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Where Minds Pollinate

Class 12
Physics

Chapter 20
Handwritten
Notes

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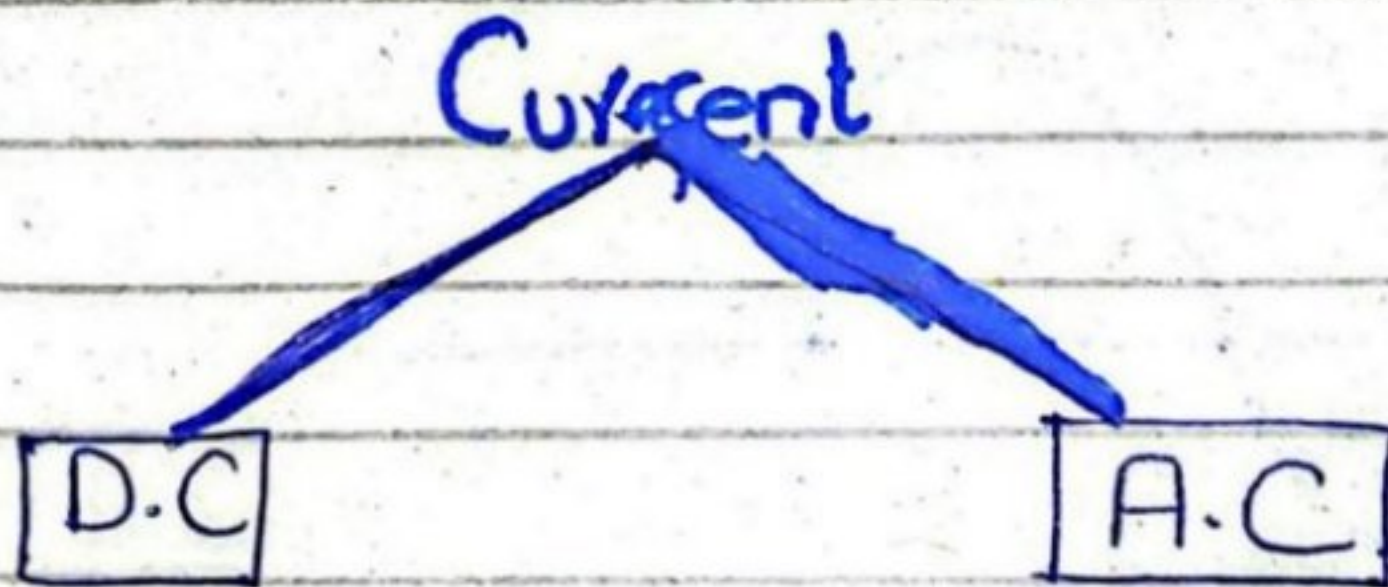
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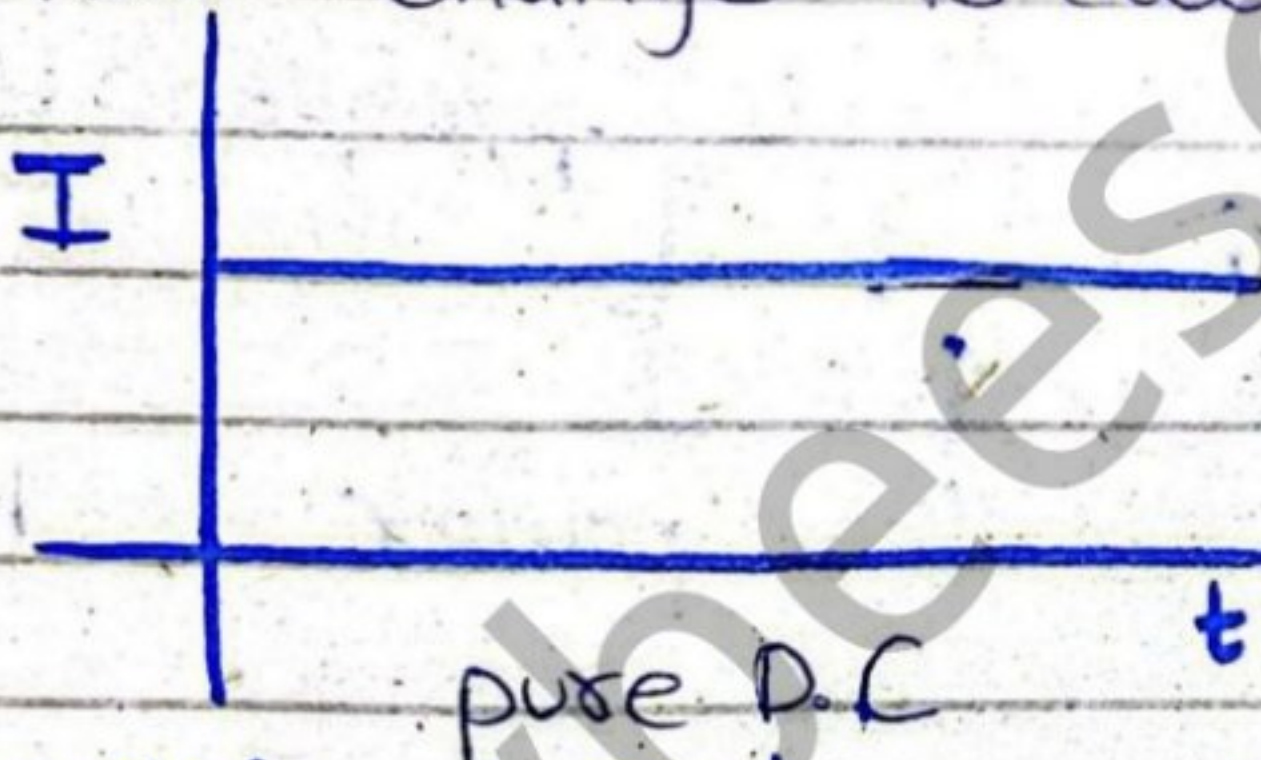
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CHAPTER # 20

