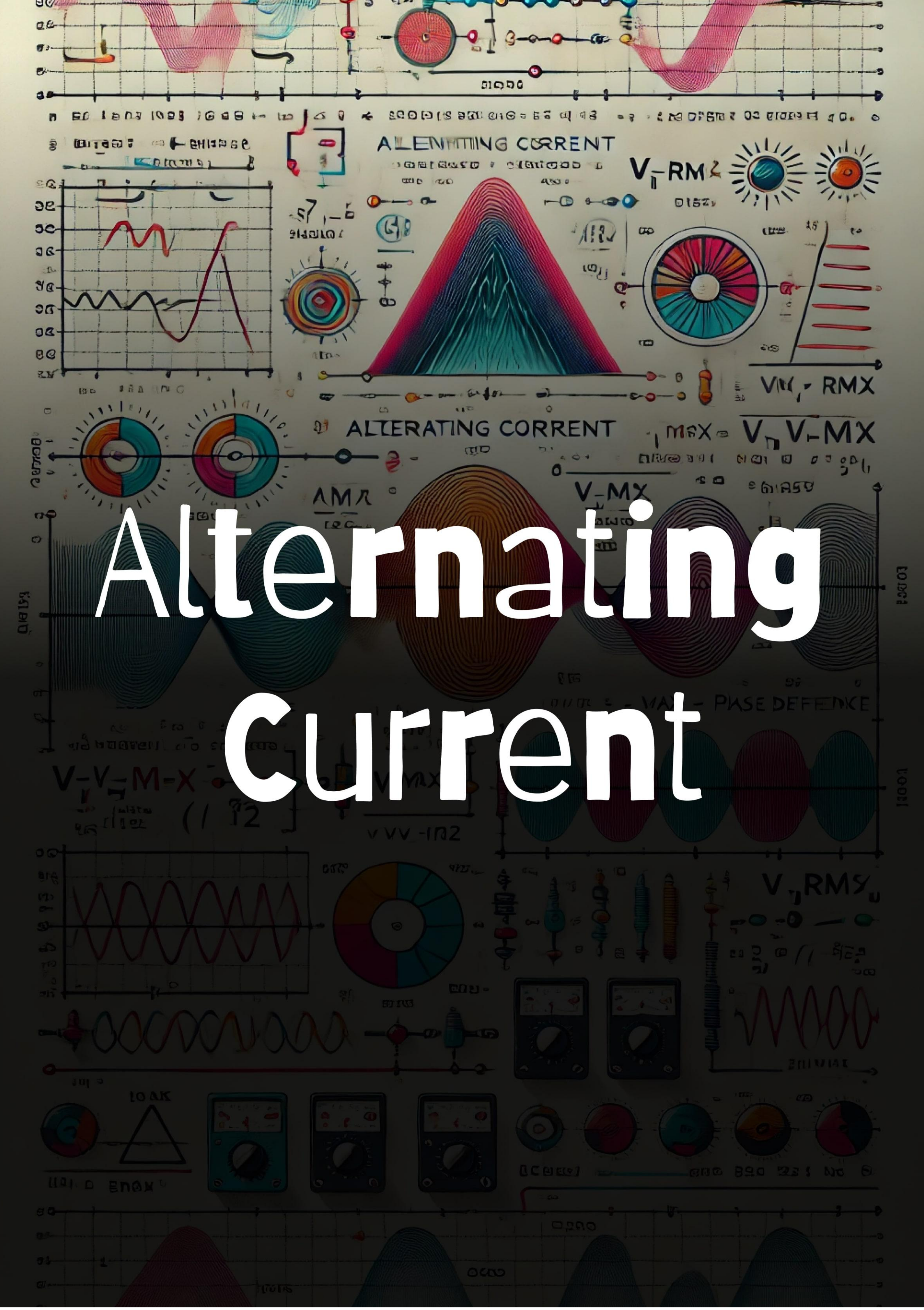
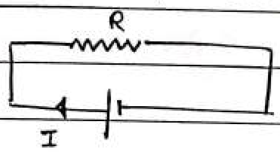
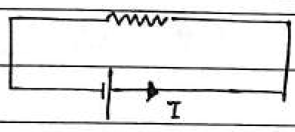


Alternating Current

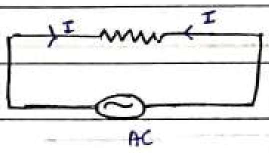
ALTERNATING CURRENT

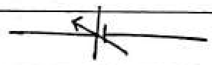
DC current
↓
unidirectional current





A/c Current
↓
Bi-directional current is called A/c





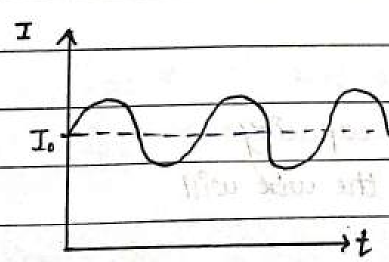
Variable DC source

it does not meant constant current, it means same direction.

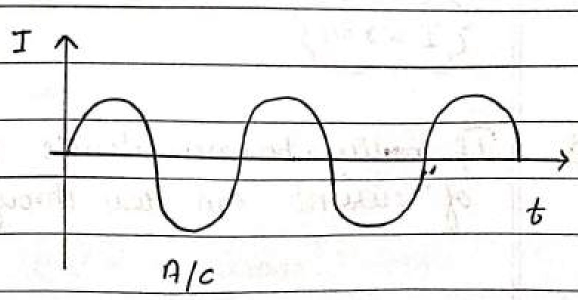
Q A current is varying from +5A to +15 Amp Sinusoidally then this current is.

a) AC

~~b)~~ DC because the current is always positive

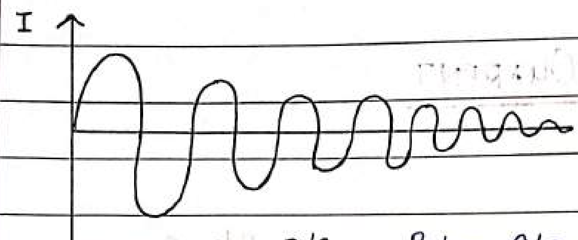


D/C

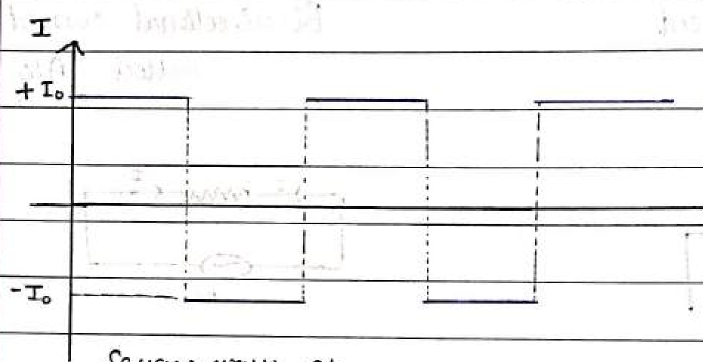


A/c

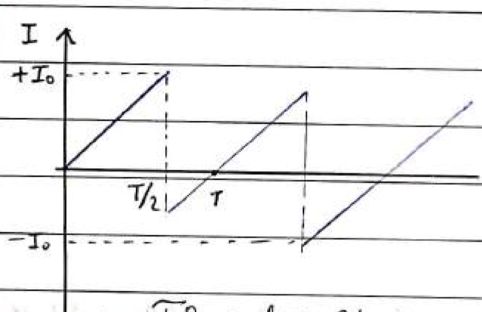
Sine wave A/c

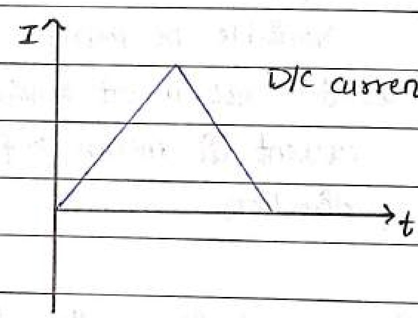


A/C Bekar A/C



Square wave A/C





Triangular A/C

D/C current

D/C flows through cross section area of wire
↳ use single wire

$I \propto r^{3/2}$

Q. If radius becomes double then capacity of current can flow through the wire will

ANS $\frac{I_1}{I_2} = \frac{r_1^{3/2}}{r_2^{3/2}}$

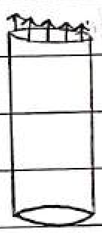
$$\frac{I_1}{I_2} = \left(\frac{\cancel{r}}{2\cancel{r}}\right)^{3/2}$$

$$\frac{I_1}{I_2} = \frac{1}{(2)^{3/2}}$$

$$I_2 = I_1 (2)^{3/2}$$

$$I_2 = 2\sqrt{2}\, I_1$$

But A/C flows through surface area.



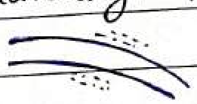
due to variable current
↳ magnetic flux would change
↳ ∴ high resistance will develop across the cross section area
↓
hence current prefer to go from surface area
↓
hence we prefer multiwise connection for A/C

DISADVANTAGE OF D/C

D/C can't be supply over large distance
Power loss is maximum in transmission
D/C supply at constant voltage (Can't be step-up and step down)

$I_{D/C} \propto r^{3/2}$ (cross section area)
$I_{A/C} \propto$ surface area

Disadvantage of A/C → skin effect and Corona discharge.



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5) A/C can't be stored
6) DC can be stored

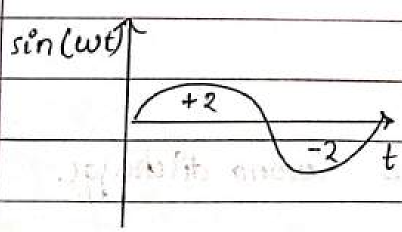
D/C current is measured by moving coil galvanometer.
A/C ($f = 100\ Hz$) can't be measured by moving coil galvanometer due to inertia.

Moving coil galvanometer	Hot wire ammeter
Torque on current carrying coil	Heat loss
Only D/C can be measure	Both A/C & D/C can be measured
$\theta \propto I$	$\theta \propto I^2$
Linear scale	Non linear scale

Find average value of $\sin(\omega t)$ in full cycle?

Ans $\langle \sin(\omega t) \rangle = \dfrac{\int_0^T \sin(\omega t)\,dt}{\int_0^T dt} = \dfrac{-[\cos(\omega t)]_0^T}{\omega (t)_0^T} = -\dfrac{1}{\omega T}\left[\cos\left(\frac{2\pi}{T} \times T\right) - \cos 0\right]$

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



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$\langle \cos \omega t \rangle_{\text{full cycle}} = 0$

$\langle \sin(\omega t) \cdot \cos(\omega t) \rangle = 0$

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

$\sin(2\theta) = 2\sin\theta \cdot \cos\theta$

$\langle \sin(\omega t + \frac{\pi}{6}) \rangle_{\text{full cycle}} = 0$

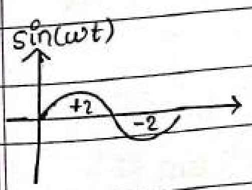
Find average of $\sin(\omega t)$ in half cycle.

$$\langle \sin(\omega t) \rangle_{\text{Half cycle}} = \frac{\int_0^{T/2} \sin(\omega t)\, dt}{\int_0^{T/2} dt} = \frac{-[\cos(\omega t)]_0^{T/2}}{\omega (t)_0^{T/2}} = -\left[\frac{\cos\left(\frac{2\pi}{T} \times \frac{T}{2}\right) - \cos 0}{\omega \times T/2}\right]$$

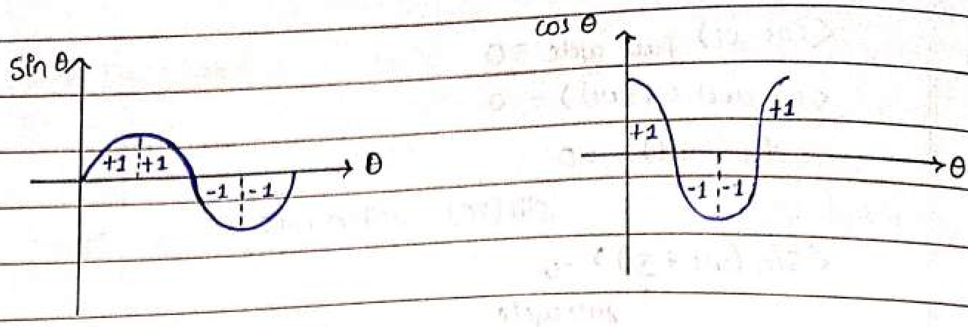
$$= -\frac{[\cos \pi - 1]}{\frac{\omega T}{2}}$$

MR*

$$\langle \sin(\omega t) \rangle_{\text{Half cycle}} = \frac{\frac{1}{\omega}\int^{T/2} \sin(\omega t)\, d\omega t}{\int_0^{T/2} dt} = \frac{-[-1-1]}{\frac{2\pi}{T} \cdot \frac{T}{2}} = \frac{2}{\pi}$$



$$\Rightarrow \frac{1 \times 2}{\omega \times \frac{T}{2}} = \frac{2}{\frac{2\pi}{T} \times \frac{T}{2}} = \frac{2}{\pi}$$



* $\langle \cos(\omega t)\rangle_{\text{Half cycle}} = \frac{2}{\pi}$
* $\langle \cos(\omega t)\rangle_{\text{full cycle}} = 0$
* $\langle \sin(\omega t)\rangle_{\text{Half cycle}} = \frac{2}{\pi}$
* $\langle \sin(\omega t)\rangle_{\text{full cycle}} = 0$
* $\langle \sin^2(\omega t)\rangle_{\text{full cycle}} = \frac{1}{2}$
* $\langle \sin^2(\omega t)\rangle_{\text{Half cycle}} = \frac{1}{2}$

$\langle \cos^2(\omega t)\rangle_{\text{full / Half}} = \frac{1}{2}$

$$\langle \sin^2(\omega t)\rangle = \frac{\int_0^T \sin^2(\omega t)\,dt}{\int_0^T dt} \qquad \sin^2(\omega t) = \frac{1-\cos(2\omega t)}{2}$$

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

0 (for full cycle)

$$\Rightarrow \frac{\frac{1}{2}T}{T} = \frac{1}{2}$$

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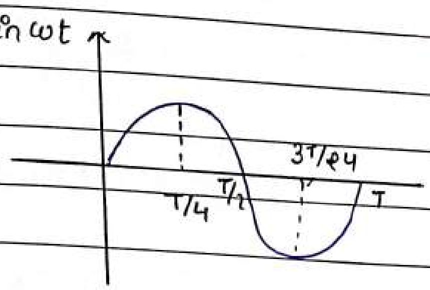
Q Avg value of $\sin(\omega t)$ in half cycle may be??

