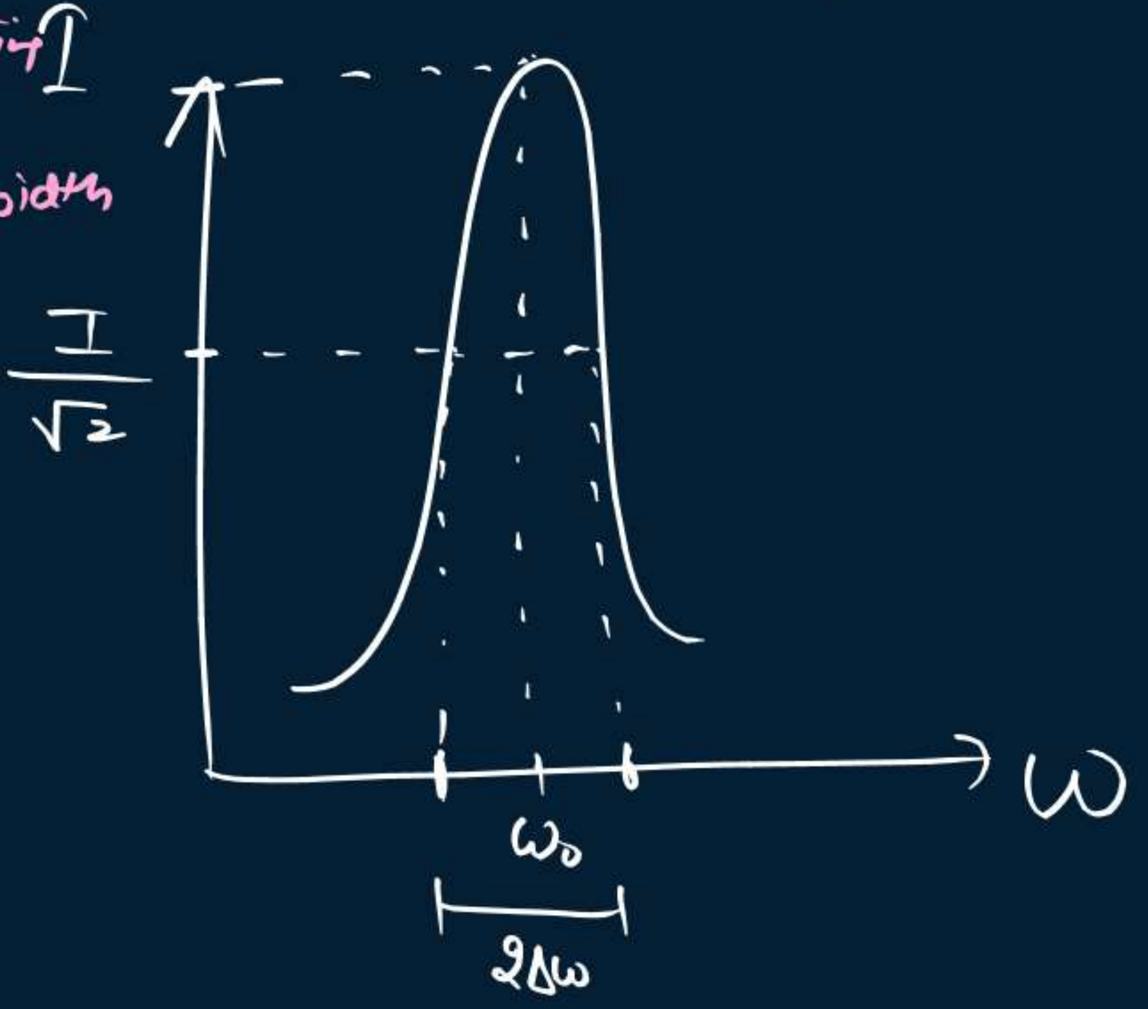
quality factor

ω_0 → resonating freq

$2\Delta\omega$ → Bandwidth

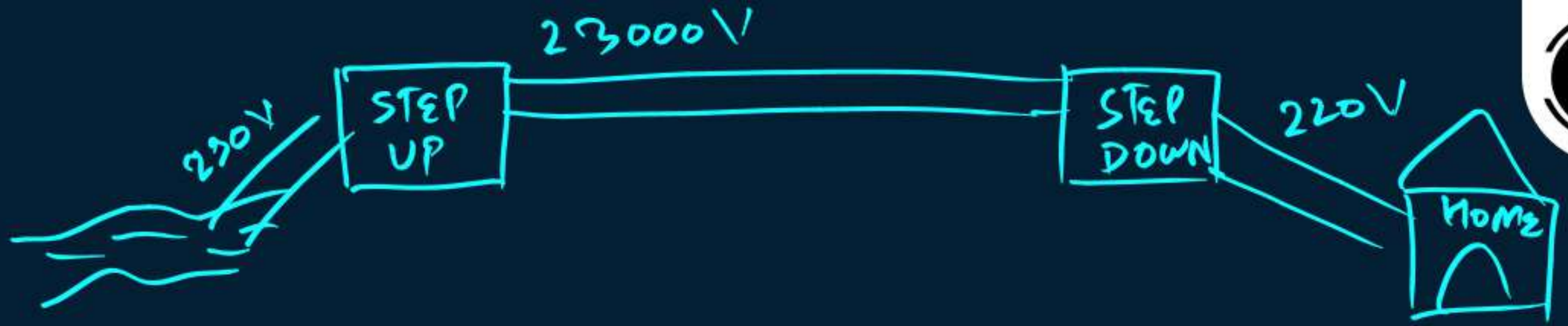


Q ↓



Q ↑

Transformer



To step up or step down the voltage.

Principle :- Based on mutual inductance between two coils. Whenever there is change in current in primary coil, there is emf induced in the secondary coil.