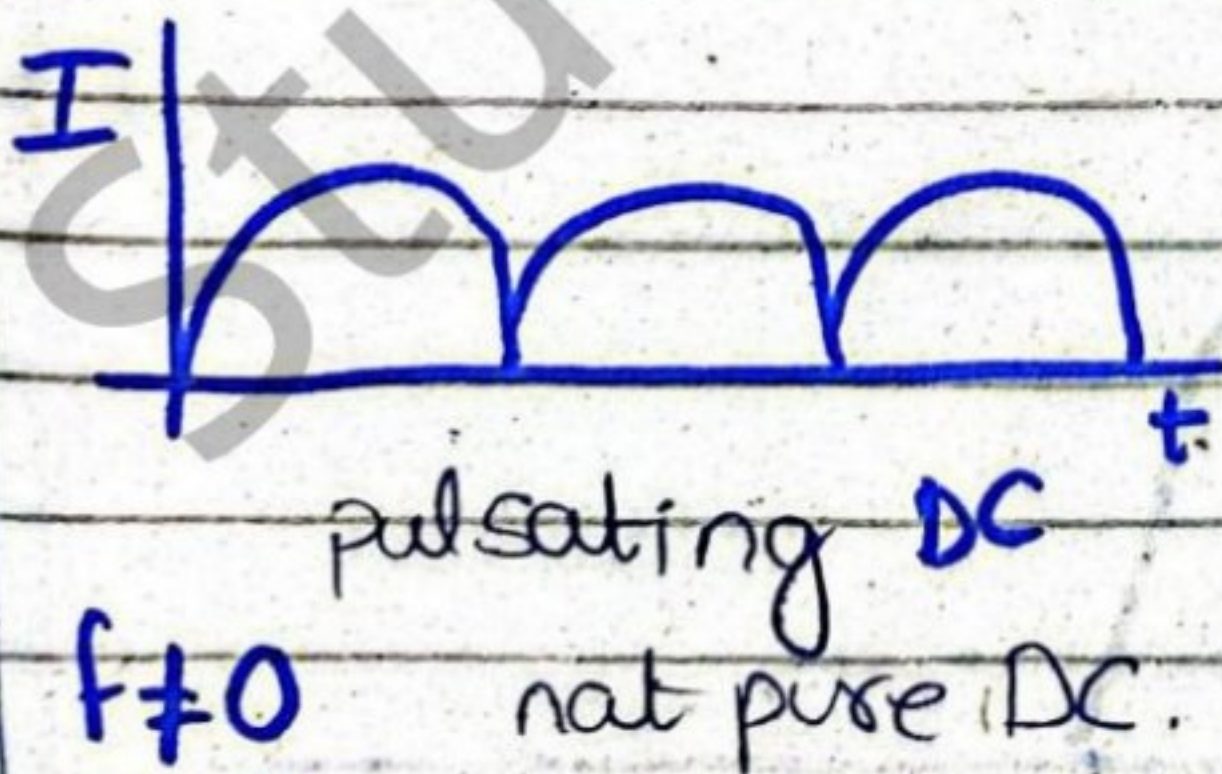
Alternating Current



• Direct Current: A current whose magnitude may or may not change but direction does not change is called direct current.



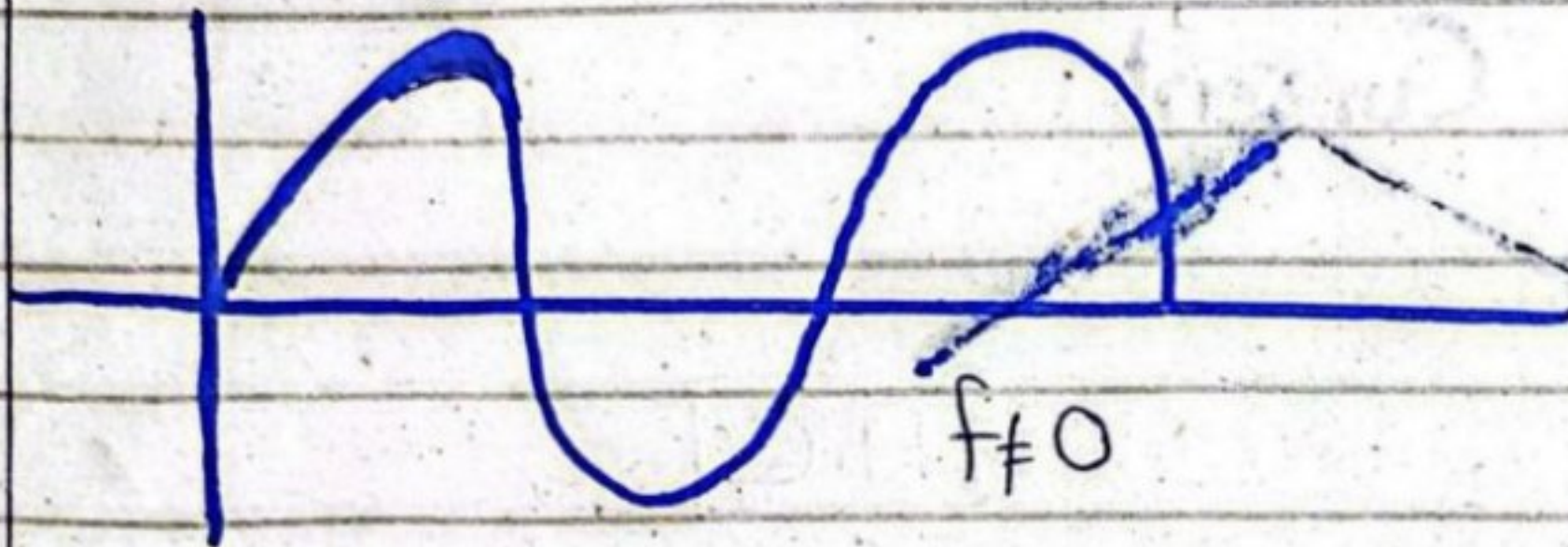
Steady state current
 $f=0$ (cell, battery),
(pure DC)