(a) zero (b) $2/\pi$ (c) $1/\pi$ (d) both (a) and b



$\langle \sin(\omega t)\rangle_{Half\ cycle} = 0$

when I consider from $T/4$ to $3T/4$

$\langle \sin^2(\omega t)\rangle_{full/half} = \frac{1}{2}$

$\langle \sin(\omega t)\rangle_{full} = \langle \cos(\omega t)\rangle_{half/full} = 0$

$\langle \sin(\omega t).\cos(\omega t)\rangle_{full} = 0$

$\langle \sin(\omega t)\rangle_{Half\ cycle} = 2/\pi$

ALTERNATING CURRENT [Sinusoidal] AC

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

I_0 = maximum current (Peak current)

I = Instantaneous current

ω = Angular frequency

ϕ = Phase difference (initial)

R.M.S. current = root mean square current

$I_{Rms} = \sqrt{\langle I^2\rangle}$

$I_{Rms} = \sqrt{\langle I_0^2 \sin^2(\omega t+\phi)\rangle}$

$I_{Rms} = \frac{I_0}{\sqrt{2}}$

$\langle I\rangle_{Half} = \langle I_0 \sin(\omega t+\phi)\rangle_{Half} = I_0 \langle \sin(\omega t+\phi)\rangle_{Half} = \frac{2I_0}{\pi}$

$\langle I\rangle_{full} = 0$

Q Electricity bill me kiska paisa dete hai ?

a) current (b) voltage
c) Power ~~(d)~~ Heat

$H = I_{DC}^2 Rt$ — ①

$\langle H \rangle = \langle I_{A/C}^2 \rangle Rt$ — ②

① = ②

$I^2_{DC} \cancel{Rt} = \langle I^2_{A/C} \rangle \cancel{Rt}$

effective current of A/C

$I_{D/C} = \sqrt{\langle I^2_{AC} \rangle} = I_{Rms}$ ← virtual current

Hot wire ammeter reads this current.

$\boxed{I_{AD/C} = I_{Rms}}$

Q The voltage of domestic AC is 220V. what does this represent.

1) Mean voltage 2) Peak voltage
3) Root mean voltage ~~4)~~ Root mean square voltage.

Q The equation of an alternating voltage is $v = 100\sqrt{2} \sin 100\pi t$ volt. The Rms value of voltage and frequency will be.

~~a)~~ 100V, 50Hz (b) 50V, 100Hz
c) 150V, 50 Hz (d) 200V, 50 Hz

Ans $Rms = \frac{V_0}{\sqrt{2}} = \frac{100\cancel{\sqrt{2}}}{\cancel{\sqrt{2}}} = 100$

$100\cancel{\pi} = 2\cancel{\pi} f$

$f = 50$ Hz

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Q Equation of alternating current is given by $I = 10\sqrt{2}\sin(100\pi t + \frac{\pi}{6})$. The time taken by current to reach the root mean square value from t=0 is t then the value of t is.

(a) $\frac{1}{1200}$ s (b) $\frac{1}{250}$ s

c) $\frac{1}{200}$ s (d) $\frac{1}{800}$ s

Ans $I = \frac{I_0}{\sqrt{2}} = \frac{10\sqrt{2}}{\sqrt{2}} = 10$

$\cancel{10} = 1\cancel{0}\sqrt{2}\sin(100\pi t + \frac{\pi}{6})$

$100\pi t + \frac{\pi}{6} = \frac{\pi}{4}$

$100\cancel{\pi}t = \frac{\cancel{2\pi}}{\cancel{24}\,12}$

$t = \frac{1}{1200}$ s

Q In the AC current, the current is expressed as $I = 100\sin 200\pi t$. In this circuit the current rises from zero to peak value in time

(a) $\frac{1}{400}$ s (b) $\frac{1}{300}$ s

c) $\frac{1}{100}$ s (d) $\frac{1}{200}$ s

Ans $1\cancel{0}0 = \cancel{100}\sin 200\pi t$

$200\cancel{\pi}t = \frac{\cancel{\pi}}{2}$

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

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Q The phase difference between current and voltage in term an AC circuits is $\frac{\pi}{4}$ radian. If the frequency of AC is 50 Hz, then the phase difference is equivalent to the time difference of.

a) 0.75 s (b) 10.5 ms
c) 2.5 ms (d) 0.25 m/s

MIT
$$\boxed{\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda} = \frac{\Delta t}{T}}$$

ANS $\frac{\Delta\phi}{2\pi} T = \Delta t$

$$\Delta t = \frac{\pi}{4\times 2\pi}\frac{1}{f} = \frac{1}{8}\times\frac{1}{50}$$

$$\Delta t = \frac{\cancel{1000}^{2.5}}{\cancel{400}}\times 10^{-3} = 2.5\,ms$$

Q The peak value of an alternating emf $E = E_0 \sin \omega t$ is 10 volt and its frequency is 50 Hz.
At a time $t = \frac{1}{600}$ the instantaneous value of the emf is.

1) 1 volt 2) $5\sqrt{3}$ v
3) 5 volt 4) 10V

ANS $E = 10 \sin \cancel{2}\pi \cancel{50} \times \frac{1}{\cancel{600}\,\cancel{12}\,6}$

$$E = 10\times\frac{1}{2} = 5V$$

Q The time required for a 50 Hz sinusoidal alternating current to change its value from zero to the rms value.

a) 1.5×10^{-2} s (b) 2.5×10^{-3} s
c) 10^{-1} s (d) 10^{-6} s

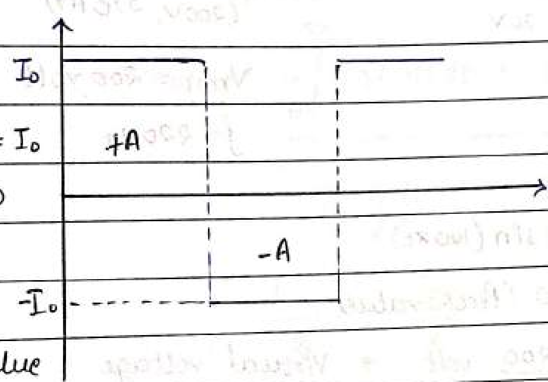
Ans $I = I_0 \sin(\omega t)$

$$\frac{\cancel{I_0}}{\sqrt{2}} = \cancel{I_0} \sin(2\pi f\, t)$$

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

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

$$t = \frac{1000 \times 10^{-3}}{400} = 2.5 \times 10^{-3} s$$



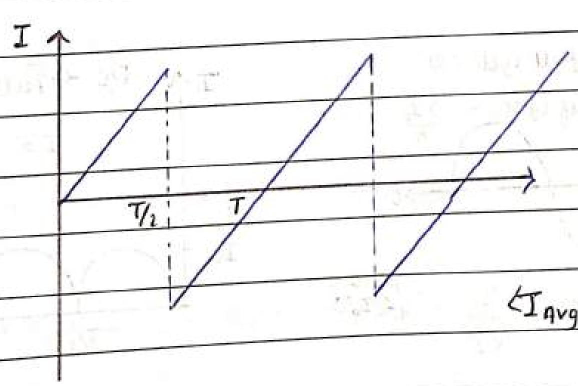
$(I_{Avg})_{Half} = I_0$

$(I_{Avg})_{full} = 0$

$(I_{Rms}) = I_0$

since value of I_0 is same, only direction is changing.

Square wave A/C



$$(I_{Avg})_{Half} = \frac{\int_0^{T/2} I.dt}{\int_0^{T/2} dt}$$

$$= \frac{\frac{1}{2} \times \frac{\cancel{T}}{2} \times I_0}{\frac{\cancel{T}}{2}}$$

$$= \frac{I_0}{2}$$

$\langle I_{Avg} \rangle_{full} = 0$

$$I_{Rms} = \frac{I_0}{\sqrt{3}}$$

If $I = 10 \sin\left(\omega t + \frac{\pi}{6}\right)$ then find Avg current

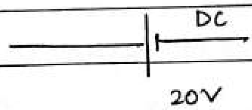
→ $\langle I \rangle_{full} = 0$

$\langle I \rangle_{Half} = \frac{2 I_0}{\pi} = \frac{20}{\pi}$

$\langle I \rangle_{rms} = \frac{10}{\sqrt{2}}$ Amp

↑

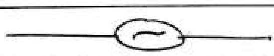
Half / full



(200V, 220 Hz)

$V_{rms} = 200$ volt

$f = 220 Hz$



$V = 200 \sin(100\pi t)$

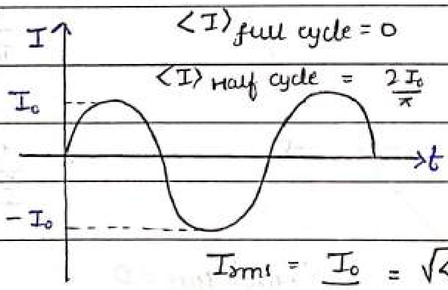
$V_0 = 200$ (Peak value)

$V_{rms} = \frac{200}{\sqrt{2}}$ volt → Virtual voltage
effective voltage
reading of voltmeter

$(V_{Avg})_{Half} = \frac{2 \times 200}{\pi}$

$\langle I \rangle_{full\ cycle} = 0$

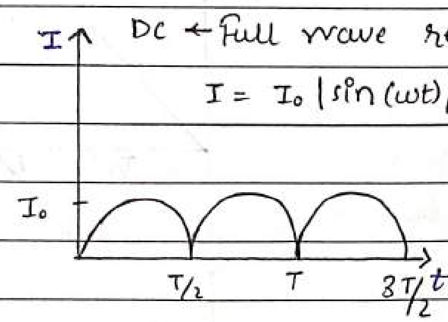
$\langle I \rangle_{Half\ cycle} = \frac{2 I_0}{\pi}$



$I_{rms} = \frac{I_0}{\sqrt{2}} = \sqrt{\langle I_0^2 \rangle}$

DC ← Full wave rectifier

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

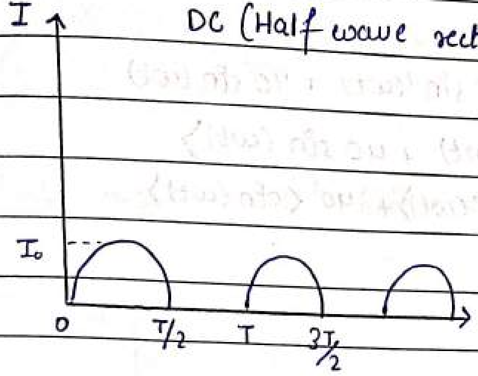


$\langle I \rangle_{half} = \frac{2 I_0}{\pi}$

$\langle I \rangle_{full} = \frac{2 I_0}{\pi}$

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

DC (Half wave rectifier)



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

$$\langle I \rangle_{Half} = \frac{2I_0}{\pi}, 0$$

$$\langle I \rangle_{full} = \frac{I_0 \int_0^{T/2} \sin(\omega t)\,dt + \int_{T/2}^{T} 0\,dt}{\int_0^T dt}$$

$$= \frac{\cancel{2} I_0 \cancel{T}}{\pi \cancel{T} \cancel{2}} = \frac{I_0}{\pi}$$

$$I_{rms} = \sqrt{\langle I^2 \rangle} = \frac{I_0}{\sqrt{2} \times \sqrt{2}} = \frac{I_0}{2}$$

A/C and D/C Mixture

\# $I = \underbrace{4}_{DC} + \underbrace{5\sin(\omega t)}_{AC}$

$\langle I \rangle_{full\ cycle} = \langle 4 + 5\sin(\omega t) \rangle_{full\ cycle} = \langle 4 \rangle + 5 \langle \sin(\omega t) \rangle$

$= 4 + 5 \times 0 = 4$ Ans

$\langle I \rangle_{half\ cycle} = \langle 4 + 5\sin(\omega t) \rangle_{Half\ cycle} = \langle 4 \rangle + 5 \langle \sin(\omega t) \rangle_{Half\ cycle}$

$= 4 + 5 \times \frac{2}{\pi}$

$= 4 + \frac{10}{\pi}$

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$I_{Rms} = ?$

$I^2 = (4+5\sin(\omega t))^2$

$= 16 + 25\sin^2(\omega t) + 40\sin(\omega t)$

$\langle I^2\rangle = \langle 16 + 25\sin^2(\omega t) + 40\sin(\omega t)\rangle$

$= \langle 16\rangle + 25\langle \sin^2(\omega t)\rangle + 40\langle \sin(\omega t)\rangle$

$= 16 + 25\times\frac{1}{2} + 0$

$\sqrt{\langle I^2\rangle} = \sqrt{28.5}$

$I_{Rms} = \sqrt{(4)^2 + \frac{(5)^2}{2}}$

Eg $I = a + b\cos(\omega t)$

$I_{Rms} = \sqrt{a^2 + \frac{b^2}{2}}$

$I = a\sin(\omega t) + b\cos(\omega t)$

$I_{Rms} = \sqrt{\frac{a^2+b^2}{2}}$

Q 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) $\frac{I_1+I_2}{\sqrt{2}}$ (b) $\frac{(I_1+I_2)^2}{2}$

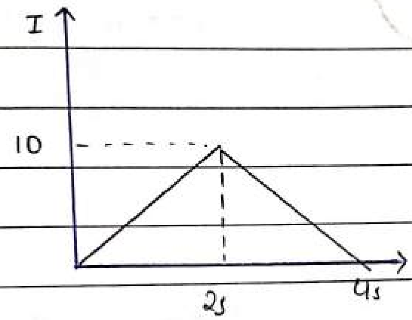
~~c)~~ $\sqrt{\frac{I_1^2+I_2^2}{2}}$ (d) $\frac{\sqrt{I_1^2+I_2^2}}{2}$

Q If instantaneous current in a circuit is given by $I = (2+3\sin\omega t)$ A, then the effective value of resulting current is

a) $\sqrt{\frac{17}{2}}$ A (b) $\sqrt{\frac{2}{17}}$ A $\quad I_{rms} = \sqrt{2^2+\frac{3^2}{2}}$

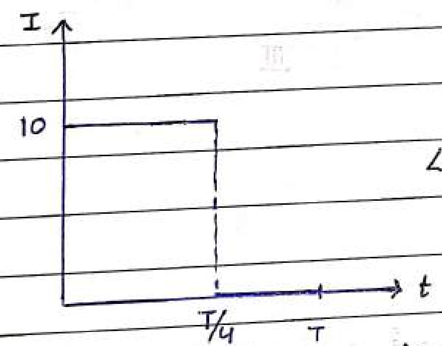
c) $\sqrt{\frac{3}{\sqrt{2}}}$ A (d) $\sqrt{\cancel{2}\sqrt{2}}$ $\quad 3\sqrt{2}$ A $\quad = \sqrt{4+\frac{9}{2}} = \sqrt{\frac{17}{2}}$ Am

Q Find Avg current between 0 to 4sec.



$$\langle I \rangle = \frac{\int_0^4 I\,dt}{\int_0^4 dt} = \frac{\frac{1}{2}\times 4\times 10}{4} = 5 \text{ Amp}$$

Q Find Avg ~~at~~ and rms current between (0 to T)



$$\langle I \rangle = \frac{\int_0^T I\,dt}{\int_0^T dt} = \frac{10\times \cancel{T}/4}{\cancel{T}} = 2.5 \text{ Amp}$$

★ $I_{rms} = \sqrt{\langle I^2 \rangle}$

Imp

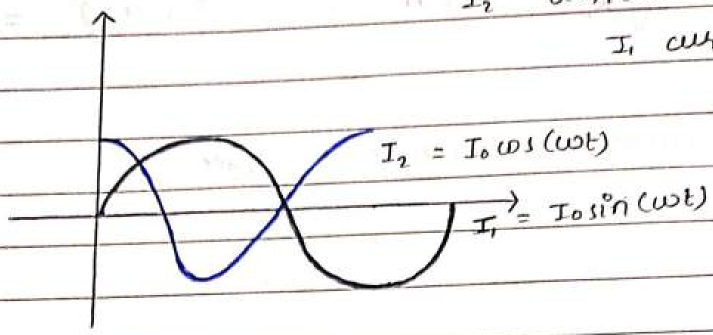
$$\langle I^2 \rangle = \frac{\int_0^{T/4} I^2\,dt + \int_{T/4}^{T} 0\,dt}{\int_0^T dt}$$

