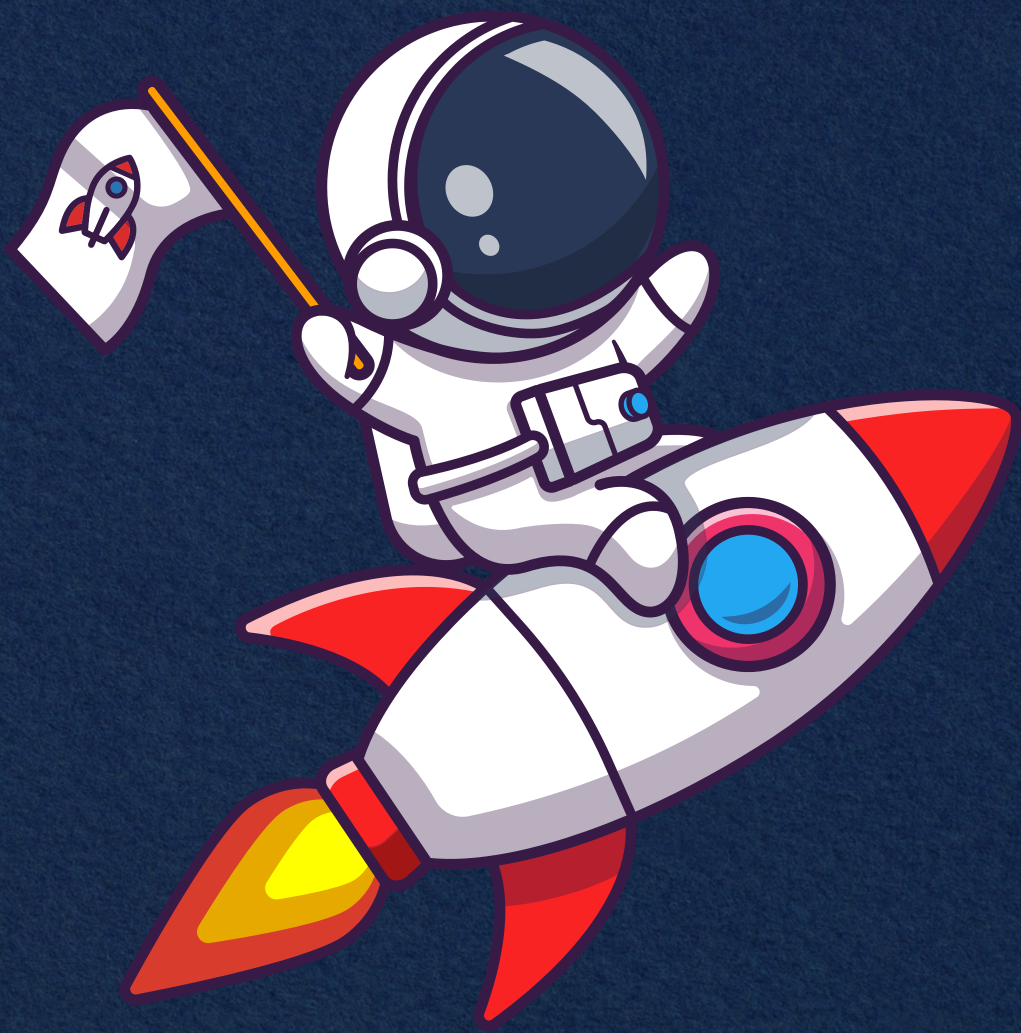
Class 12

PHYSICS

SHORT NOTES



Chapter - 7

Alternating Current

✱. Types of Current :-

① **Direct Current :-** current whose direction of flow does not change with time.

→ frequency is zero.

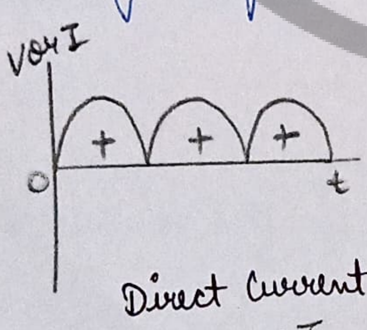
→ Polarity does not change with time.

→ Obtained from cell, Battery or DC generator.

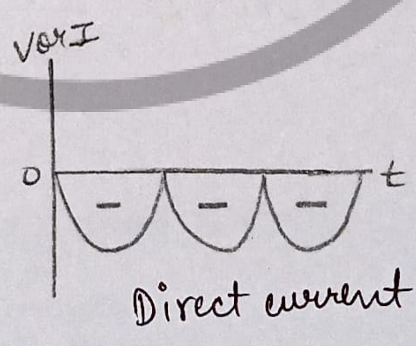
② **Alternating Current :-** current whose direction and magnitude change with time.