∴ AC is used for long distance travelling because it can be step up & step down while DC cannot. In AC there is less energy losses than DC.

∴ DC cannot used for large distance travelling

AC: A current whose magnitude changes continuously and direction periodically.



Q) which is more dangerous AC or DC?

Ans) AC is more dangerous because it increases chances of heart attack. It has ~~frequency~~.

Step up AC means $\uparrow V$ $\downarrow I$

Step down AC means $\downarrow V$ $\uparrow I$

} Transformers

Step up transformers means less power loss by decreasing current and increasing voltage.

* The Output of AC generator:-

• $V = V_0 \sin \omega t$

Instantaneous voltage max voltage phase

• $I = I_0 \sin \omega t$

$V = V_0 \sin\left(\frac{2\pi}{T}\right)t$

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

Sinoidal graph.

$$V = V_0 \sin \left(\frac{2\pi}{T} t \right)$$

$$t=0, \boxed{V=0}$$

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

$$V = V_0 \sin \frac{2\pi}{T} \times \frac{T}{4}$$

$$\boxed{V=V_0}$$

$$\rightarrow t = \frac{T}{2}; V = V_0 \sin \frac{2\pi}{T} \times \frac{T}{2}$$

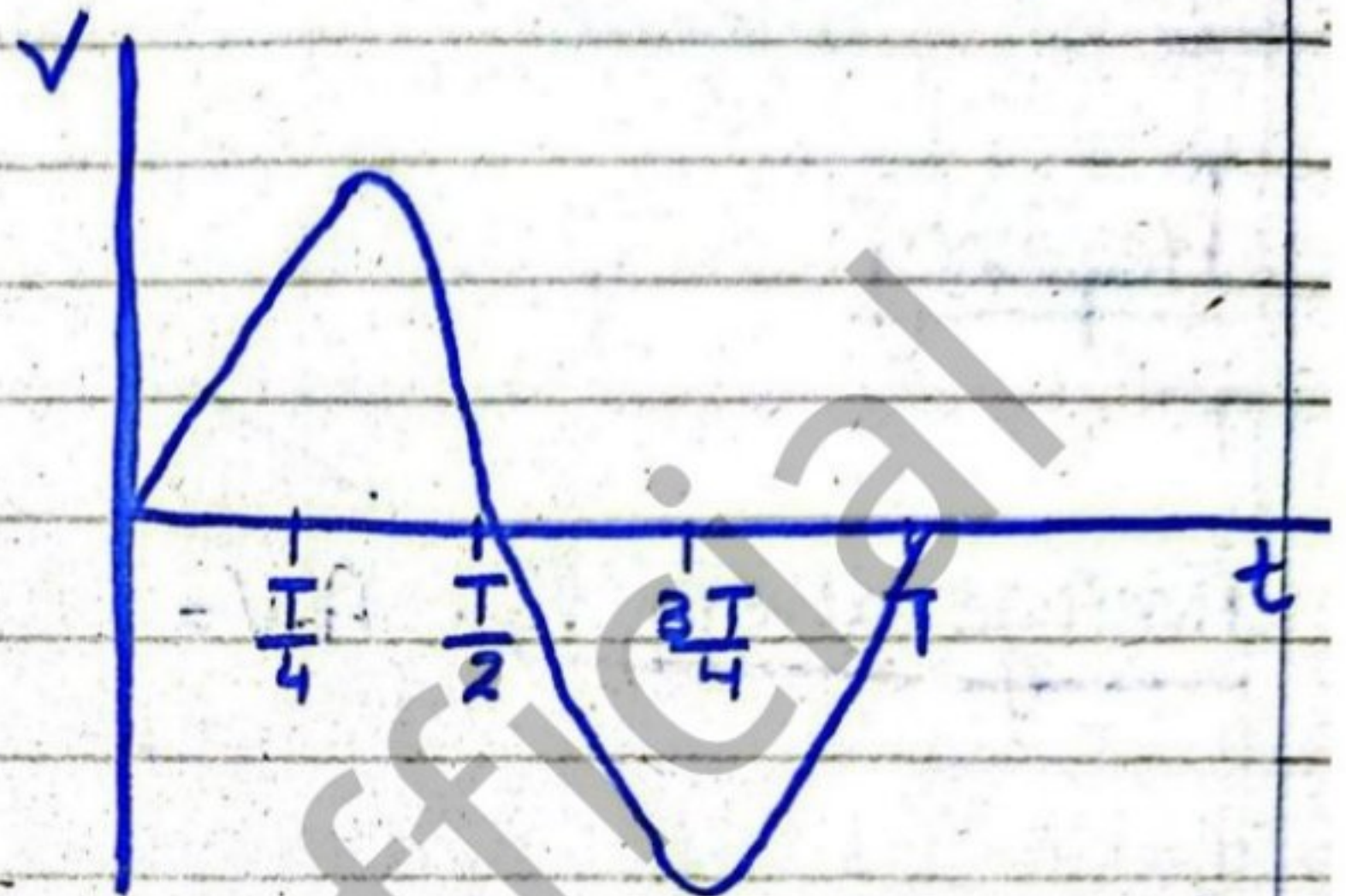
$$\boxed{V=0}$$

$$\rightarrow t = \frac{3T}{4}; V = V_0 \sin \frac{2\pi}{T} \times \frac{3T}{4}$$