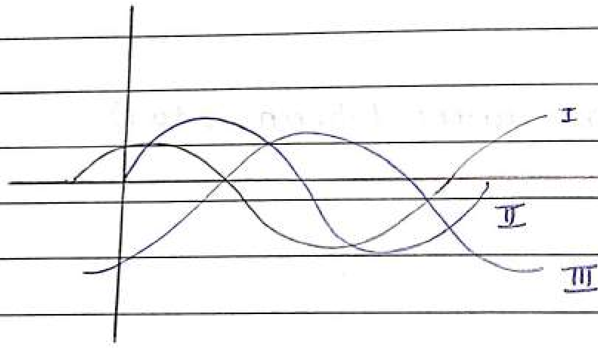
$$\langle I^2 \rangle = \frac{100\,\frac{\cancel{T}}{4} + 0}{\cancel{T}} = 25 \text{ Amp}$$

$$\sqrt{\langle I^2 \rangle} = \sqrt{25} = 5 \text{ Amp.}$$

Graph of A/C Current

I_2 current leads I_1 current by $\frac{\pi}{2}$



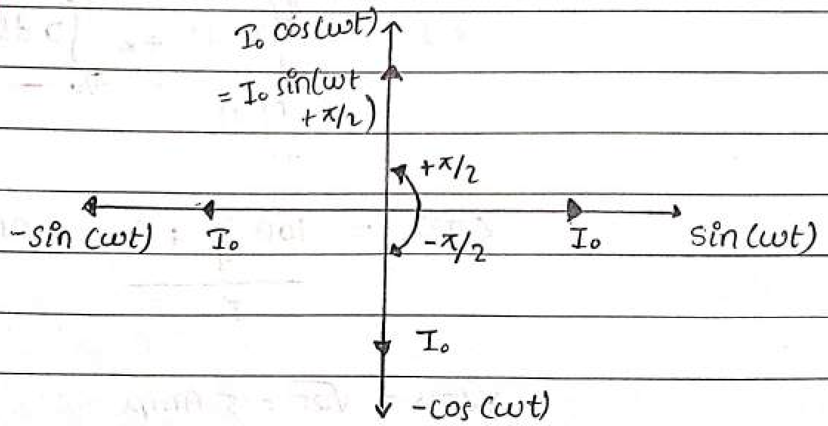


$I_2 = I_0 \sin(\omega t)$

$I_1 = I_0 \sin(\omega t + \phi)$

$I_3 = I_0 \sin(\omega t - \phi)$

Representation of AC current and voltage by Phasor diagram



$I_1 = 4\sin(\omega t + \frac{\pi}{6})$

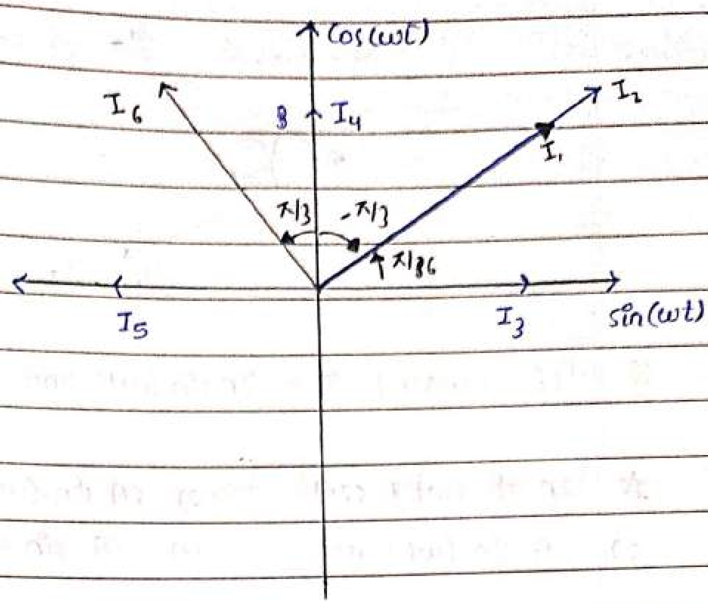
$I_2 = 5\cos(\omega t - \frac{\pi}{3})$

$I_3 = 4\cos(\omega t - \frac{\pi}{2})$

$I_4 = 3\cos(\omega t)$

$I_5 = -4\sin(\omega t)$

$I_6 = 4\cos(\omega t + \frac{\pi}{3})$



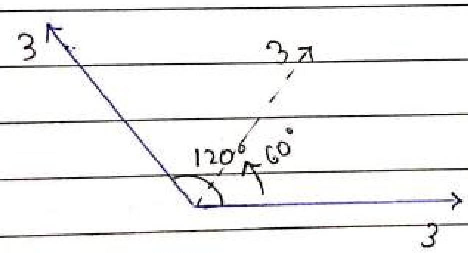
Q Two AC is superimposed

$I_1 = 3\sin(\omega t)$

$I_2 = 3\cos(\omega t + \frac{\pi}{6})$

then find $I_1 + I_2$

ANS

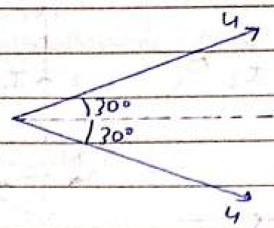


$I_{net} = 3\sin(\omega t + \frac{\pi}{3})$

Q Two A/C are superimposed then find $I = I_1 + I_2$

$I_1 = 4\sin(\omega t - \frac{\pi}{6})$

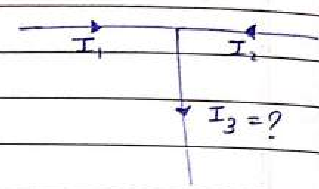
$I_2 = 4\ \cancel{\sin}\cos(\omega t - \frac{\pi}{3})$



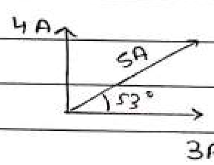
$I_{net} = 4\sqrt{3} \sin(\omega t)$

Q If current $I_1 = 3A \sin(\omega t)$ and $I_2 = 4A \cos(\omega t)$

1) $5A \sin(\omega t + 53°)$ 2) $5A \sin(\omega t + 37°)$
3) $5A \sin(\omega t + 45°)$ 4) $5A \sin(\omega t + 30°)$



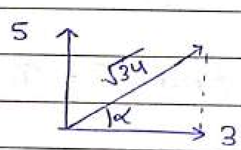
ANS



$\Rightarrow 5A \sin(\omega t + 53°)$

Q $I_1 = 3 \sin(\omega t)$
$I_2 = 5 \cos(\omega t)$
find $I_1 + I_2$

ANS



$\tan \alpha = \frac{5}{3}$

$\alpha = \tan^{-1}\left(\frac{5}{3}\right)$

$I = \sqrt{34} \sin\left(\omega t + \tan^{-1}\left(\frac{5}{3}\right)\right)$

Important

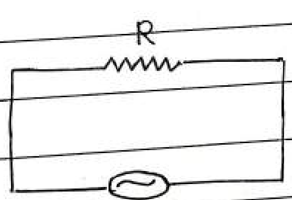
A/C →	Sinusoidal A/C	Square A/C	Triangular A/C
$(I)_{Avg}$ full	0	0	0
$(I)_{Avg}$ half	$\frac{2I_0}{\pi}$	I_0	$\frac{I_0}{2}$
$(I)_{rms}$	$\frac{I_0}{\sqrt{2}}$	I_0	$\frac{I_0}{\sqrt{3}}$

Q Assertion (A): Average value of current in half cycle of an AC circuit cannot be zero.

Reason (R): For positive half cycle average value of current is i_0/π where i_0 is the peak value of current.

a) Both A and R are true & R is the correct explanation of A
b) Both A and R are true but R is not the correct explanation of A
c) A is true but R is false
d) A is false and R is also false

A/C source across pure resistance



$\epsilon_B = \epsilon_0 \sin(\omega t)$
↑
Peak emf of battery.

Potential drop across Resistance = ϵ_B (emf of battery)

$$V_R = E_B$$

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

$$I = \frac{E_0 \sin(\omega t)}{R}$$

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

I_0 → peak current

$$x = A\sin(\underbrace{\omega t + \phi}_{\text{phase}})$$

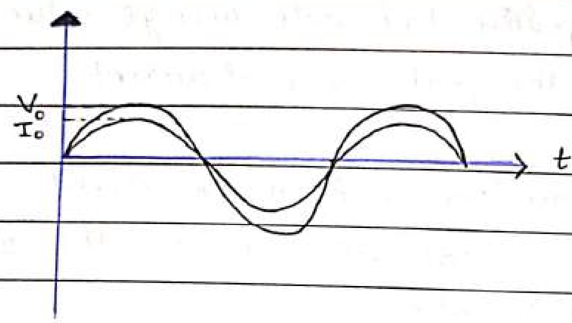
ϕ → initial phase

$$V_R = E_0 \sin(\omega t) \quad \text{——} (1)$$

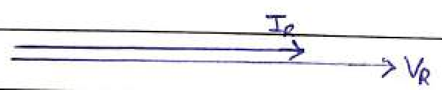
$$I_R = I_0 \sin(\omega t) \quad \text{——} (2)$$

Current and voltage are in same phase in pure resistive circuit.

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



Phase diagram



Power loss across resistance

$$P = V_t I_t$$

$$P = E_0 \sin(\omega t)\, I_0 \sin(\omega t)$$

$$P = E_0 I_0 \sin^2(\omega t)$$

$$\langle P \rangle = E_0 I_0 \langle \sin^2(\omega t) \rangle$$

$$\langle P \rangle = \frac{I_0 E_0}{2}$$

$$\langle P \rangle_{loss} = \frac{I_0^2 R}{2}$$

$$\langle P \rangle_{loss} = \left(\frac{I_0}{\sqrt{2}}\right)^2 R$$

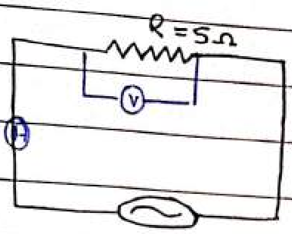
$$\langle P \rangle_{loss} = I_{Rms}^2 R$$

$$\langle P \rangle_{loss} = \frac{E_{Rms}^2}{R} = E_{Rms} I_{Rms}$$

$$E_0 = I_0 R$$

$$E_{Rms} = I_{Rms} R$$

Q



Ans $I_{Rms} = \frac{E_{Rms}}{R} = \frac{20\sqrt{2}}{\sqrt{2}\,5} = 4A$

↓

Reading of Ammeter

Reading of Voltmeter = Rms voltage $= \frac{E_0}{\sqrt{2}} = 20\,V$ Ans

Power loss $= I_{Rms}^2 R$

$= 16 \times 5 = 80\,W$ Ans

Q What is the approximate peak value of an alternating current producing four times the heat produced per second by a steady current of 2A in a resistor?

a) 2.8 A (b) 4.0 A

(c) 5.6 A (d) 8.0 A

Ans $(P)_{A/C} = 4 \times I^2 R$

$I_{Rms}^2 \cancel{R} = 4 \times 4 \cancel{R}$

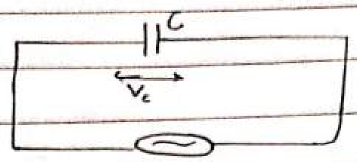
$I_{Rms} = 4$

$\frac{I_0}{\sqrt{2}} = 4$

$I_0 = 4\sqrt{2}$

$= 5.6\,A$ Ans

A/C Source across Pure Capacitor.



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

$$V_c = E_B$$

$$\frac{q}{C} = E_0 \sin(\omega t)$$

$$q = CE_0 \sin(\omega t)$$

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

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

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

$$I = CE_0 \cancel{t} \cos(\omega t)\, \omega$$

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

$$I = \frac{E_0 \cos(\omega t)}{X_c}$$

X_c = Capacitive ~~Resistance~~ Reactance

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

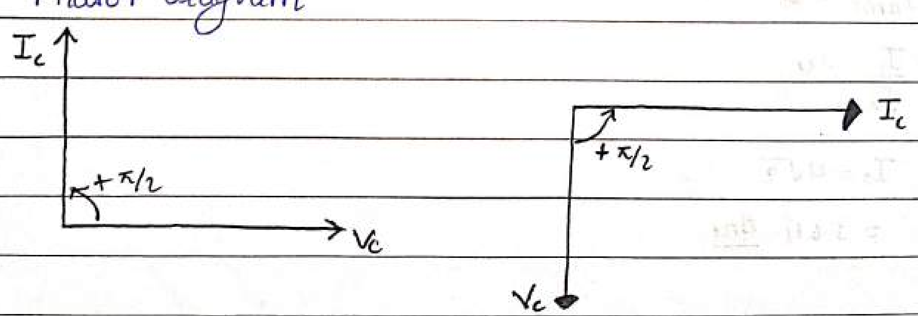
$$I = \frac{E_0 \cos(\omega t)}{\frac{1}{\omega C}}$$

$$I_c = I_0 \cos(\omega t)$$

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

Current leads voltage by $\frac{\pi}{2}$

Phasor diagram



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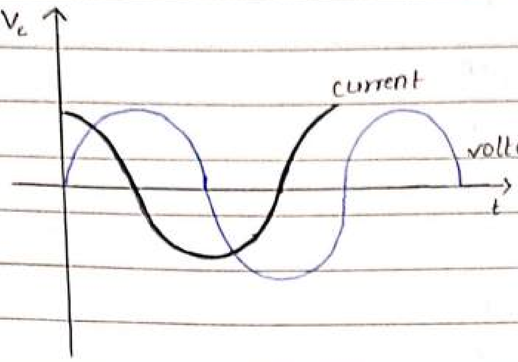
$I_c = I_0 (\sin \omega t + \frac{\pi}{2})$

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



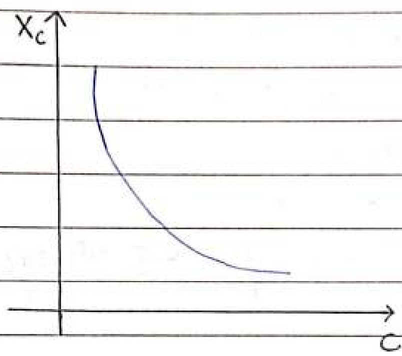
$I_0 = \frac{E_0}{X_c}$

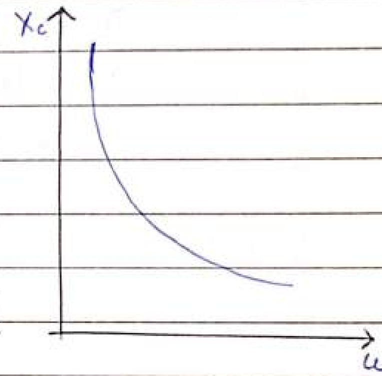
$I_{rms} = \frac{E_{rms}}{X_c}$

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

$X_c \propto \frac{1}{C}$

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





For DC source

$f = 0$

$X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \infty$

Capacitor will behave as Broken wire for D/C source

↓

∴ Capacitor is DC filter.

For High frequency A/C

$X_c = \frac{1}{2\pi f C} \approx 0$

Capacitor will behave as simple wire.