→ frequency is 50 Hz.

→ Polarity changes in equal time interval.



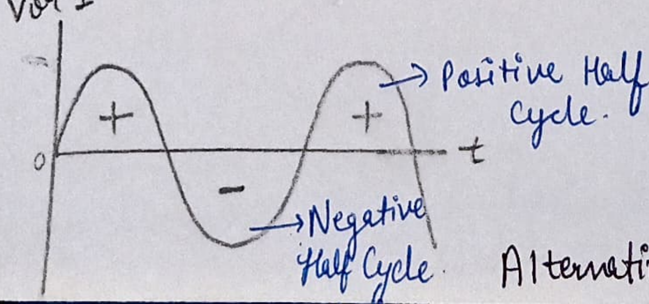
Direct Current



Direct current

$V = V_0 \sin \omega t$

$I = I_0 \sin \omega t$.



Alternating current.

☆. Advantages & disadvantages of A.C current :-

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• Advantages :-

1. A.C is cheaper than DC.
2. A.C can transmitted at negligible power loss.
3. A.C can be converted into DC by using Rectifier.
4. A.C can be stepped up or stepped down by transformer.

• Disadvantage :-

→ DC current flows through whole cross section area of wire but A.C flows through upper surface and inner part not be used.

→ To solve this problem, wire is made of thin wires to transmit current at high frequency.

☆. Mean Or Average A.C current :-

for +ve half cycle :- $\boxed{I_{avg} = \frac{2I_0}{\pi} = 0.637\, I_0}$

where I_0 = Peak current.

→ I_{avg} for one complete cycle is zero.

• Note :-

1. I_{avg} can be write as $\langle i \rangle$ or $\bar{i}$
2. for one complete cycle $\boxed{I_{avg} = 0}$ & $\boxed{V_{avg} = 0}$

☆. Root Mean Square Value of A.C :-

$$\boxed{I_{rms} = \left[\frac{\int_0^T I^2\,dt}{T}\right]^{1/2}}$$

• I_{rms} for one complete cycle :-

$$\boxed{I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707\, I_0}$$

• Note :-

① $I_{rms} = 70.7\%$ of I_0

② If Resistance is R then $\boxed{V_{rms} = \frac{V_0}{\sqrt{2}}}$

→ D.C ammeter or D.C voltmeter can not measure the value of A.C current or voltage because A.C current has high frequency.

→ It always show zero reading.

★. Short tricks to find I_{rms} for 1 complete cycle :-

① $\overline{\sin \omega t} = \frac{1}{T} \int_0^T \sin \omega t \, dt = 0$

② $\overline{\cos \omega t} = \frac{1}{T} \int_0^T \cos \omega t \, dt = 0$

③ $\overline{\sin^2 \omega t} = \frac{1}{T} \int_0^T \sin^2 \omega t \, dt = \frac{1}{2}$

④ $\overline{\cos^2 \omega t} = \frac{1}{T} \int_0^T \cos^2 \omega t \, dt = \frac{1}{2}$

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

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

$$= \sqrt{\langle I_0^2 \sin^2 \omega t \rangle}$$

$$= \sqrt{\langle I_0^2 \left(\tfrac{1}{2}\right)} = \frac{I_0}{\sqrt{2}}$$

✱. Pure Resistive Circuit, Pure Inductive Circuit, Pure Capacitive Circuit.

→ Resistance can reduce A.C as well as D.C

→ Inductance (L) can not reduce D.C but reduce only A.C.

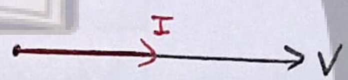
→ C blocks D.C but allows A.C to pass through.

- for R, A.C and A.V are in same phase.
- for L, A.C lags behind the A.V by $\pi/2$.
- for C, A.C leads the A.V by $\pi/2$.

* Pure Resistive Circuit :-

$V = V_0 \sin \omega t$

$I = I_0 \sin \omega t$



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

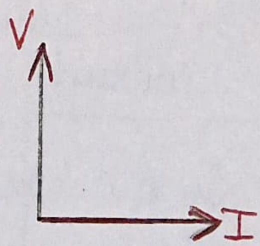
- Average Power :-

$$\boxed{P_{avg} = \frac{1}{2} I_0^2 R}$$

* Pure Inductive Circuit :-

$V = V_0 \sin \omega t$

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



$$\boxed{I_0 = \frac{V_0}{X_L}}$$ where $\boxed{X_L = \omega L}$

ω is angular frequency

L is Inductance.