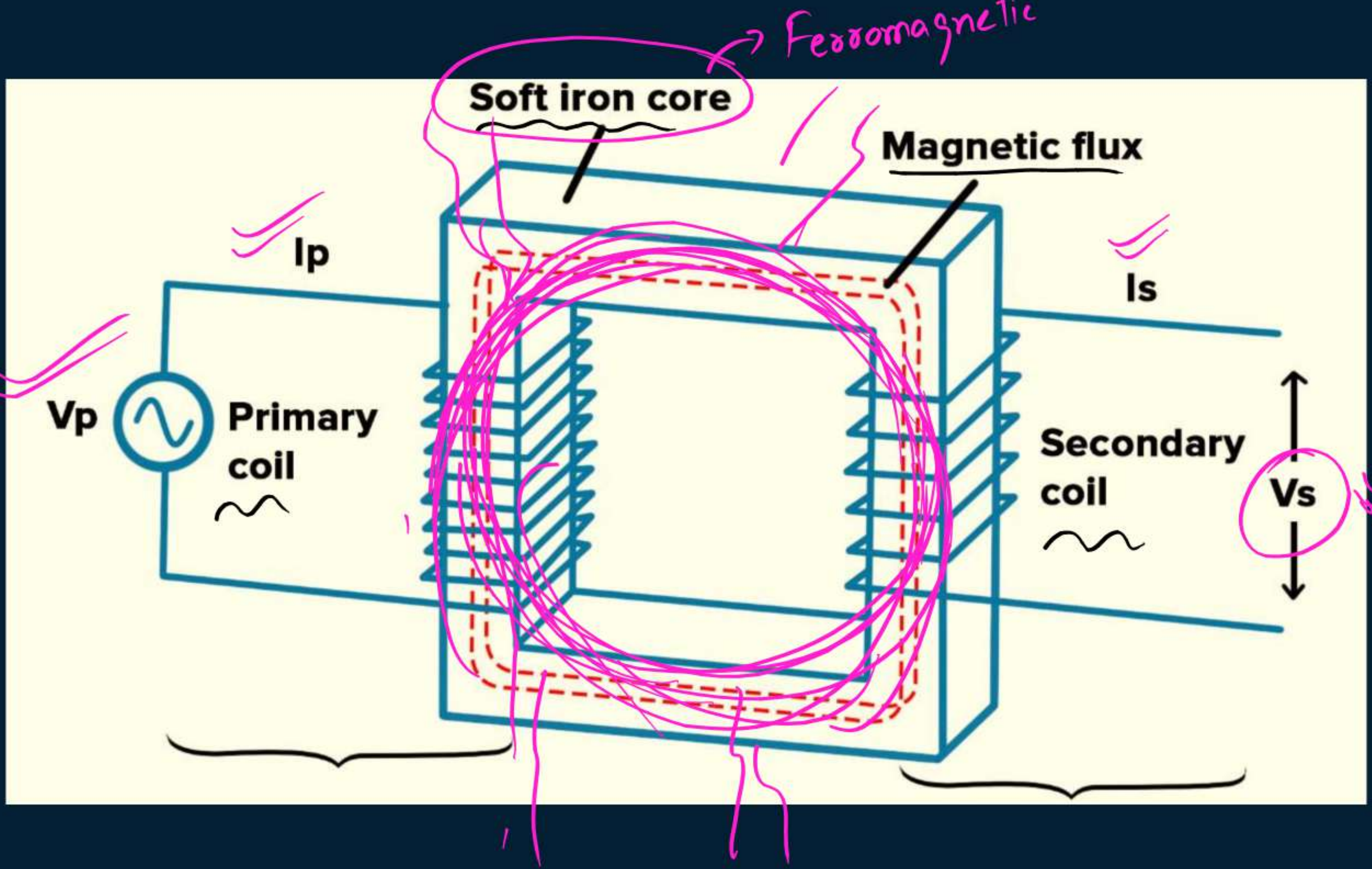
Asli Transformer

OPTIMUS
PRIME !!!

Construction and Working

V_p - Primary emf

i_p - Primary current

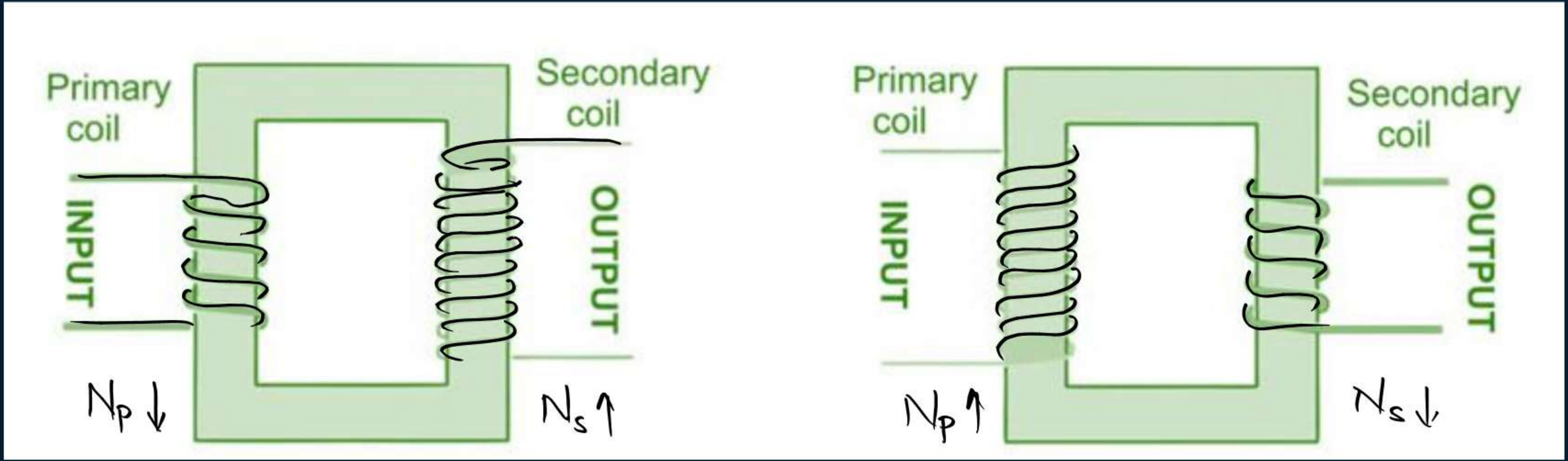


V_s - Secondary emf

i_s - Secondary Current

a. Step-up Transformer

b. Step-down Transformer



$\mathcal{E}_p \downarrow$ $\quad \mathcal{E}_e \propto N$ $\quad \mathcal{E}_s \uparrow$ $\quad\quad \mathcal{E}_p \uparrow$ $\quad \mathcal{E}_s \downarrow$