Q A 40 μF capacitor is connected is connected to a 200V, 50Hz AC supply. The Rms value of the current in the circuit is nearly.

a) 1.7 A (b) 2.05A
(c) 2.5 A (d) 25.1 A

ANS $E_{Rms} = 200V$

$E_{Rms} = I_{Rms} X_c$

$200 = I_{Rms} \frac{1}{\omega C}$

$I_{Rms} = 200 \times 2\pi f \times 40 \times 10^{-6}$

$I_{Rms} = 200 \times 2\pi \times 50 \times 40 \times 10^{-6}$

$= 4\pi \times 5 \times 4 \times 10^{-2}$

$= 0.16 \times 5\pi$

$= 0.8 \times \frac{22}{7} = \frac{\cancel{19.8}}{\cancel{7}}$ ~~2.8~~ $\frac{17.6}{7} = 2.5A$

*Q A small signal voltage $V(t) = V_0 \sin(\omega t)$ is applied across an ideal capacitor C.

a) Current I(t) is in phase with voltage V(t).
b) Current I(t) leads voltage V(t) by 180°.
c) Current I(t) lags voltage V(t) by 90°.
d) Over a full cycle the capacitor C does not consume any energy from the voltage source.

ANS Power loss in capacitor

$P = V_t I_t$

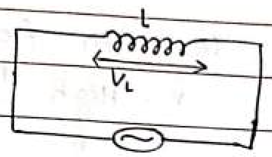
$P = E_0 \sin(\omega t) . I_0 \cos(\omega t)$

$\langle P \rangle = E_0 I_0 \langle \sin(\omega t) . \cos(\omega t) \rangle$

$\langle P \rangle$ Avg Power loss in pure capacitor $= 0$

Pure capacitive circuit is wattless circuit.

A/C source across Pure Inductor



L = self inductance

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

$$V_L = E_B$$

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

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

$$I = \frac{E_0}{L} \int \sin(\omega t)\, dt$$

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

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

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

$$I = \frac{E_0}{X_L} \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$X_L = \omega L$$

↓

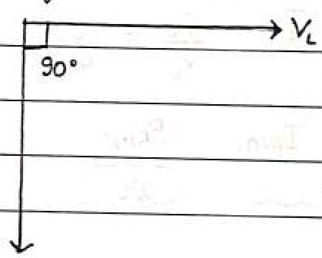
inductive reactance

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

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

Voltage leads current by $\frac{\pi}{2}$

Phasor diagram



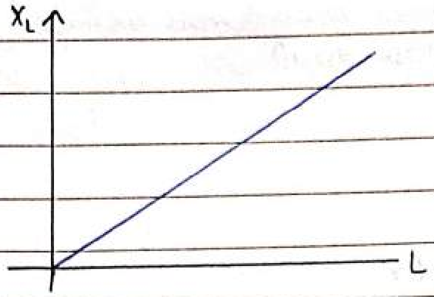
Inductive Reactance (X_L)

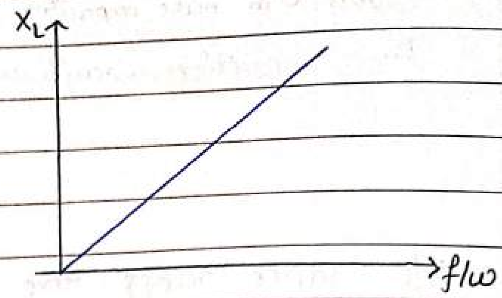
$$X_L = \omega L = 2\pi f L$$

$$X_L \propto \omega$$

$$X_L \propto L$$

$$X_L \propto f$$





For D/C

$f = 0$

$X_L = 0$ behave as simple wire for D/C

For high frequency A/C

$X_L =$ High $[f = \infty,\ X_L = \infty]$

↓

A/C filter

Power loss in inductor

$P = V_t I_t$

$= I_0 E_0 \sin(\omega t)(-\cos(\omega t))$

$\langle P \rangle = -I_0 E_0 \langle \sin(\omega t) . \cos(\omega t) \rangle = 0$

↓

Pure inductor is also a wattless circuit

$$I_0 = \frac{E_0}{X_L} = \frac{E_0}{\omega L}$$

$$I_{rms} = \frac{E_{rms}}{\omega L}$$

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Q Assertion (A): Inductive reactance of an inductor in DC circuit is zero.

Reason (R): Angular frequency of DC circuit is zero.

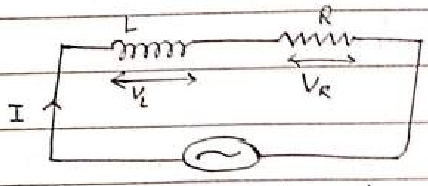
a) Both A & R are true and R is the correct explanation of A
b) Both A & R are true and R is not the correct explanation of A
c) A is true but R is false
d) A is false and R is also false.

Q Assertion (A): The alternating current lags behind the emf by a phase angle of $\pi/2$, when AC flows through an inductor.

Reason (R): The inductive reactance increases as the frequency of AC source decrease.

a) Both A & R are true and R is the correct explanation of A
b) Both A & R are true and R is not the correct explanation of A.
c) A is true but R is false
d) A is false and R is also false.

Series L-R Circuit



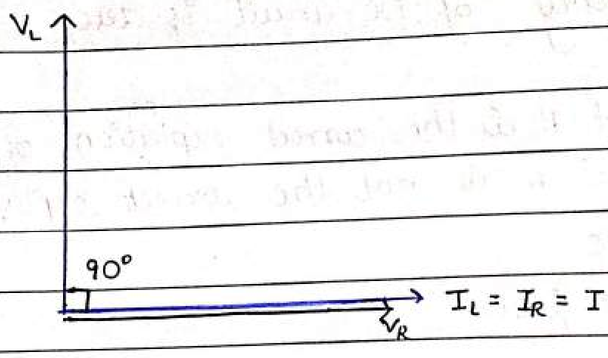
$E = E_0 \sin(\omega t)$

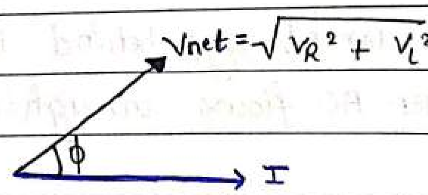
$E_t = (V_L)_t + (V_R)_t$

$E_0 = (V_0)_R + (V_0)_L$ X

$(I_R)_t = (I_L)_t$

Phasor diagram.





$V_{net} = E_0 \sin(\omega t)$

$I = \frac{E_0}{Z} \sin(\omega t - \phi)$

$V_{net} = \text{"}IZ\text{"} = \sqrt{V_R^2 + V_L^2}$

Complete resistance

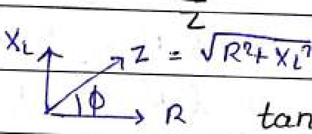
Impedence

$IZ = \sqrt{I^2R^2 + I^2X_L^2}$

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

$I_{Rms} = \frac{E_{Rms}}{Z}$

$I_0 = \frac{E_0}{Z}$



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

$\cos\phi = \frac{V_R}{V_{net}} = \frac{R}{Z}$

Q An AC voltage is applied to a resistance R and an inductor L in series. If R and the inductor inductive reactance are both equal to 3Ω, the phase difference between the applied voltage and the current in the circuit is.

a) $\pi/6$ (b) $\pi/4$

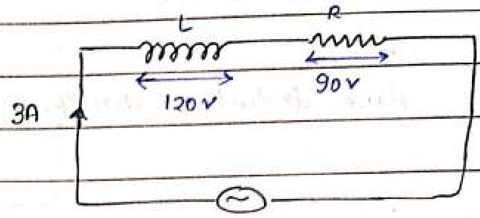
c) $\pi/2$ (d) zero

Ans $\tan\phi = \frac{X_L}{R} = \frac{3}{3} = 1$

$\phi = \pi/4$

Q Impedence of the circuit shown in the figure is.

a) 100Ω ~~b)~~ 50Ω
c) 30Ω (d) 40Ω.



ANS $V_L = 120V$

$V_L = IX_L$

$X_L = \frac{120}{3} = 40\Omega$

$V = IR$

$90 = 3 \times R$

$R = 30\Omega$

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

$= 50\Omega.$

Q A coil has resistance 30Ω and inductive reactance 20 ohm at 50 Hz frequency. If an AC source of 200 volt, 100 Hz is connected across the coil the current in the coil will be.

a) 2A ~~b)~~ 4.0A
c) 8.0A (d) $20/\sqrt{13}$ A

ANS X_L at 100 Hz $= 20 \times 2 = 40\Omega$ $(\because X_L \propto f)$

$Z = \sqrt{R^2 + X_L^2} = 50\Omega$

$I = \frac{V}{Z} = \frac{200}{50} = 4A$

Q In an AC source the current flowing is $I = 5\sin(100t - \pi/2)$ Ampere and the potential difference is $V = 200\sin(100t)$ volts. The power consumption is equal to.

a) 20W ~~b)~~ 0W
c) 1000W d) 40W.

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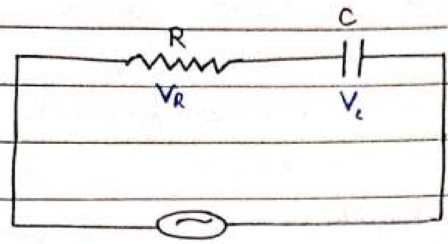
→ $I = 5 \sin(100t - \pi/2)$

$V = 200 \sin(100t)$

↓

Pure inductive circuit.

SERIES R-C circuit



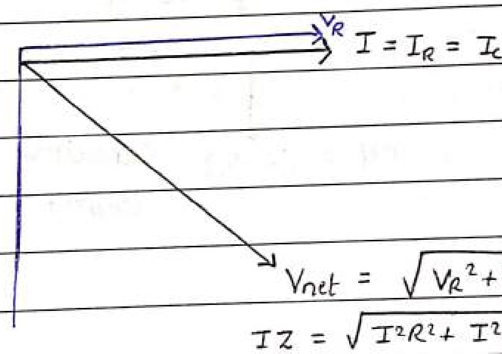
$E = E_0 \sin(\omega t)$

$(V_R)_t + (V_c)_t = E_t$

$(V_0)_R + (V_0)_c = E_0$ X

$I = I_R = I_c$

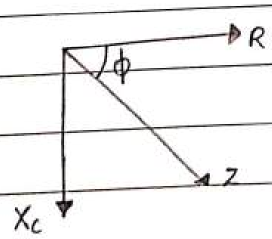
Phasor diagram



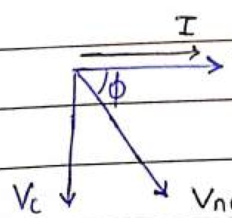
$V_{net} = \sqrt{V_R^2 + V_c^2}$

$IZ = \sqrt{I^2R^2 + I^2X_c^2}$

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



$\tan\phi = \dfrac{V_c}{V_R} = \dfrac{X_c}{R}$



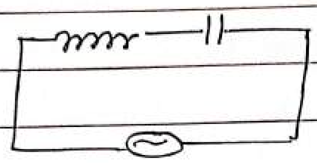
$V_{net} = E_0 \sin(\omega t)$

$V_{net} = E_0 \sin(\omega t)$

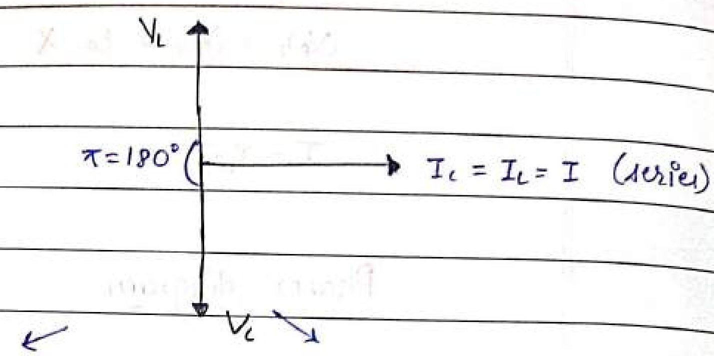
$I = I_0 \sin(\omega t + \phi)$

$I_0 = \frac{E_0}{Z}$

Pure L-C circuit.

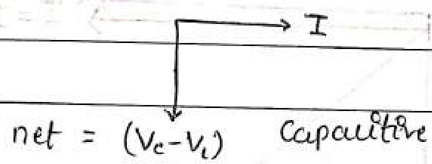


$E = E_0 \sin(\omega t)$



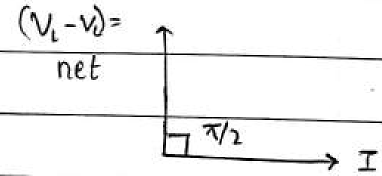
$\langle P \rangle_{Avg} = 0$

If $V_c > V_L$



Capacitive circuit)

If $V_L > V_c$ (Inductive)

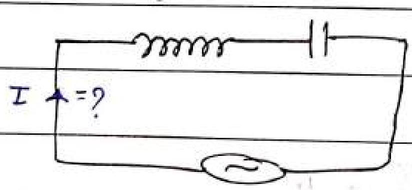


$V_{net} = IZ = V_L - V_c$

$IZ = IX_L - IX_c$

$Z = (X_L - X_C)$

Q



$E = 20 \sin(\omega t)$

Ans $I_{rms} = \frac{E_{rms}}{Z} = \frac{20}{\sqrt{2} \times 4} = 5/\sqrt{2}$ A.

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Q A coil of self inductance L is connected in series with a bulb B and an AC source. Brightness of the Bulb decreases when.

a) a capacitance of reactance $X_C = X_L$ is included in the same circuit
b) an iron rod is inserted in the coil
c) frequency of the AC source is decreased
d) No of turns in the coil is reduced.

ANS If $X_L \uparrow$ $I \downarrow$ $\left(\because I = \frac{V}{X_L}\right)$

In 1^{st} case $I = \frac{V}{Z}$ and $Z = X_C - X_L$

If $X_C = X_L$

$Z = 0$

$I = \infty$

In 2nd case

$\mu_m > \mu_0$

$L = \mu_m l A n^2$

$L \uparrow$

$\uparrow X_L = \omega L \uparrow$

$I \downarrow$

In 3rd case

$X_L = \omega L$

$\downarrow \omega \uparrow$ $X_L \uparrow \downarrow$

$I \downarrow \uparrow$

In fourth case

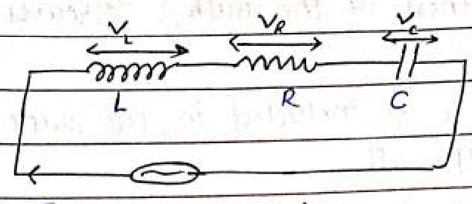
$X_L = \omega L$

$\downarrow L = \mu_0 l A n^2 \downarrow$

$X_L \downarrow$

$I \uparrow$

Series LCR Circuit



I $\quad E_B = E_0 \sin(\omega t)$

$I_R \neq I_L \neq I_c$ (wrong)

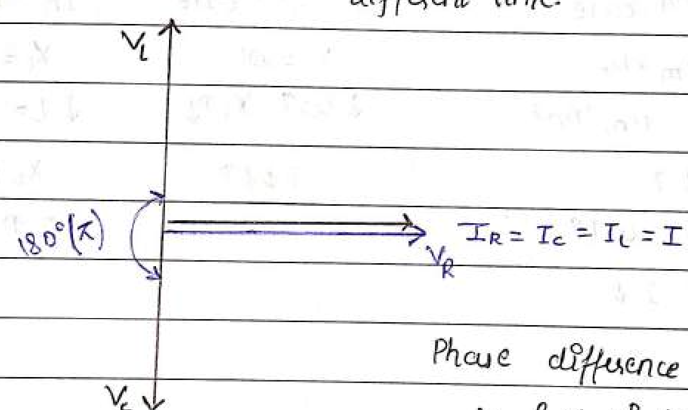
$I = I_R = I_L = I_c$

$E_B = (V_R)_t + (V_L)_t + (V_c)_t$ (at any time energy conservation)

supply by battery

$(E_0)_B = (V_0)_R + (V_0)_L + (V_0)_c$ → wrong

Peak of all at different time.