- Average Power :-

$$\boxed{P_{avg} = -\frac{V_0 I_0}{2} \sin 2\omega t}$$

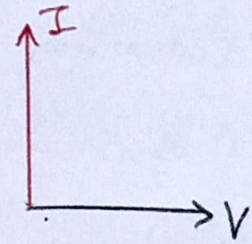
for 1 complete cycle, $\sin 2\omega t = 0$

$$\boxed{P = 0}$$

* Pure Capacitive Circuit :-

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

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



$$\boxed{I_0 = \frac{V_0}{X_C}}$$

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

C = Capacitance

- Average Power :-

$$\boxed{P_{avg} = \frac{1}{2} V_0 I_0 \sin 2\omega t}$$

for one complete cycle, $\langle \sin 2\omega t \rangle = 0$

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

☆. Note :-

→ for DC circuit, frequency = 0

So, $\boxed{X_L = 0}$

So, Pure Inductance offers zero resistance to direct current.

→ In D.C circuit $f = 0$ so, $\boxed{X_C = \infty}$

So, a capacitor will block D.C.

2019

A. LCR Series Circuit :-

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

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

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

• Case I :- If $(V_0)_L > (V_0)_C$ [or $X_L > X_C$]

$$\boxed{(V_0)_{LCR} = I_0\sqrt{R^2 + (X_L - X_C)^2}}$$

$$\boxed{(V_0)_{LCR} = I_0 Z}$$

where Z is impedance of LCR.

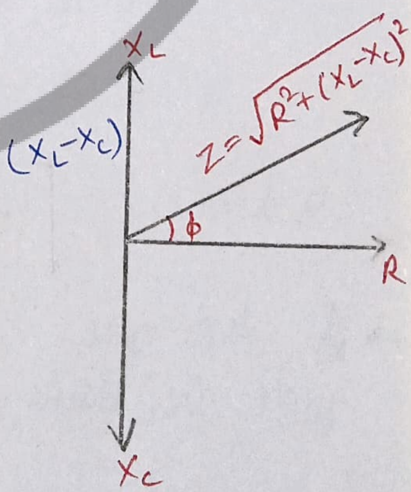
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

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

→ Resultant voltage is ahead of current by angle ϕ. It behaves as LR circuit.

→ Phase Angle :-

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



• Case - II :- If $(V_0)_L < (V_0)_C$ or [$X_L < X_C$]

$$\boxed{(V_0)_{LCR} = I_0\sqrt{R^2 + (X_C - X_L)^2}}$$

$$\boxed{(V_0)_{LCR} = I_0 Z}$$

where Z is impedance

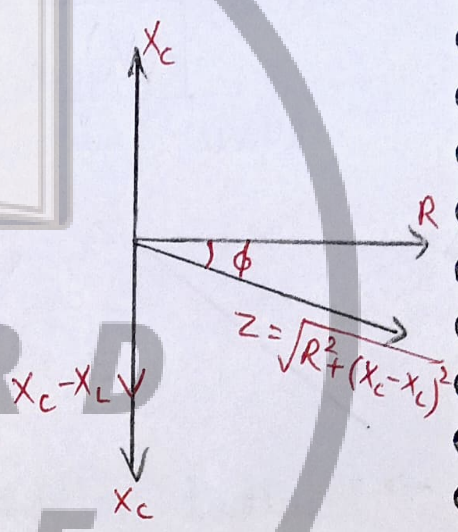
$$Z = \sqrt{R^2 + (X_C - X_L)^2}$$

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

→ In this case, "Resultant voltage lags behind of current by angle 'ϕ'. It behaves as a 'RC' circuit.

→ Phase Angle :-

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



• Case - III :- $(V_0)_L = (V_0)_C$ or $X_L = X_C$

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

$$\boxed{(V_0)_{LCR} = I_0 R}$$

→ In this case, Phase of current and resultant voltage will be same. This condition is called Resonance.

→ Phase Angle :-

$$\theta = \frac{X_C - X_L}{R} = \frac{0}{R}$$

$$\theta = 0^\circ$$

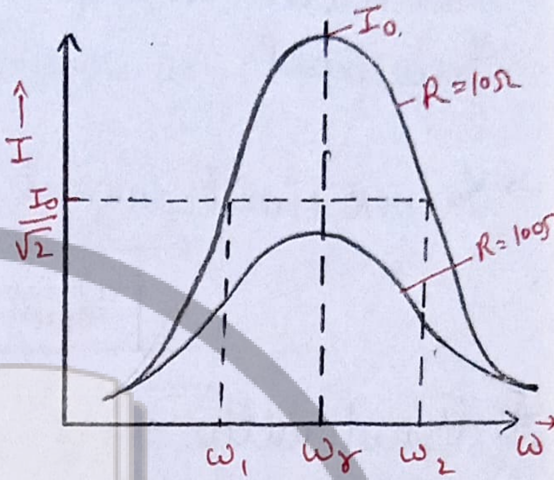
☆. Resonance in LCR Circuit :-

At a particular frequency, X_L becomes equal to X_C and maximum current flows through circuit. This is called Electrical Resonance.