$$\boxed{V=-V_0}$$

$$\rightarrow t = T; V = V_0 \sin \frac{2\pi}{T} \times T$$

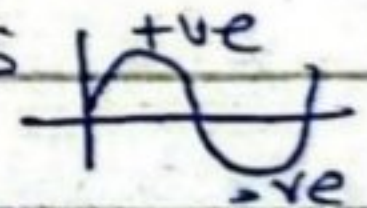
$$\boxed{V=0}$$



Info $f = 50\text{Hz}$ (Pakistan)

$\therefore$ no of peaks in 50 cycle = 100

$\therefore$ In one cycle AC changes direction one times



Q) A bulb shows how many brightness in 1 sec?

Ans) A bulb shows 100 time max brightness in 1 sec.

MCQ. Change in direction in one cycle (one time).

AC terminologies:-

Peak Value:

Maximum value of AC is called peak value of AC. (V_0)

Peak to Peak:

Sum of the positive peak & negative peak value of AC is called peak to peak value of AC.

Cycle: one complete set of +ve & -ve values of alternating quantity is called a cycle.

Instantaneous value: value of alternating quantity at any instant of time is called instantaneous value.

Time period: Time required to complete one cycle of an alternating quantity is called time period.

Frequency: No. of cycle in one second is called frequency.

Average value of AC: $A.V = \frac{\text{total area under curve}}{\text{time}}$

Average of all its values over a period of time for one complete cycle.

Average value of AC = 0. (equal +ve & -ve curve)

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

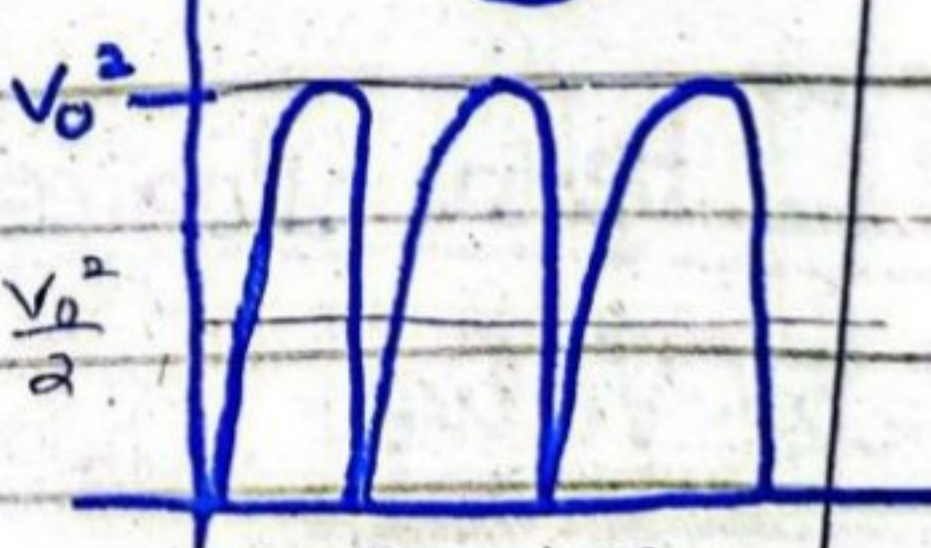
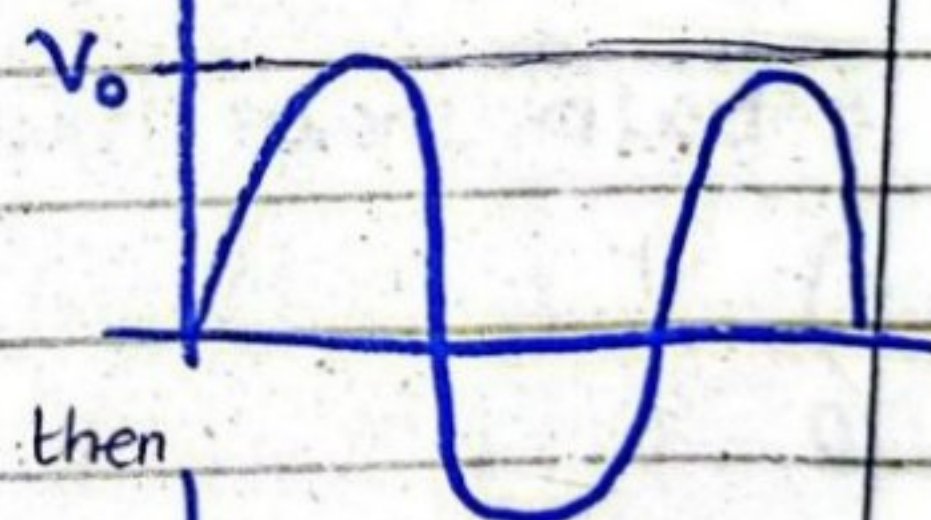
$$\langle \cos \omega t \rangle = 0$$

$$A_c = \frac{A.V - V.}{t} = \frac{A + A}{t} = \frac{0}{t} = 0$$

$$A_c = 0$$

∴ Voltmeter can't measure AC. they measure

$V_{r.m.s}$



$$\text{mean} = \frac{V_0^2}{2}$$

Taking square root

$$V_{r.m.s} = \frac{V_0}{\sqrt{2}}$$

DC equivalent of AC

(means voltmeter)