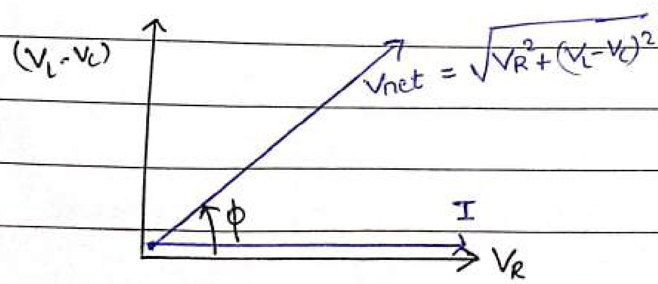


Phase difference between V_L & V_c is $180° (\pi)$

Now three cases are possible

Case -1

$V_L > V_c$ (Inductive LCR circuit)



Let Z = total Resistance

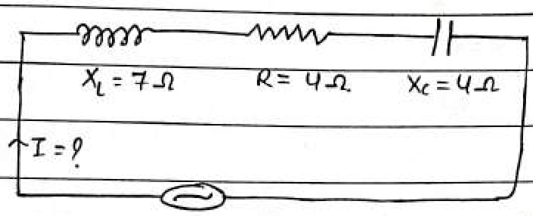
Z = Impedeance

$$IZ = \sqrt{IR^2 + (IX_L - IX_C)^2}$$

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

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

Q



$E = 20\sqrt{2}\sin(\omega t)$

Ans

$$I_{Rms} = \frac{E_{Rms}}{Z} = \frac{20\sqrt{2}}{\sqrt{2}\,Z} = \frac{20}{Z}$$

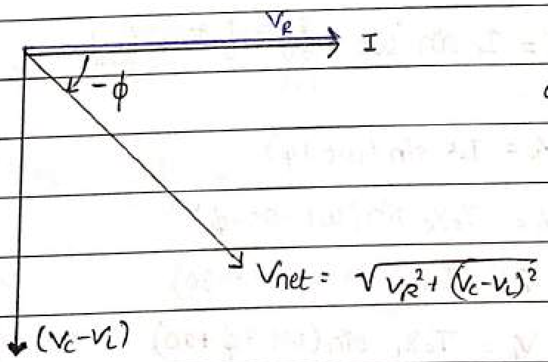
$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{16 + 9} = 5\Omega$$

$I_{Rms} = 4A$ Ans

Case-2

$V_L < V_C$ (Capacitive circuit)

$X_L < X_C$

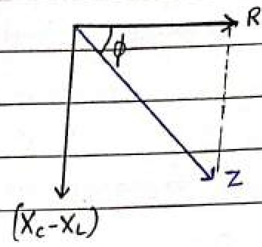


$$\cos\phi = \frac{V_R}{V_{net}}$$

$$IZ = \sqrt{(IR)^2 + (IX_C - IX_L)^2}$$

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

Impedance triangle

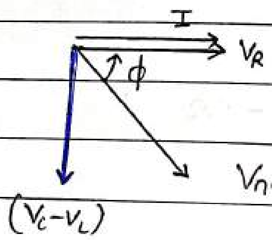


$$\tan\phi = \frac{|X_c - X_L|}{R}$$

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

$$I_0 = \frac{E_0}{Z}$$

$$I_{Rms} = \frac{E_{Rms}}{Z}$$



$$V_{net} = E_0 \sin(\omega t)$$

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

$$\tan\phi = \frac{|X_L - X_c|}{R}$$

Equation of current

$$I = I_0 \sin(\omega t + \phi) \quad \left[I_0 = \frac{E_0}{Z} \right]$$

$$V_R = I_0 R \sin(\omega t + \phi)$$

$$V_c = I_0 X_c \sin(\omega t - (90 - \phi))$$

$$V_c = I_0 X_c \sin(\omega t + \phi - 90)$$

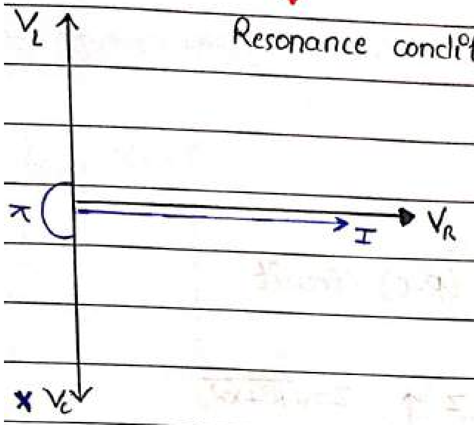
$$V_L = I_0 X_L \sin(\omega t + \phi + 90)$$

Case - 3

$V_L = V_C$ (Pure resistive)

↓

Resonance condition



$$V_{net} = V_R = E_0 \sin(\omega t)$$

$$\cancel{I} Z = \cancel{I} R$$

$$Z = R$$

$$Z_{min} = R$$

$\phi = 0°$ $\qquad \xrightarrow{I} V_{net} = V_R$

$\cos\phi = 1$

Resonance Condition

$$V_L = V_C$$

$$\cancel{I} X_L = \cancel{I} X_C$$

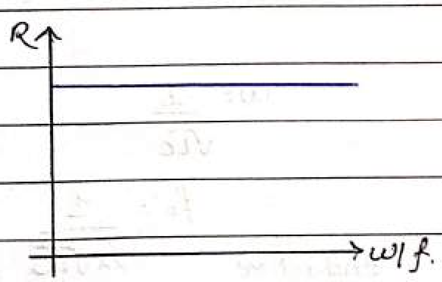
$$X_L = X_C$$

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

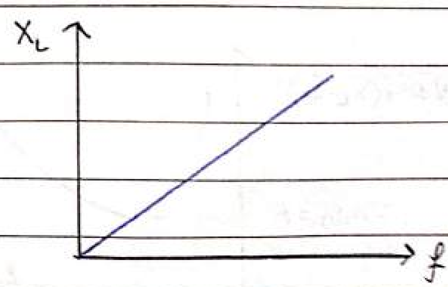
$$\omega^2 = \frac{1}{LC}$$

resonance angular frequency $\longrightarrow \omega_0 = \frac{1}{\sqrt{LC}}$ $\longrightarrow f_0 = \frac{1}{2\pi\sqrt{LC}}$

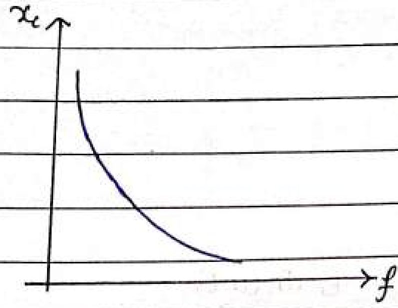
Pure Resistance



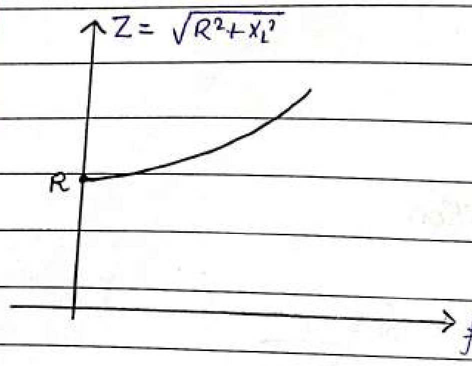
Pure inductive circuit



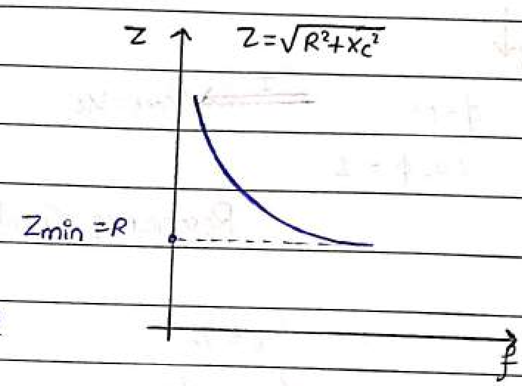
Pure capacitive circuit



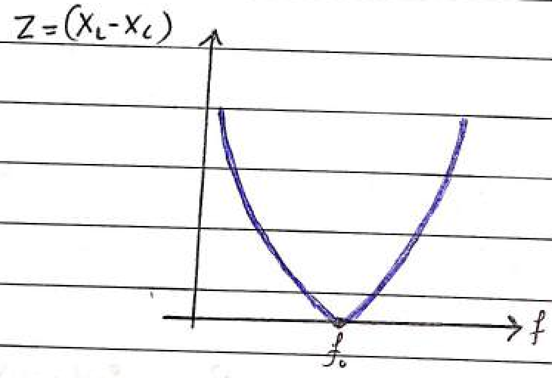
(R-L) Circuit



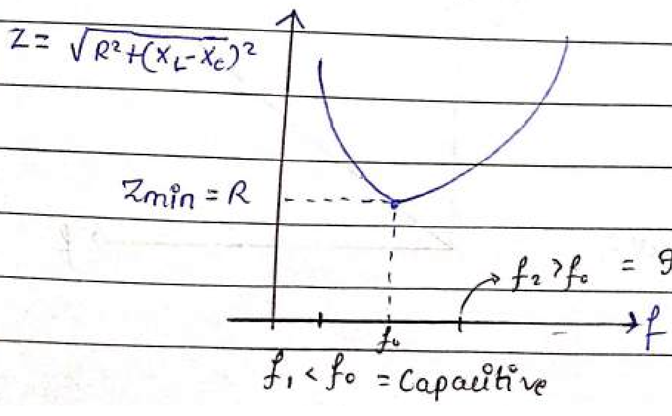
(R-C) Circuit



L-C Circuit.



Series LCR.



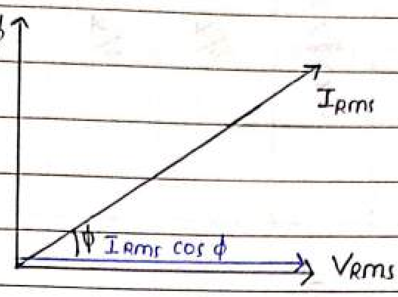
$$\omega = \frac{1}{\sqrt{LC}}$$

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

By increase in frequency Z first incr decreases and then increases.

Power loss in A/C Circuit

Wattless current = $I_{Rms} \sin\phi$



Wattless current = $(I_{Rms}) \sin\phi$

$\langle P \rangle = I_{Rms} \cdot V_{Rms} \cos\phi$

$\langle P \rangle = V_{Rms} \cdot I_{Rms} \cos\phi$

Power factor

$\langle P \rangle = \frac{V_{Rms}^2}{Z} \cos\phi \qquad \left[I_{Rms} = \frac{V_{Rms}}{Z} \right]$

$\langle P \rangle = V_{Rms} I_{Rms} \cos\phi$

Pure resistive

$\phi = 0°$

$\cos 0° = 1$

$\langle P \rangle = V_{Rms} \cdot I_{Rms}$

Pure inductor.

$\cos\phi = 0° \quad [\phi = 90°)$

$\langle P \rangle = 0$

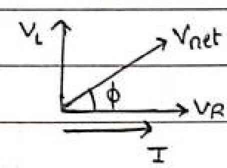
Pure capacitor

$\phi = 90°$

$\cos\phi = 0$

$\langle P \rangle = 0$

Series R-L



$\cos\phi = \frac{V_R}{V_{net}} = \frac{R}{Z}$

$\langle P \rangle = V_{Rms} \cdot I_{Rms} \frac{R}{Z}$

$\frac{P_0}{2} = P_{rms}$

Circuit	Phase difference between I and V	Power factor $\cos\phi = \frac{R}{Z}$	Impedence (Z)	Who leads	Power loss
Pure Resistive	0	1 $[\cos 0°]$	R	Same phase	$P = I_{rms} V_{rms}$
Pure Capacitive	$\pi/2$	zero $(\cos \pi/2)$	$X_C = \frac{1}{\omega C}$	Current	Zero
Pure Inductive	$\pi/2$	zero	$X_L = \omega L$	Voltage	Zero
R-L	$0 < \phi < \pi/2$	between 0 to 1	$Z = \sqrt{R^2 + X_L^2}$	Voltage	$P = I_{rms} . V_{rms} \frac{R}{Z}$
R-C	$0 < \phi < \pi/2$	between 0 to 1	$Z = \sqrt{R^2 + X_C^2}$	Current	$P = I_{rms} . V_{rms} \frac{R}{Z}$
L-C	$\pi/2$	Zero	$Z = X_L - X_C$	Depends	Zero
Series L.C.R.	$0 \leq \phi < \pi/2$	1 or between 0 to 1.	$Z = \sqrt{R^2 + (X_L - X_C)^2}$	Depends	$P = I_{rms}^2 R$

Q The instantaneous values of alternating current and voltages in a circuit are.

$$i = \frac{1}{\sqrt{2}} \sin(100\pi t) \text{ ampere}$$

$$e = \frac{1}{\sqrt{2}} \sin\left(100\pi t + \frac{\pi}{3}\right) \text{ volt}$$

The average power in watts consumed in the circuit is.

a) 1/4 (b) $\sqrt{3}/4$
c) 1/2 (d) 1/8

$\Rightarrow \langle P \rangle = I_{rms} \cdot V_{rms} \cdot \cos\phi$

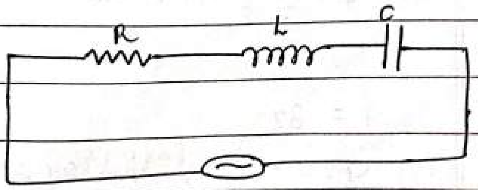
$\Rightarrow \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}$ Ans

Q A circuit when connected to an AC source of 12V gives a current of 0.2A. The same circuit when connected to a DC source of 12V, gives a current of 0.4A. The circuit is.

a) Series LR (b) series RC
c) series LC (d) series LCR.

ANS When the circuit is connected to a DC source the value of current increases or it does not fall to zero which means capacitor is definitely not present in the circuit.

Q In the following circuit the emf of source is $E_0 = 200$ volt $R = 20\Omega$, $L = 0.1$ Henry, $C = 10.6$ farad and frequency is variable then the current at frequency $f = 0$ and $f = \infty$ is.



1) zero, 10A
2) 10 A, zero
3) 10A, 10A
4) zero, zero.

At $f=0$ At $f=\infty$

$X_C = \infty$ $X_L = \infty$

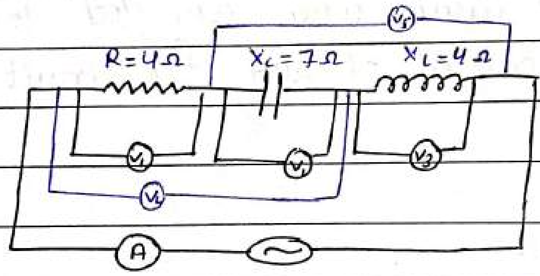
Q In an LCR circuit $L = 8.0$ henry, $C = 0.5\,\mu F$ and $R = 100$ ohm are in series. The resonance angular frequency is.