$i_p \uparrow$ $\quad i_s \downarrow$ $\quad\quad i_p \downarrow$ $\quad i_s \uparrow$

Ideal Transformer

$$\varepsilon \propto N \propto \frac{1}{i}$$

$$P_{input} = P_{output}$$

$$\varepsilon_p i_p = \varepsilon_s i_s$$

Sach

$$\boxed{\frac{N_p}{N_s} = \frac{\varepsilon_p}{\varepsilon_s} = \frac{i_s}{i_p}}$$

$$\varepsilon \propto N \propto \frac{1}{i}$$

Non - Ideal Transformer

$$P_{in} > P_{out}$$

effeciency of a Transformer

$$\boxed{\%\eta = \frac{P_s}{P_p} \times 100}$$

'Eta'

ideal transformer $\Rightarrow \eta = 100\%$

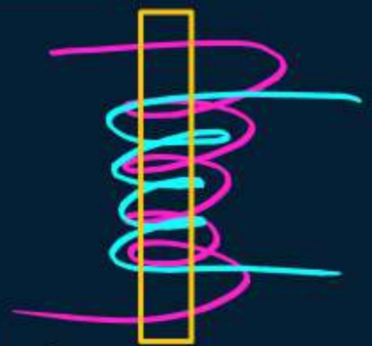
Losses in Transformer:

laquer

1. **Copper Loss:** Due to resistance of the windings, the heat is produced. To reduce it, we use thick wires.

   A↑ R↓

2. **Iron Losses:** Due to eddy currents being produced in the soft iron core, heat is produced. To reduce it we, use laminated core. ⇒ laquer (insulated Material)



3. **Flux Loss:** To reduce it, we mount both coils on a single vertical pole.

4. **Hysterisis Loss:** Due to repeated magnetization and de – magnetization, there will be magnetic fatigue. There will be more energy losses.

5. **Magneto-striction:** Due to humming noise of the transformer.

QUESTION - 7.1

A 100 resistor is connected to a 220 V, 50 Hz ac supply.

(a) What is the rms value of current in the circuit?

(b) What is the net power consumed over a full cycle?

$$P_{av} = V_{rms}\, i_{rms} \cos\phi$$

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

$$= 22\cancel{0} \times 2.2$$

$$= 484\ W$$

$V_{rms} = 220V$

$i_{rms} = ?$

$$V_{rms} = i_{rms} R$$

$$220 = i_{rms} \times 100$$

$$i_{rms} = \frac{22\cancel{0}}{10\cancel{0}} = 2.2A$$

QUESTION - 7.2

(a) The peak voltage of an ac supply is 300 V. What is the rms voltage?
(b) The rms value of current in an ac circuit is 10 A. What is the peak current?

b) $i_{rms} = 10A$

$i_0 = ?$

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

$$10 = \frac{i_0}{\sqrt{2}}$$

$$i_0 = 1.414 \times 10 = 14.14\,A$$

a) $V_0 = 300\,V$

$$V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{300}{\sqrt{2}}\,V$$

QUESTION - 7.3

V_{rms}

A 44 mH inductor is connected to 220 V, 50 Hz ac supply. Determine the rms value of the current in the circuit.

$L = 44 \times 10^{-3}$ H

$V_{rms} = 220$ V

$\nu = 50$ Hz

$i_{rms} = ?$

$V = IR$

$V_{rms} = I_{rms} X_L$

$V_{rms} = I_{rms}\, \omega L$

$V_{rms} = I_{rms}\, 2\pi\nu L$

$220 = I_{rms} \times 2 \times 3.14 \times 50 \times 44 \times 10^{-3}$

QUESTION - 7.4

A 60 uF capacitor is connected to a 110 V, 60 Hz ac supply. Determine the rms value of the current in the circuit.

$$C = 60\,\mu F = 60 \times 10^{-6}\,F$$

$$V_{rms} = 110\,V$$

$$\nu = 60\,Hz$$

$$i_{rms} = ?$$

$$V = IR$$

$$V_{rms} = I_{rms} X_C$$

$$V_{rms} = I_{rms} \frac{1}{\omega C}$$

$$V_{rms} = I_{rms} \frac{1}{2\pi\nu C}$$

$$V_{rms}\, 2\pi\nu C = I_{rms}$$

$$110 \times 2 \times 3.14 \times 60 \times 60 \times 10^{-6} = I_{rms}$$

QUESTION - 7.5

In Exercises 7.3 and 7.4, what is the net power absorbed by each circuit over a complete cycle. Explain your answer.