$$I_{r.m.s} = \frac{I_0}{\sqrt{2}}$$

$$I_{r.m.s} = 0.7 I_0$$

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

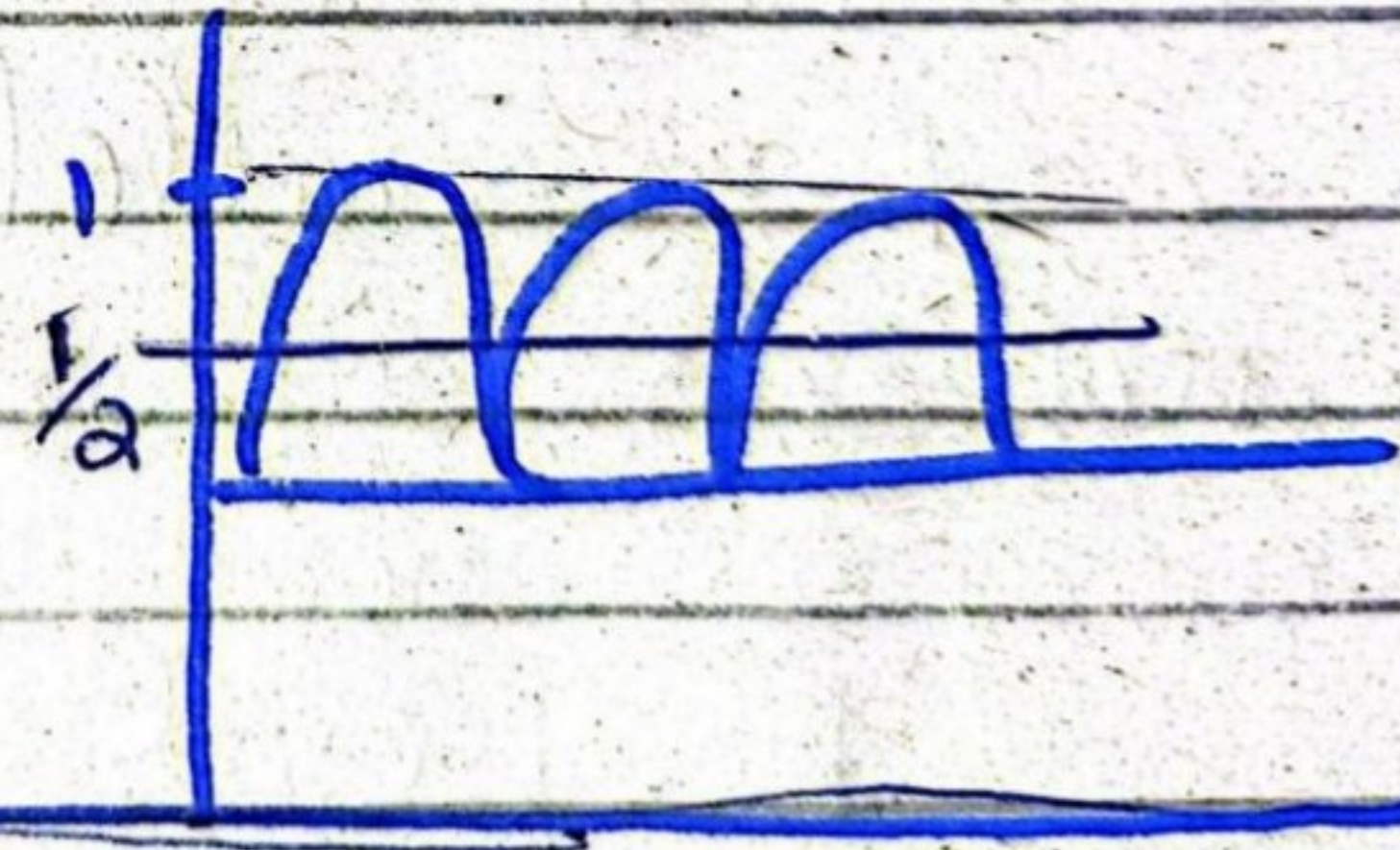
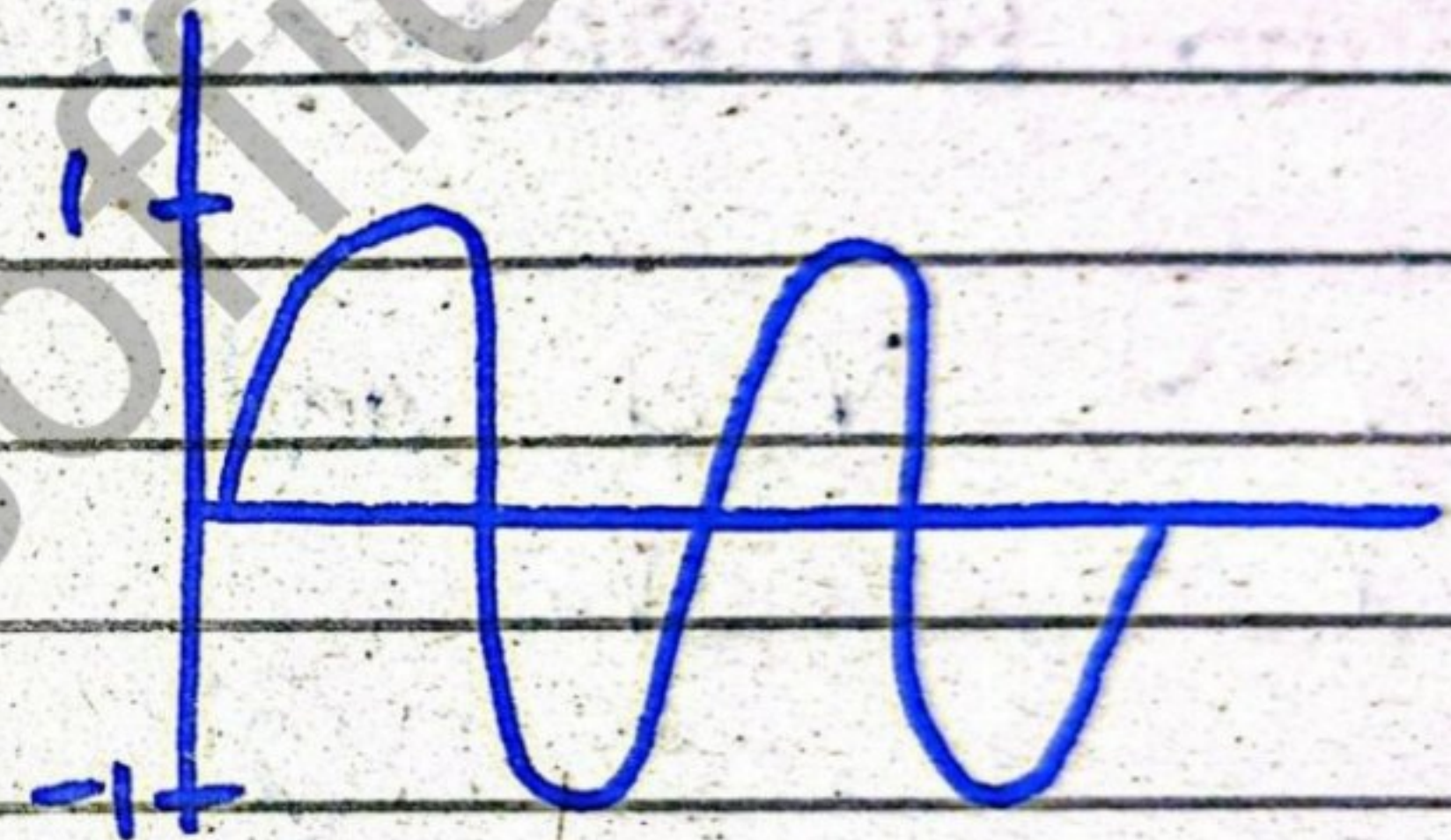
Power of AC: $P_{av} = I^2 R$