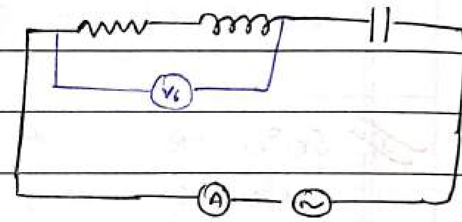
~~a)~~ 500 rad/s (b) 600 rad/s

c) 800 rad/s (d) 1000 rad/s.

ANS $\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8 \times 0.5\,\mu}} = \frac{1}{2 \times 10^{-3}} = \frac{1000}{2} = 500$

* Q





$E = 100\sqrt{2}\,\sin(\omega t)$

Find reading of $V_1, V_2, V_3, V_4, V_5, V_6$ and (A) & impedence, Power factor & Power loss.

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

$Z = \sqrt{16+9}$

$Z = 5\,\Omega$.

$A = I_{Rms} = \frac{E_{Rms}}{Z} = \frac{100\sqrt{2}}{\sqrt{2} \times 5} = 20A$

$\cos\phi = \frac{R}{Z}$ = Power factor $= \frac{4}{5}$

$\phi = 37°$

$\langle P \rangle = I_{Rms} \cdot V_{Rms} \cos\phi = I_{Rms}^2 Z \cos\phi = (20)^2 \times 4 = 1600\,W$

$V_1 = I_{Rms} \times R$

$= 20 \times 4 = 80V$

$V_2 = I_{Rms} \times X_c$

$= 20 \times 7 = 140V$

$V_3 = I_{Rms} \times X_L$

$= 20 \times 4 = 80V$

$V_4 = I_{Rms} \times \sqrt{R^2 + X_c^2}$

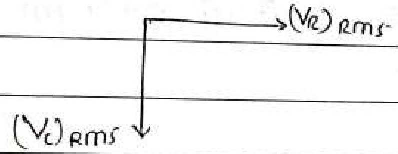
$= 20 \times \sqrt{65}$

$= 20\sqrt{65}$

OR

$V_4 = \sqrt{(V_R)^2_{Rms} + (V_c)^2_{Rms}}$

$V_4 = \sqrt{(80)^2 + (140)^2}$



$V_5 = (X_c - X_L) I_{Rms}$

$= 3 \times 20 = 60V$

OR

$V_5 = V_c - V_L = 140 - 80 = 60V$

$V_6 = (\sqrt{R^2 + X_L^2})\, I_{Rms}$

$= \sqrt{32} \times 20$

$= 20\sqrt{32}$

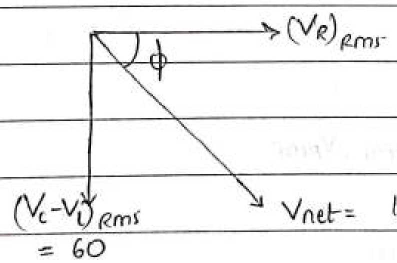
OR

$\sqrt{(V_L)^2_{Rms} + (V_R)^2_{Rms}} = \sqrt{(80)^2 + (80)^2}$

Find equation of current

$\Rightarrow \cancel{I = I_0}$

Nature of this LCR circuit = Capacitive $(X_c > X_L)$



$V_{net} = \frac{100\sqrt{2}\sin(\omega t)}{\sqrt{2}} = 100$

$\tan\phi = \frac{(V_c - V_L)}{V_R} = \frac{3\cancel{60}}{4\cancel{80}} = \frac{3}{4}$

$\phi = 37°$

$I_0 = \frac{V_0}{Z} = \frac{100\sqrt{2}}{5} = 20\sqrt{2}$

$I = 20\sqrt{2}\sin(\omega t + 37°)$

$$V_R = 80\sqrt{2}\ \sin(\omega t + 37^\circ)$$

$$V_c = \cancel{80}^{140}\sqrt{2}\ \sin(\omega t + 37^\circ - 90^\circ)$$

$$V_c = 140\sqrt{2}\ \sin(\omega t - 53^\circ)$$

$$V_L = 80\sqrt{2}\ \sin(\omega t + 37^\circ + 90^\circ)$$

ELECTRICAL RESONANCE

Electrical resonance is said to take place in a series L.C.R. circuit when the circuit allows maximum current for a given frequency of the source of alternating supply for which capacitive reactance becomes equal to the inductive reactance. Impedence of this L.C.R. circuit is minimum & hence current is maximum.

$$X_L = X_C$$

$$V_L = V_C$$

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

$$V_{net} = V_R$$

$$\longrightarrow V$$
$$\longrightarrow I$$

$$\phi = 0^\circ$$

$$\cos\phi = 1$$

$$\langle P\rangle_{max} = I_{rms} \cdot V_{rms}$$

$$\downarrow$$

$$I_{max} = max^m$$

Q In a series L-C.R. circuit, the capacitance C is changed to 4C. To keep the resonant frequency same, the inductance must be changed by

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a) $2L$ (b) $L/2$
c) $4L$ ~~(d)~~ $L/4$

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

$\sqrt{LC}$ = constant

$\therefore L' = \frac{L}{4}$

Q A bulb rated 60 W at 220 V is connected across a household supply of alternating voltage of 220 V. Calculate the maximum instantaneous current through the filament.

ANS (a)

$I_{rms} = \frac{E_{rms}(P)}{V^2}$

$I_0 = \frac{\cancel{220} \times 6\cancel{0}\sqrt{2}}{\cancel{220} \times 22\cancel{0}}$

$I_0 = \frac{6\sqrt{2}}{22}$

Q A transistor - oscillator using a resonant circuit with an inductor L (of negligible resistance) and a capacitor C in series produces oscillations of frequency f. If L is doubled and C is changed to 4C, the frequency will be

a) $f/2$ (b) $f/4$
c) $8f$ ~~(d)~~ $f/2\sqrt{2}$

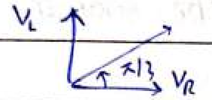
ANS $f = \frac{1}{2\pi\sqrt{LC}}$ $f' = \frac{1}{2\pi\sqrt{2L \times 4C}} = \frac{f}{2\sqrt{2}}$

Q * A series LCR circuit is connected to an AC voltage source. When L is removed from the circuit, the phase difference between current and voltage is $\pi/3$. If instead C is removed from the circuit, the phase difference is again $\pi/3$ between current & voltage. The power factor of the circuit is.

a) zero (b) 0.5

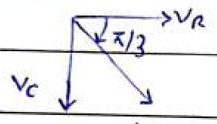
c) 1.0 (d) -1.0

ANS



$\longrightarrow \sqrt{3}\, V_R = V_L$

since angle is same in both $\therefore V_L = V_C$



$\therefore Z = R$ [Resonance condition]

$\longrightarrow \sqrt{3} V_R = V_C$

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

OR $\phi = 0°$ [for resonance]

or

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

$$\tan\phi = \frac{0}{V_R} = 0°$$

$$\phi = 0°$$

$$\cos\phi = \cos 0° = 1$$

Q The equation of an alternating voltage is $V = 220 \sin(\omega t + \frac{\pi}{6})$ and the equation for current $I = 10 \sin(\omega t + \frac{\pi}{6})$. The impedence (in ohm) of the circuit is.

a) 11 (b) 44
c) 20 ~~(d)~~ 22

ANS $I_0 = \frac{E_0}{Z}$

$Z = \frac{220}{10} = 22\,\Omega.$

Q A coil and a bulb are connected in serie with a 12 volt direct current source. A soft iron core is now inserted in the coil. then

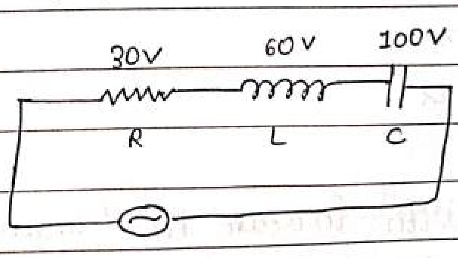
a) The Intensity of the bulb remains same
b) The intensity of the bulb decreases
c) The intensity of the bulb increases
d) Nothing can be said.

ANS Because $X_L = 0$ $[X_L = \omega L = 2\pi f \mu_0 l A n^2]$

$f = 0$

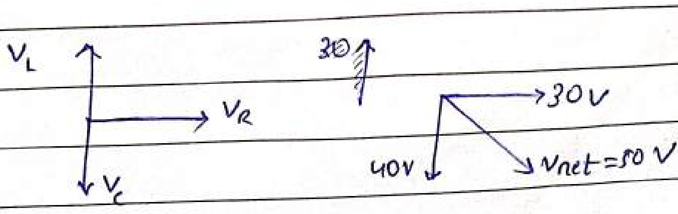
$\therefore X_L = 0$

Q In a series RLC circuit, potential difference across R L and C are 30, 60 and 100V respectively as shown in the figure. The emf of source (in volts) is.

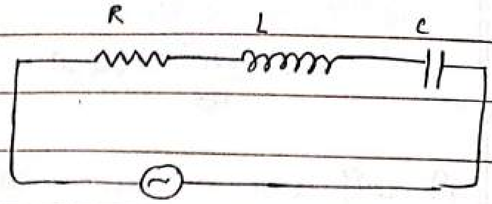


a) 190
b) 50
c) 70
d) 40

ANS

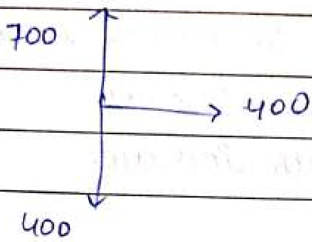


Q In a series RLC circuit, the rms voltage across the resistor and the inductor are respectively 400 V & 700 V. ~~as~~ If the equation for the applied voltage is $E = 500\sqrt{2}\sin\omega t$, then the peak voltage across the capacitor is.



a) 1200 V b) $1200\sqrt{2}$ V
c) 400 V d) $400\sqrt{2}$ V

Ans $E_{rms} = 500$



$(V_C)_{rms} = 400$

$(V_0)_c = 400\sqrt{2}$

Q In series LCR circuit, the phase difference between voltage across L and voltage across C is.

a) zero
b) π
c) $\pi/2$
d) 2π

With increase in frequency of an A.C. supply, the impedence of an LCR series circuit.

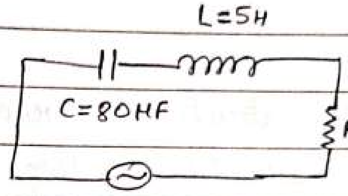
a) Remains constant

b) Decreases

c) Increases

d) Decreases at first, becomes minimum and then increases.

Q Figure shows a series LCR circuit, connected to a variable frequency 200V source $C = 80\,\mu F$ and $R = 40\Omega$. The source frequency which drives the circuit at resonance is.

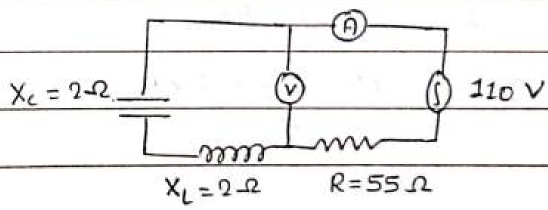


a) 25 Hz ~~b)~~ $\frac{25}{\pi}$ Hz

c) 50 Hz (d) $\frac{50}{\pi}$ Hz

Ans $f = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi \times 20 \times 10^{-3}} = \frac{100\cancel{0}}{4\cancel{0}\pi} = \frac{\cancel{20}\,25}{\pi}$ Hz

Q The reading of the ammeter is



~~a)~~ 2A

b) 3A

c) zero

d) 1A

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

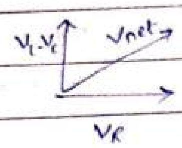
$Z = R$

$I_{rms} = \frac{E_{rms}}{Z} = \frac{\cancel{110}\,2}{\cancel{55}} = 2A$ Ans

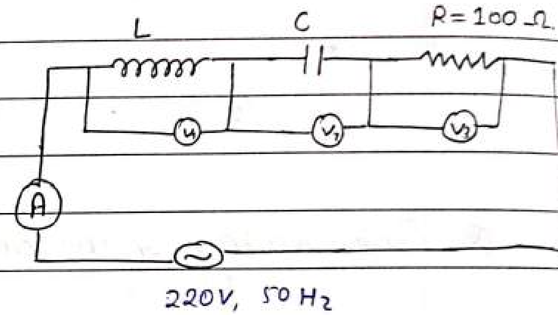
Q The potential differences across the resistance, capacitance and inductance are 80V, 40V and 100V respectively in a LCR circuit. The power factor of the circuit is :-

1) 0.4 (b) 0.5
~~(c)~~ 0.8 (d) 1.0

Ans $\cos\phi = \frac{V_R}{V_{net}} = \frac{80}{100} = 0.8$



Q In the given circuit the reading of voltmeter V_1 and V_2 are 300 volts each. The reading of the voltmeter V_3 and ammeter A is respectively.

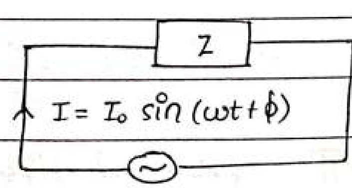


a) 150V, 2.2A ~~(b)~~ 220V, 2.2A
c) 220V, 2.0A (d) 100V, 2.0A

Ans Resonance condition

$I = \frac{220}{100} = 2.2\ A$

Q In a box 2 unknown elements, L or R or any other combination, an AC voltage $E = E_0 \sin(\omega t + \phi + \frac{\pi}{4})$. Then unknown element in the box may be.



a) Only capacitor
~~b)~~ Inductor and resistor both
c) Either, capacitor, resistor and inductor or only capacitor and resistor
d) Only resistor.

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Q In a series LCR circuit which is connected to an AC voltage source, chose the incorrect statement

a) Algebraic sum of instantaneous voltage across L, C, R is a variable

b) $(V_L)_{inst} + (V_C)_{inst} + (V_R)_{inst} = (V_{source})_{inst}$

c) Voltage across inductor, capacitor, resistance behave as a vector

d) Current is same in inductor, capacitor and resistance.

Q Assertion (A):- If an inductor coil is connected to DC source, the current supplied by it is I_1. If the same coil is connected with an AC source of same voltage. Then current is I_2. Then $I_2 < I_1$.

Reason :- In an AC circuit, inductor coil offers more resistance.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A

c) A is true but R is false

d) A is false and R is also false.

Q Assertion (A): Capacitor serve as a barrier for DC and offers an easy path to AC.

Reason (R): Capacitive reactance is directly proportional to frequency.

a) Both A and R are true & R is the correct explanation of A

b) Both A and R are true but R is not the correct explanation of A

c) A is true but R is false

d) Both A & R are false.

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Q Assertion (A): In series LCR circuit, voltage across capacitor is always less than the applied voltage.

Reason (R): In series, LCR circuit $V = \sqrt{V_R^2 + (V_L + V_C)^2}$

a) Both A and R are correct and R is the correct explanation of A
b) Both A and R are correct but R is not the correct explanation of A.
c) A is true but R is false
~~d)~~ Both A and R are false.

Q Assertion (A) :- If $X_C > X_L$, ϕ is positive and the circuit is predominantly capacitive. The current in the circuit leads the source voltage.

Reason (R):- If $X_C > X_L$, ϕ is negative and the circuit is predominantly inductive. The current in the circuit lags the source voltage.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A
~~c)~~ A is true but R is false
d) Both A and R are false.