7.3 → Pure Inductive ($\phi = 90^\circ$)

7.4 → Pure Capacitive ($\phi = 90^\circ$)

$$P_{av} = V_{rms}\, i_{rms} \cos\phi$$

$$= V_{rms}\, i_{rms} \cos(90^\circ)$$

$$P_{av} = 0$$

QUESTION - 7.6

A charged 30 μF capacitor is connected to a 27 mH inductor. What is the angular frequency of free oscillations of the circuit?

$$\omega = ?$$

$$C = 30\,\mu F = 30 \times 10^{-6}\,F$$

$$L = 27\,mH = 27 \times 10^{-3}\,H$$

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

$$\omega = \frac{1}{\sqrt{}}$$

rad/sec

QUESTION - 7.7

A series LCR circuit with R= 20 Ohm, L= 1.5 H and C= 35 uF is connected to a variable-frequency 200 V ac supply.
When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one complete cycle?

Resonance ($Z = R$)

$V_{rms} = 200\,V$

$i_{rms} = ?$

$V_{rms} = i_{rms} Z$

$V_{rms} = i_{rms} R$

$\cancel{200}^{10} = i_{rms} \times \cancel{20}$

$i_{rms} = 10\,A$

$P_{av} = V_{rms} i_{rms} \cos\phi$

$= V_{rms} i_{rms}$

$= 200 \times 10$

$= 2000$ Watt

QUESTION - 7.8

$V_{rms} = i_{rms} Z$

$230 = i_{rms} R$

V_{rms}

A series LCR circuit connected to a variable frequency 230 V source.
L = 5.0 H, C = 80uF, R = 40 Ohm.

(a) Determine the source frequency which drives the circuit in resonance.

(b) Obtain the impedance of the circuit and the amplitude of current at the resonating frequency.

(c) Determine the rms potential drops across the three elements of the circuit. Show that the potential drop across the LC combination is zero at the resonating frequency.

a) $\omega_0 = \frac{1}{\sqrt{LC}}$

rad/sec

b) At resonance

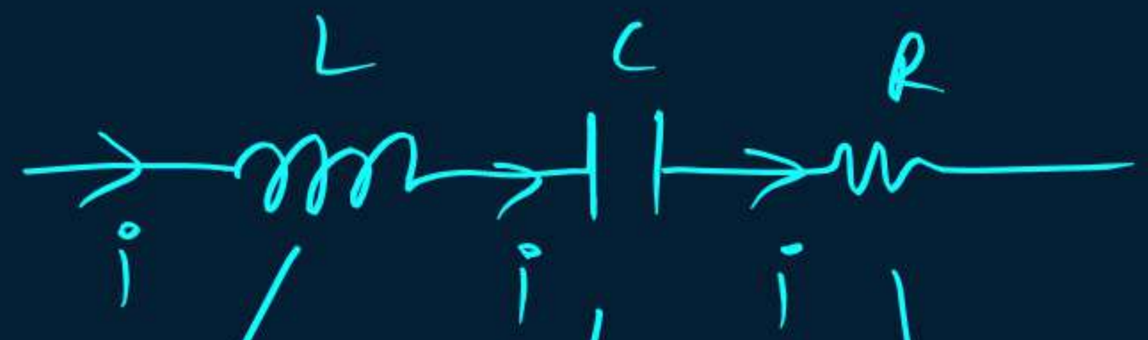
$Z = R$

$Z = 40\,\Omega$

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

$i_0 = \sqrt{2}\, i_{rms}$

c)



$V_L = I X_L$

$= I_{rms}\,\omega L$

$V_C = I X_C$

$= \dfrac{I_{rms}}{\omega C}$

$V_R = I R$

$= I_{rms} R$

Homework

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