Resonance Angular frequency :- $\boxed{\omega_r = \frac{1}{\sqrt{LC}}}$

Resonance frequency :- $\boxed{f_r = \frac{1}{2\pi\sqrt{LC}}}$

$\boxed{Z = R}$.



Here Impedance is minimum of LCR, So maximum current will flow. $\boxed{I_0 = \frac{V_0}{Z} = \frac{V_0}{R}}$.

- **Power :-**

At resonance, $Z_{min} = R$, $(I_0)_{max} = \frac{V_0}{R}$

$$\boxed{P_{max} = \frac{I_0^2 R}{2}}$$

→ At resonance, V & I are at same phase, so $\phi = 0$.

→ Resonance frequency depends only on L & C not R.

- **Applications of Resonance :-**

→ Used in radio and TV receiver sets.

☆. Average Power in LCR circuit :-

$\boxed{P_{avg} = V_{rms} I_{rms} \cos\phi}$ where ϕ is angle between V & I.

☆. Half Power Frequencies :-

The frequencies at which power become half of the maximum power and current becomes $\frac{1}{\sqrt{2}}$ times of maximum current are called half power frequencies.

→ In LCR circuit, current at resonance is maximum.

$$\boxed{\text{Power} \propto I^2}$$

☆. Bandwidth :-

The difference between the two half power frequencies in a circuit is called Bandwidth.

$$\boxed{\Delta f = (f_2 - f_1) = \frac{R}{2\pi L}}$$

where f_1 & f_2 are half power frequency

or

$$\boxed{\Delta \omega = \omega_2 - \omega_1 = \frac{R}{L}}$$

→ In LCR circuit, R affects $(I_0)_{max}$. Hence, it affects bandwidth or sharpness of curve.

→ As R decreases, Bandwidth also decreases and curve will be sharp.

→ for sharp & clear tuning:-

① Resonance should be sharp.

② Bandwidth should be small.

✯. Q factor (Quality factor) of Resonance :-

The sharpness of Resonance is quantitatively described by a dimensionless number known as Quality factor.

$$\boxed{Q = \frac{\text{Resonance frequency}}{\text{Band width}}}$$

$$\boxed{Q = \frac{f_r}{f_2 - f_1} \quad \text{or} \quad \frac{\omega_r}{\omega_2 - \omega_1}}$$

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

→ for sharp resonance, Q should be large. Hence,

R↓, L↑ & C↓.

→ Q value is generally more than 1.

✯. Power factor :-

The ratio of true power and apparent power is called Power factor.

$$\boxed{\text{Power factor} = \frac{\text{True Power (P)}}{\text{Apparent Power}}}$$

$$\boxed{\text{Power factor} = \cos\phi = \frac{P}{V_{rms} I_{rms}}}$$

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

→ Power factor remains maximum at $X_L = X_C$

So, $\cos\phi = 1$

$\phi = 0°$ (for Max.)

★ Transformer :- A transformer is a electrical device which is used for changing the A.C voltages.

→ Increase A.C voltage → Step-up transformer

Decrease A.C voltage → Step-down transformer.

• Principle :- Mutual Induction.

• formula :-

$$\boxed{\frac{E_P}{E_S} = \frac{I_S}{I_P} = \frac{N_P}{N_S} = K}$$

where E_P = E.m.f in primary coil

E_S = E.m.f in secondary coil

I_S = Current in secondary coil

I_P = Current in primary coil

N_P = Number of turns in primary coil

N_S = Number of turns in secondary coil

K = Transformation Ratio.

- Types of transformer:-

1. Step up transformer :- If $N_p < N_s$

then $E_p < E_s$ (voltage increase)

&

$I_p > I_s$

2. Step down transformer :- If $N_p > N_s$

then $E_p > E_s$ (voltage decreases)

&

$I_p < I_s$

- Efficiency :- The ratio of output power to the input power.

$$\boxed{\eta = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%}$$

$$\boxed{\eta = \frac{E_s I_s}{E_p I_p} \times 100\%}$$

- Note :-

Transformer can not work on D.C. It only changes A.C voltage or current. It does not affect frequency of A.C.

A. Energy loses in a transformer :-

1. Copper loss

2. Iron loss

3. Hysteris Loss

4. Leakage of Magnetic flux.