Q Assertion (A):- Resonance phenomenon is exhibited by a circuit only, if both L and C are present in the circuit.

Reason :- Voltage across L and C does not cancel each other and the current amplitude is V_m/R, the total source voltage appearing across R causes resonance

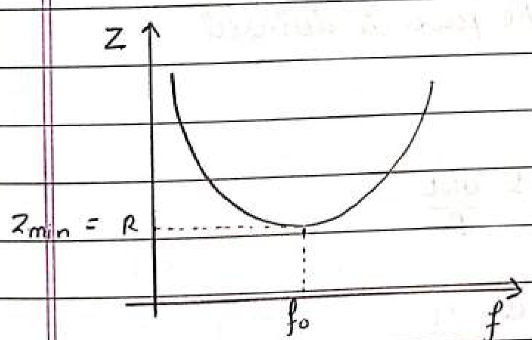
a) Both A and R are true R is the correct explanation of A
b) Both A and R are fo true but R is not the correct explanation of A.
c) Both A and R are false
d) A is true but R is false.

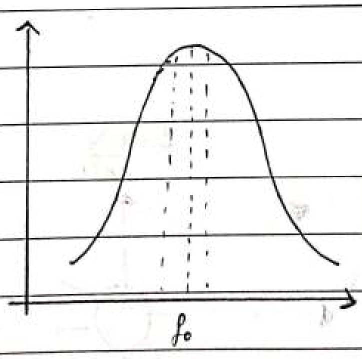
Q A capacitor acts as an infinite resistance for.

a) DC (b) AC
c) DC as well as AC d) neither AC nor DC.

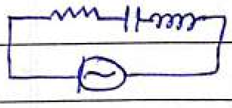
Q Assertion (A):- At resonance, power of LCR series circuit is zero.
Reason (R) :- At resonance, $X_c > X_L$

a) Both A and R are true and R is the correct explanation of A
b) Both A and R are true but R is not the correct explanation of A
c) Both A and R are false
d) A is true but R is false



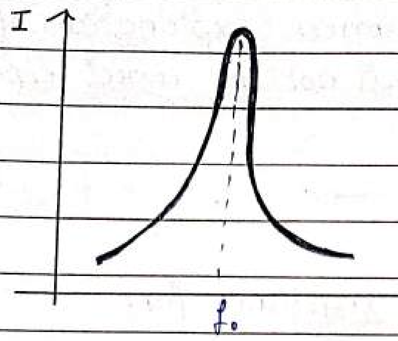


Radio
↓
series LCR
circuit



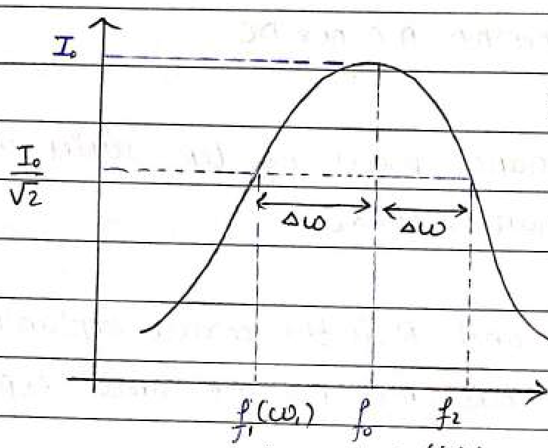
Ramlal ka
Radio $f = \frac{1}{2\pi\sqrt{LC}} = 98.3 Hz$

To get a particular frequency we
change value of C and L such that
$\frac{1}{2\pi\sqrt{LC}}$ haves value equal to that frequency.



$Q_{M.R.} > Q_{parallel}$

MR ka Radio



Bandwidth $= 2\Delta\omega$

$\Delta\omega = \omega_0 - \omega_1$

$\omega_2 - \omega_0$

$Q(\text{Quality factor}) \propto \frac{1}{2\Delta\omega}$

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

ω_0 = resonance frequency

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

Half power frequency → frequency at which half of the power is delivered

Q:

- $Q = \frac{\omega_0}{2\Delta\omega}$
- $Q = \frac{\omega_0 L}{R}$
- $Q = \frac{X_L}{R}$
- $Q = \frac{X_C}{R}$
- $Q = \frac{X_C I}{RI} = \frac{V_C}{V_R}$
- $Q = \frac{V_L}{V_R}$
- $Q = \frac{1}{\sqrt{LC}}\frac{L}{R}$
- $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Q Bandwidth of the resonant L-C-R circuit is.

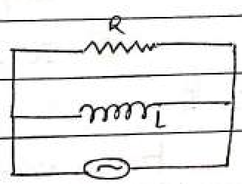
(a) R/L (b) $R/2L$
(c) $2R/L$ (d) $4R/L$

Q Which of the following combinations should be selected for better tuning of an LCR circuit used for communication.

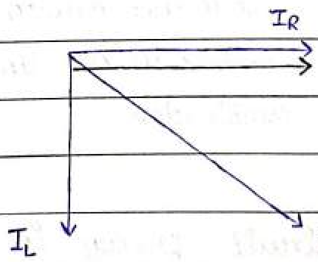
a) $R = 20\Omega,\ L = 1.5H,\ C = 35\mu F$
b) $R = 25\Omega,\ L = 2.5H,\ C = 45\mu F$
c) $R = 15\Omega,\ L = 3.5H,\ C = 30\mu F$
d) $R = 25\Omega,\ L = 1.5H,\ C = 45\mu F$

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

PARALLEL R-L Circuit



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



$E_R = E_L = E_B = E_0 \sin(\omega t)$

$(E_R)_t = (E_L)_t = E_B$

$(I_R)_t \neq (I_L)_t$

$I_{net} = \sqrt{I_L^2 + I_R^2}$

* Reciprocal of impedence is admittance

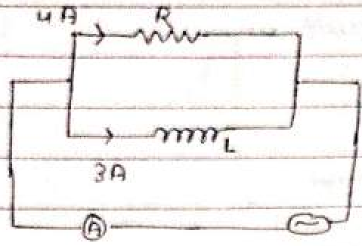
$E_L = I_L X_L$

$E_R = I_R R$

$E = I_{net} Z$

$I_{net} = \sqrt{\left(\frac{\cancel{E}}{X_L}\right)^2 + \left(\frac{E_R}{R}\right)^2} = \frac{\cancel{E}}{Z}$

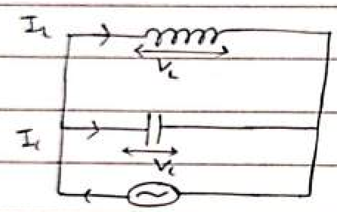
$\frac{1}{Z} = \sqrt{\frac{1}{X_L^2} + \frac{1}{R^2}}$



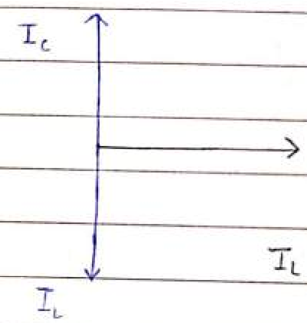
Find reading of ammeter.

$$I_{net} = \sqrt{I_L^2 + I_R^2} = \sqrt{16+9} = \sqrt{25} = 5\text{ A}$$

PARALLEL L-C Circuit



$I_c - I_L$ $\quad E = E_0 \sin(\omega t)$



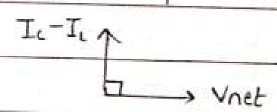
$E_B = V_L = V_c$

I_L & I_c me phase diff. $= \pi$

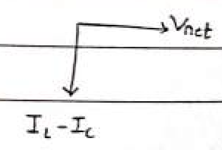
$(V_c)_t = (V_L)_t = E_0$

Phase difference between V_L and V_c is zero in parallel combination.

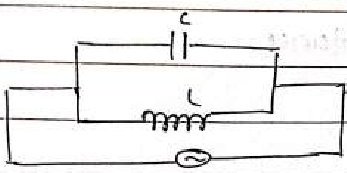
If $I_c > I_L$



If $I_L > I_c$



Q For the circuit shown in the figure the current through the inductor is 1.6A, while the current through the condensor is 0.4A, then the current I drawn from the source is



1) $2\sqrt{2}$ A $\quad$ (b) 1.65 A

~~(a)~~ 1.2A $\quad$ (d) 2.0A

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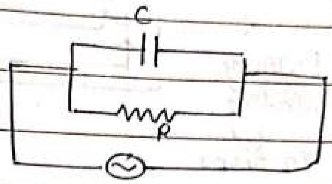
Ans $I_{net} = I_L - I_C = 1.6 - 0.4 = 1.2$.

Q In the alternating current circuit shown in the figure, the currents through resistor and capacitor are 3A and 4A respectively. The current drawn from the generator is.

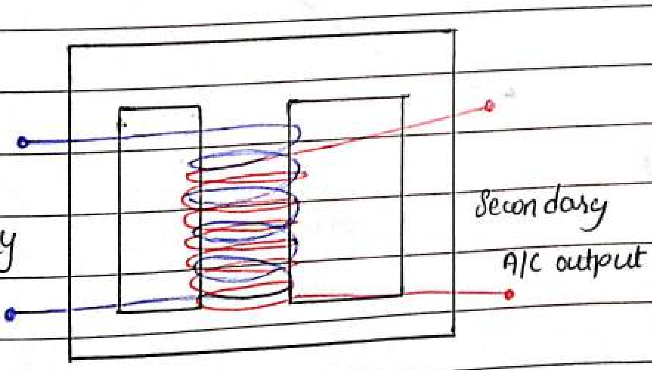
1) 7A (2) 1A
(3) 5A (d) 12A



TRANSFORMER. [To step up & step down the voltage]

→ Based on mutual inductance
→ use to step-up or step-down alternating current voltage
→ only for A/C source not for D/C
Step up → Power house
step down → sub station.

→ $\eta_{efficient} \leq 95\%$
→ For ideal transformer ($P_{loss} = 0$)
$\eta_{ideal} = 100\%$



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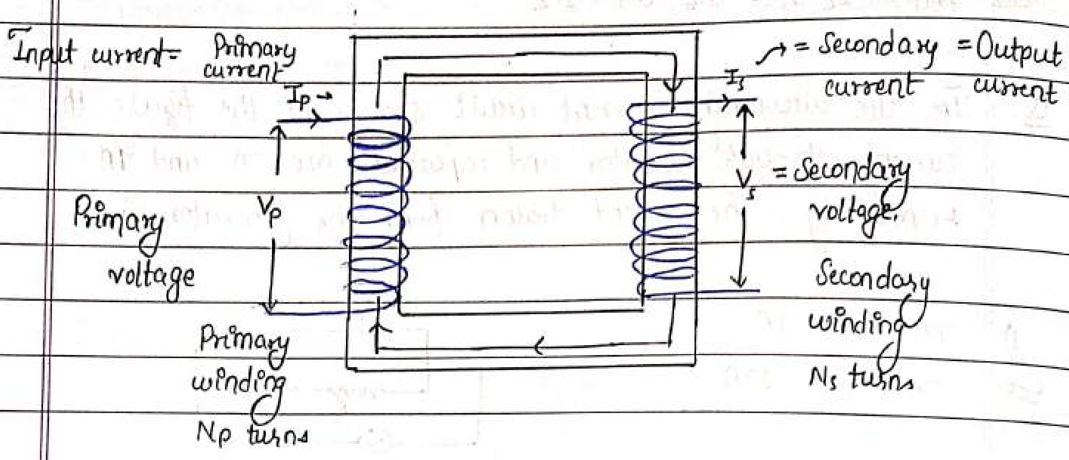

total flux passing through primary coil $= N_p \phi_0 = \phi_p$
total flux passing through secondary coil $= N_s \phi_0 = \phi_s$

$$\phi_p = N_p \phi_0 \quad \text{—①}$$
$$\phi_s = N_s \phi_0 \quad \text{—②}$$
differentiate w.r.t. time

flux passing through primary coil and secondary coil is not same but flux through one turn of Primary coil and one turn of secondary coil is same

$$\frac{\frac{d\phi_p}{dt} = N_p \cancel{\frac{d\phi_0}{dt}}}{\frac{d\phi_s}{dt} = N_s \cancel{\frac{d\phi_0}{dt}}}$$

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$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} = \text{Transformation ratio}$$

$$V_s\ (V_{out}) = \frac{N_s}{N_p} V_p$$

$$\frac{V_{in}}{V_{out}} = \frac{N_p}{N_s}.$$

Voltage ∝ No of turns

$$\frac{V_{out}}{V_{in}} = \frac{N_s}{N_p}$$

$$V_{out} = \frac{N_s}{N_p} V_{in}$$

If $N_s = N_p$

$V_{in} = V_{out}$

Ideal transformed

energy loss = zero

$P_{in} = P_{out}$

$V_p I_p = V_s I_s$

$$\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$\frac{I_s}{I_p} = \frac{N_p}{N_s} \qquad I \propto \frac{1}{\text{No of turns.}}$$

Step up transformedr	Step down transformedr
$V_{out} > V_{in}$	$V_{out} < V_{in}$
$N_s > N_p$	$N_s < N_p$
$I_s < I_p$	$I_s > I_p$
$V_s > V_p$	$V_s < V_p$
$P_{in} = P_{out}$	$P_{in} = P_{out}$
$I \propto \frac{1}{\text{No of turns}}$	$\eta = \frac{P_{out}}{P_{in}} = 100\%$
$V \propto$ No of turns	

$$\eta = \frac{P_{out}}{P_{in}} = 100\%$$

Q The ratio of secondary to the primary turns in a transformed is 3:2. If the power output be P, the input power neglecting all loses must be equal to.

a) 5P (b) P
c) 1.5P (d) 2.5P

⇒ Power is independent of no. of turns.

Q An ideal transformer has 100 turns in the primary and 250 turns in the secondary. The peak value of the AC is 28V. The RMS secondary voltage is nearest to

~~a)~~ 50 (b) 70
c) 100 (d) 40

Ans $\frac{N_s}{N_p} = \frac{(V_s)_0}{(V_p)_0}$

$$(V_s)_0 = \frac{250}{100} \times 28 = 70V$$

$$(V_s)_{rms} = \frac{70}{\sqrt{2}} = 50V$$

A step down transformer is used on a 1000V line to deliver 20A at 120V at the secondary coil. If the efficiency of the transformer is 80% the current drawn from the line is.

3A (b) 30A
0.3A (d) 2.4A

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ANS $I_p = ?$

$I_s = 20A$

$V_s = 120\,V$

$V_p = 1000$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{V_s I_s}{V_p I_p} = \frac{80}{100}$$

$$\frac{\cancel{120}^{3} \times \cancel{20}}{\cancel{1000}\, I_p} = \frac{\cancel{80}^{4}}{\cancel{100}}$$

$$I_p = 3A \quad \underline{Ans}$$

Q A current of 5A is flowing at 220V in the primary of a transformer. If the voltage produced in the secondary coil is 2200 V and 50% power is lost then the current in the secondary will be.

a) 0.25 A (b) 0.5 A
c) 2.5 A (d) 5 A

ANS $P_{out} = \frac{1}{2} P_{in}$ $V_s = 2200$

$I_p = 5A$

$V_s I_s = \frac{1}{2} V_p I_p$ $V_p = 220$

$$\cancel{2200}^{10}\, 2\, I_s = \frac{1}{2} \times \cancel{220} \times 5$$

$$I_s = 0.25\,A \quad \underline{Ans}$$

Q A 220 volt input is supplied to a transformer. The output circuit draws a current of 2.0 A at 440 volts. If the efficiency of the transformer is 80%, the current drawn by the primary windings of the transformer is.

a) 3.6 A (b) 2.8 A
c) 2.5 A ~~(d)~~ 5.0 A

Ans
$$P_{in} \times \frac{80}{100} = P_{out}$$

$$V_p I_p \times \frac{80}{100} = V_s I_s$$

$$220 \times I_p \times \frac{80}{100} = 440 \times 2$$

$$I_p = 5A$$ Ans

Q The primary and secondary coils of a transformer have 50 and 1500 turns respectively. If the magnetic flux ϕ linked with the primary coil is given by $\phi = \phi_0 + 4t$ where ϕ is in Webers, t is time in seconds and ϕ_0 is constant, the output voltage across the secondary coil is.