$$P_{av} = (I_0 \sin \omega t)^2 R$$

$$P_{av} = I_0^2 (\sin^2 \omega t) R$$

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

$$P_{av} = \frac{1}{2} (I_0^2 R)$$



CH # 20

Semiconductor: A substance whose conductivity lies in b/w the Conductor and insulator is called semiconductor.

- It belongs Group IV
- At 0K they behave like insulators.
- At room temp they behave like conductors.

Types:-

Intrinsic semiconductor:- Semiconductor in its pure form is called intrinsic semiconductor.

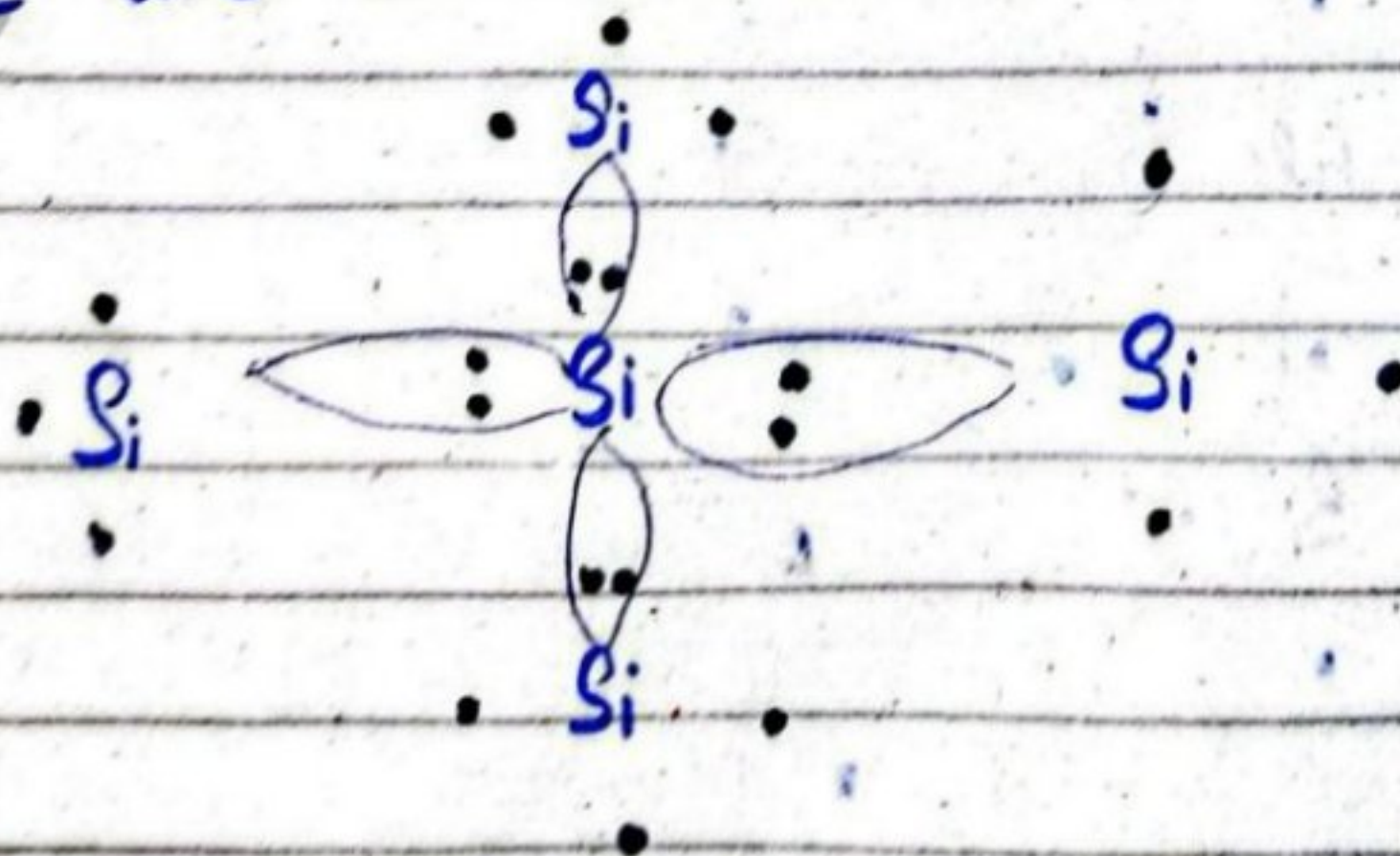
Extrinsic semiconductor:- Semiconductor in which we add impurity is called extrinsic semiconductor.

Q) why we add impurity?

Ans) To increase the conductivity of semiconductor.

Doping:- To add impurity in semiconductor is called doping. $10^6:1$

Si & Ge are semiconductors.



∴ no charge in n type & p types because both are neutral.

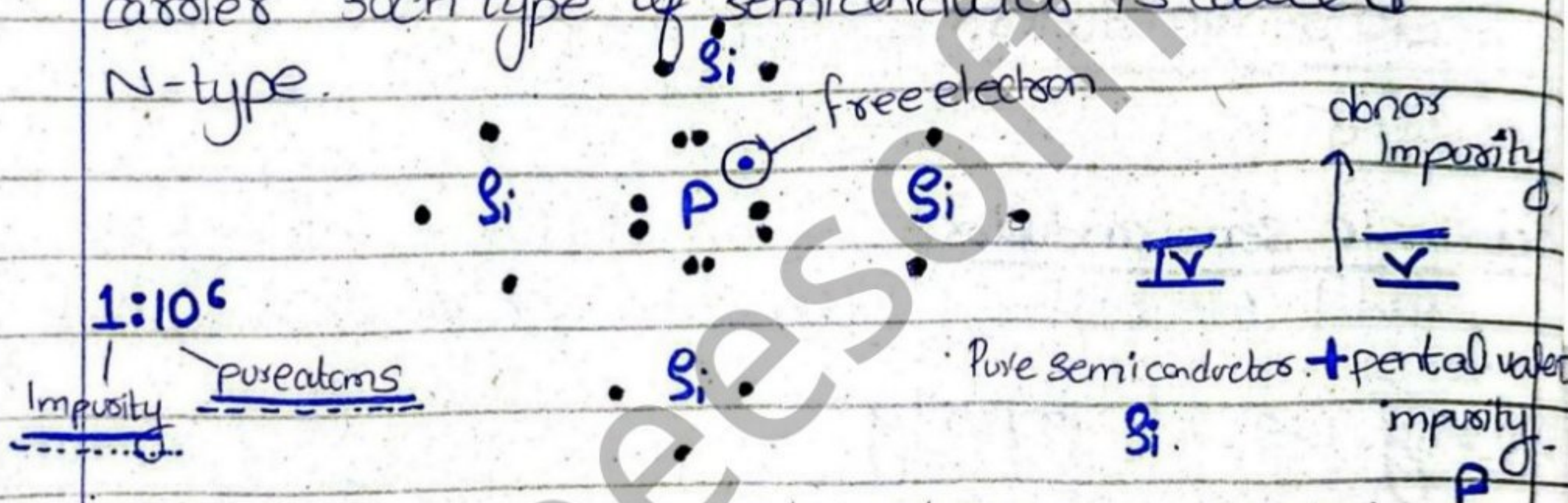
we add impurity from

Group III and V

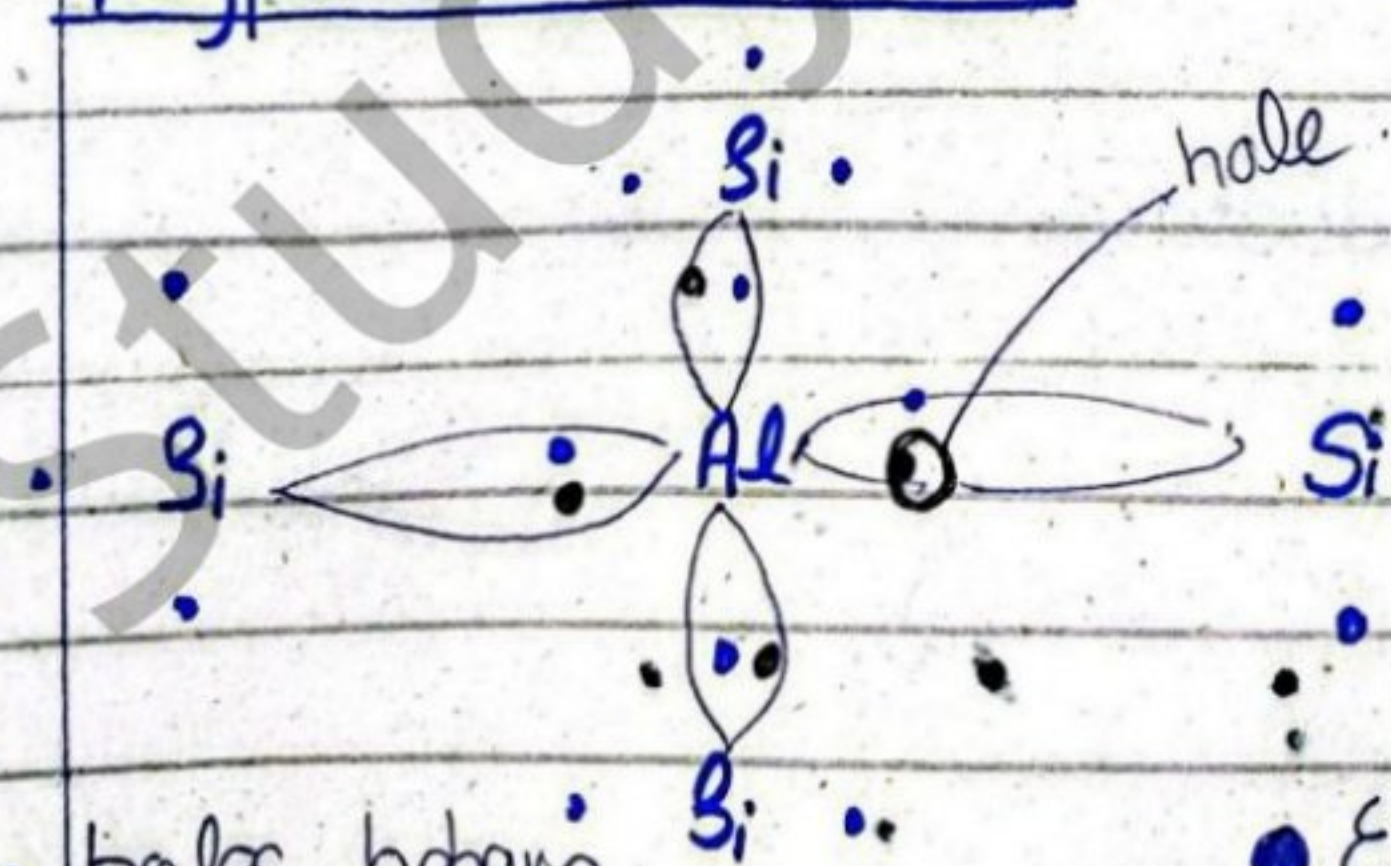
↓
acceptor impurity

↓
donor impurity

- **N-type semiconductor**:- If we add group V impurity in a pure semiconductor then $\therefore$ 1 electron become free and behave as a majority charge carrier such type of semiconductor is called N-type.



- Holes behave as a minority charge carrier.
- N-type has no charge.
- **P-type semiconductor**:-



- holes behave like a majority charge carrier.
- Electrons behave like a minority charge carrier.
- P-type has no charge.

Chapter

20

Short Question.

AC

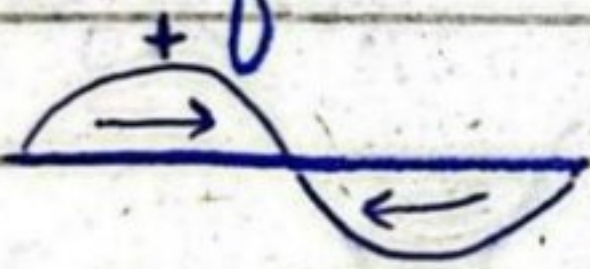
DC