~~a)~~ 120 volt (b) 220 volt
c) 30 volt (d) 90 volt

Ans
$N_p = 50$ $\frac{N_s}{N_p} = \frac{V_s}{V_p}$

$N_s = 1500$

$V_p = \frac{d\phi}{dt} = 4V$ $V_s = \frac{1500}{50} \times 4 = 120$ V Ans

$V_s = ?$

* Q A transformer is used to light a 100W and 110V lamp from a 220 V mains. If the main current is 0.5 A, the efficiency of the transformer is approximately.

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a) 50% (b) 90%
c) 10% (d) 30%

Ans $I_p = 0.5A$
$I_s = ?$
$V_p = 220$
$V_s = 110$

$\frac{220}{110} = \frac{I_s}{I_p} \Rightarrow I_s = 1A$

$\eta = \frac{P_{out}}{P_{in}} = \frac{V_s I_s}{V_p I_p} \cdot 100 = \frac{110 \times 1}{220 \times \frac{1}{2}} 100 = \frac{100}{110} \times 100 = 90.9\%$

$\eta \approx 90\%$

Q The step-up transformer operates on a 230V line and supplies a load of 2 ampere. The ratio of the primary and secondary winding is 1:25. The current in the primary coil is.

a) 15A (b) 50A
c) 25A (d) 12.5A

Ans $\Rightarrow \frac{N_p}{N_s} = \frac{1}{25} = \frac{I_s}{I_p} = \frac{2}{I_p}$

$I_p = 50\ A.$

Non ideal transformer me Power loss.

1) Flux leakage:- There is always a some flux leakage. Not all the flux due to primary passes through the secondary

2) Resistance of the winding :- Some energy is lost in the form of heat dissipation. It can be minimised by using thick wire in case of high current, low voltage windings.

3) Eddy currents :- The alternating magnetic flux induces eddy currents in the iron core and causes heating. The loss can be minimized using laminated iron core.

4) Hysteresis:- The magnetisation of core is repeatedly reversed by alternating magnetic field. The resulting expenditure of energy in the core appears as heat and is kept to a

minimum by using a material which has a low magnetic hysteresis loss.

Q The core of the transformer is laminated because.

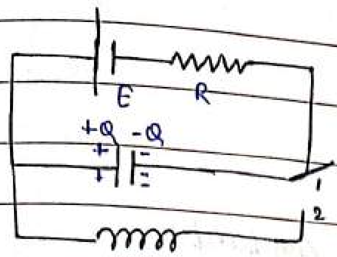
a) Ratio of voltage in primary and secondary may be increased
b) Energy loss due to eddy currents may be minimised.
c) the wt. of the transformer may be reduced
d) rusting of the core may be prevented.

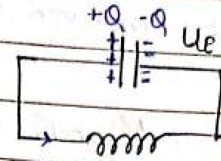
CHOKE COIL

Uses to control current in A/C circuit
It uses to divide potential without power loss.
→ It is R-L circuit

Ideal Choke coil	Practical choke coil	Bekar choke coil
↳ Pure inductor	↳ High X_L, low Resistance	High R, low X_L
↳ $\langle P \rangle = 0$	↳ R-L circuit	ϕ = small
↳ $\phi = 90°$	↳ ϕ = High	$\cos\phi$ = high
↳ $\cos 90° = 0$	$\cos\phi$ = low	High Power loss.
	Small Power loss	

L-C OSCILLATION → Always we energy conservation





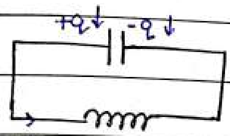
$U_E = \frac{1}{2}CV^2 = \text{maxm} \rightarrow \frac{Q^2}{2C}$

$Q_{max} = Q$

$I = 0 \quad U_m = 0$

at $t = 0$

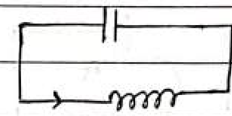
After some time



$I\uparrow \quad U_m\uparrow$

Electrostatic energy converted into magnetic energy.

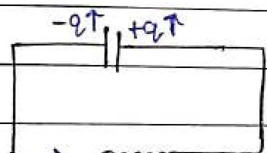
$q = 0 \quad U_E = 0$



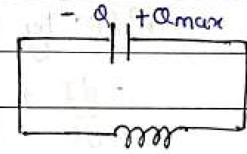
$I_{max} \quad U_B = \frac{1}{2}LI_{max}^2$

$t = T/4$

Electrostatic energy ⟶ Magnetic energy



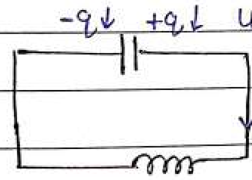
$I\downarrow$



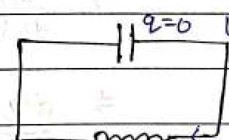
$U_E = max = \frac{Q^2}{2C}$

$t = \frac{T}{2}$

$I = 0 \quad U_m = 0$

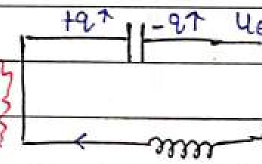


$U_m\uparrow$

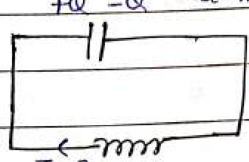


$t = \frac{3T}{4}$

$U_m = \text{maxm}$



$I\downarrow \quad U_m\downarrow$



$U_m = 0$

$t = T$

Charge oscillate
Current oscillate
Electrostatic & magnetic energy oscillate

$$Q_{max} \xrightarrow{T/4} Q=0 \xrightarrow{T/2} Q_{max}$$

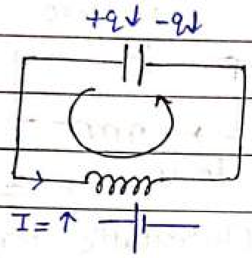
$$\underset{T}{Q_{max}} \longleftarrow \underset{3T/4}{Q=0} \longleftarrow$$

Energy will be conserved

↓

Electrostatic energy + Magnetic energy = constant

$$\frac{Q^2}{2C} + \frac{1}{2}LI^2 = \text{constant}$$



'KVL' in loop

$$-L\frac{dI}{dt} + \frac{q}{C} = 0$$

divide by L both side

$$-\frac{dI}{dt} + \frac{q}{LC} = 0$$

hint ⇒ $I = -\frac{dq}{dt}$ (q↓)

$$\Rightarrow -\frac{d}{dt}\left(-\frac{dq}{dt}\right) + \frac{q}{LC} = 0$$

$$\Rightarrow \frac{d^2q}{dt^2} + \frac{q}{LC} = 0$$

eq of SHM

$a \propto -x$

$a = -\omega^2 x$

$$\frac{d^2x}{dt^2} = -\omega^2 x$$

$$\frac{d^2x}{dt^2} + \omega^2 x = 0$$

$x = A\sin(\omega t \pm \phi)$ —(a)

LC oscillation

$$\frac{d^2q}{dt^2} + \frac{q}{LC} = 0 \quad \text{—(b)}$$

compare equation 'a' & 'b'.

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

$$q = Q \sin(\omega t \pm \phi)$$

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

$$q = q_0 \sin(\omega t \pm \phi)$$

If $q_{max} = Q_0$ at $t = 0$ $\phi = ??$

$$Q_0 = Q_0 \sin(\phi)$$

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

$$q = Q_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$q = Q_0 \cos(\omega t)$$

differentiate q w.r.t time.

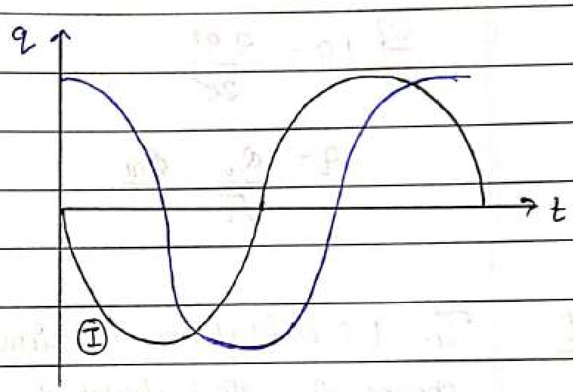
$$\frac{dq}{dt} = Q_0 \frac{d\cos(\omega t)}{dt}$$

$$I = -Q_0 \sin(\omega t)\,\omega$$

$$I = -Q_0 \omega \sin(\omega t)$$

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

$$I_0 = Q_0 \omega$$



Prove that maxm energy stored in L & C is $\frac{Q_0^2}{2C}$

$$U_E + U_m = const^n$$

$$\frac{Q^2}{2C} + \frac{1}{2} L I^2 = const^n$$

$$\frac{Q_0^2 \cos^2 \omega t}{2C} + \frac{1}{2} L Q_0^2 \omega^2 \sin^2(\omega t) = const^n$$

$$\frac{Q_0^2 \cos^2 \omega t}{2C} + \frac{1}{2} \cancel{L} Q_0^2 \frac{1}{\cancel{L}C} \sin^2(\omega t) = const^n$$

$$\frac{Q_0^2}{2C} \left(\cos^2(\omega t) + \sin^2(\omega t)\right) = const^n$$

$$\frac{Q_0^2}{2C} = constant.$$

Q In L-C oscillation if maxm charge is Q_0 then find charge in capacitor when electrostatic energy equal to magnetic energy.

Ans $(U_E + U_B)_{initial} = (U_E + U_m)_{final}$

$$\frac{Q_0^2}{2C} + 0 = 2 \times U_E$$

since $I = 0$
when Q is max

$$\frac{Q_0^2}{\cancel{2C}} + 0 = \frac{2q^2}{\cancel{2C}}$$

$$q = \frac{Q_0}{\sqrt{2}}$$ Ans

Q In L-C oscillation maximum energy is U and maximum charge Q_0, find charge ~~ch~~ energy on inductor when charge on capacitor is $\frac{Q_0}{2}$.

Ans $(U_E + U_m)_i = (U_E + U_m)_f$

$$\frac{Q_0^2}{2C} + 0 = \frac{Q_0^2}{4} \times \frac{1}{2C} + U_m$$

$$U = \frac{U}{4} + U_m$$

$$U_m = \frac{3U}{4}$$ Ans

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Q A condensor of capacity C is charged to a potential difference of V_1. The plates of the condensor are then connected to an ideal inductor of inductance L. The current through the inductor when the potential difference across the condensor reduces to V_2 is.

a) $\left(\frac{C(V_1-V_2)^2}{L}\right)^{1/2}$ (b) $\frac{C(V_1^2-V_2^2)}{L}$

c) $\frac{C(V_1^2+V_2^2)}{L}$ (d) $\left(\frac{C(V_1^2-V_2^2)}{L}\right)^{1/2}$

Ans By energy conservation.

$$(U_E+U_m)_i = (U_E+U_m)_f$$

$$\frac{1}{2}CV_1^2+0 = \frac{1}{2}CV_2^2+\frac{1}{2}LI^2$$

$$\left(\frac{C(V_1^2-V_2^2)}{L}\right)^{1/2} = I$$

Q In an oscillating LC circuit, the maximum charge on the capacitor is Q. The charge on the capacitor, when energy is stored in capacitor is half of energy stored in inductor.

a) $Q/2$ (b) $Q/\sqrt{2}$

c) $Q/\sqrt{3}$ (d) $Q/3$

Ans $(U_E+U_B)_i = (U_E+U_B)_f$

$U_E = \frac{U_B}{2}$

$$\frac{Q^2}{2C} = U_E + 2U_E$$

$$\frac{Q^2}{2C} = 3\frac{1}{2}\frac{q^2}{C}$$

$$q = \frac{Q}{\sqrt{3}}$$ Ans

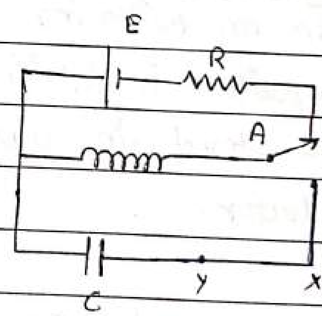
Q In oscillating L-C circuit, the total stored energy is U and maximum charge upon capacitor is Q. When the charge upon the capacitor is $\frac{Q}{4}$, the energy stored in the inductor is.

Ans
$$(U_E + U_B)_i = (U_E + U_B)_f$$
$$U = \frac{1}{2}\frac{Q^2}{(16)C} + U_B$$
$$U = \frac{Q^2}{32C} + U_B$$
$$U = \frac{U}{16} + U_B$$
$$U_B = \frac{15U}{16} \quad \text{Ans}$$

Q Switch is in position A for long time. At time $t=0$ it is switched to position B. Find the maximum charge that will accumulate on capacitor.

1) $\sqrt{LC}\,\frac{E}{R}$ 2) $\frac{E}{\sqrt{LC}\,R}$

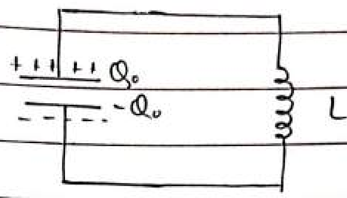
3) $\sqrt{\frac{L}{C}}\,\frac{E}{R}$ 4) $\sqrt{\frac{C}{L}}\,\frac{E}{R}$



Ans $I_{max} = \frac{E}{R}$
$$(U_E + U_B)_i = (U_E + U_B)_f$$
$$\frac{1}{\cancel{2}} L \frac{E^2}{R^2} = \frac{1}{\cancel{2}}\frac{q^2}{C}$$
$$q = \sqrt{LC}\,\frac{E}{R}$$

Q A capacitor of capacitance C has initial charge Q_0 and connected to an inductor of inductance L as shown. At t=0 switch S is closed. The current through the inductor when energy in the capacitor is three times the energy of inductor is.

a) $\frac{Q_0}{2\sqrt{LC}}$ (b) $\frac{Q_0}{\sqrt{LC}}$



c) $\frac{2Q_0}{\sqrt{LC}}$ (d) $\frac{4Q_0}{\sqrt{LC}}$

Ans $(U_E+U_B)_i = (U_E+U_B)_f$

$\frac{Q^2}{2C} = 4U_B$

$\frac{Q^2}{\cancel{2}C} = 4 \times \frac{1}{\cancel{2}} LI^2$

$I = \frac{Q_0}{2\sqrt{LC}}$ Ans

Spring mass oscillation	L-C oscillation.
mass (inertia)	L ⇒ Inductance (inertia)
$KE = \frac{1}{2}mv^2$	$U_B = \frac{1}{2}LI^2$
speed	current (I)
$PE = \frac{1}{2}kx^2$	$U_E = \frac{Q^2}{2C}$
Position	charge
K	$\frac{1}{C}$