1) Such a current whose magnitude & direction changes continuously.

2) Its source is AC generator.

3) Symbol:- 

4) Wave form:



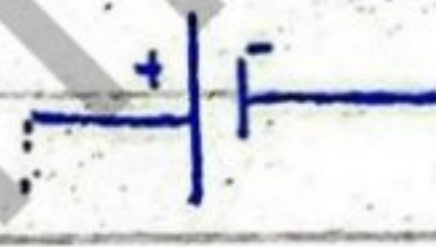
Sinoidal wave

5) In Pakistan its frequency is 50Hz

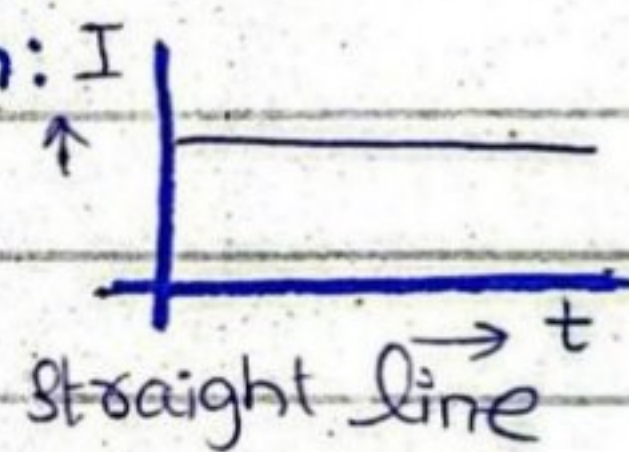
6) AC can be step up and step down.

1) Such current whose magnitude & direction remain constant

2) Its source is DC battery, solar cells, cells.

3) Symbol:- 

4) Wave form:



5) Its $f = 0$ (pure DC).

6) DC cannot be step up and step down it remain constant.

Equation For Alternating Quantities:-

• Alternating current & Alternating voltage.

$$x = x_0 \sin \phi$$

x = Instantaneous value of alternating quantities.

x_0 = Max-value / Peak value of alternating quantities

$\phi = \omega t$ = phase angle of alternating quantities.

Peak value in one cycle is 2

I — inst
 I_0 — Peak
 I_{rms} — rms

⇒ Equation of Alternating current:-

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

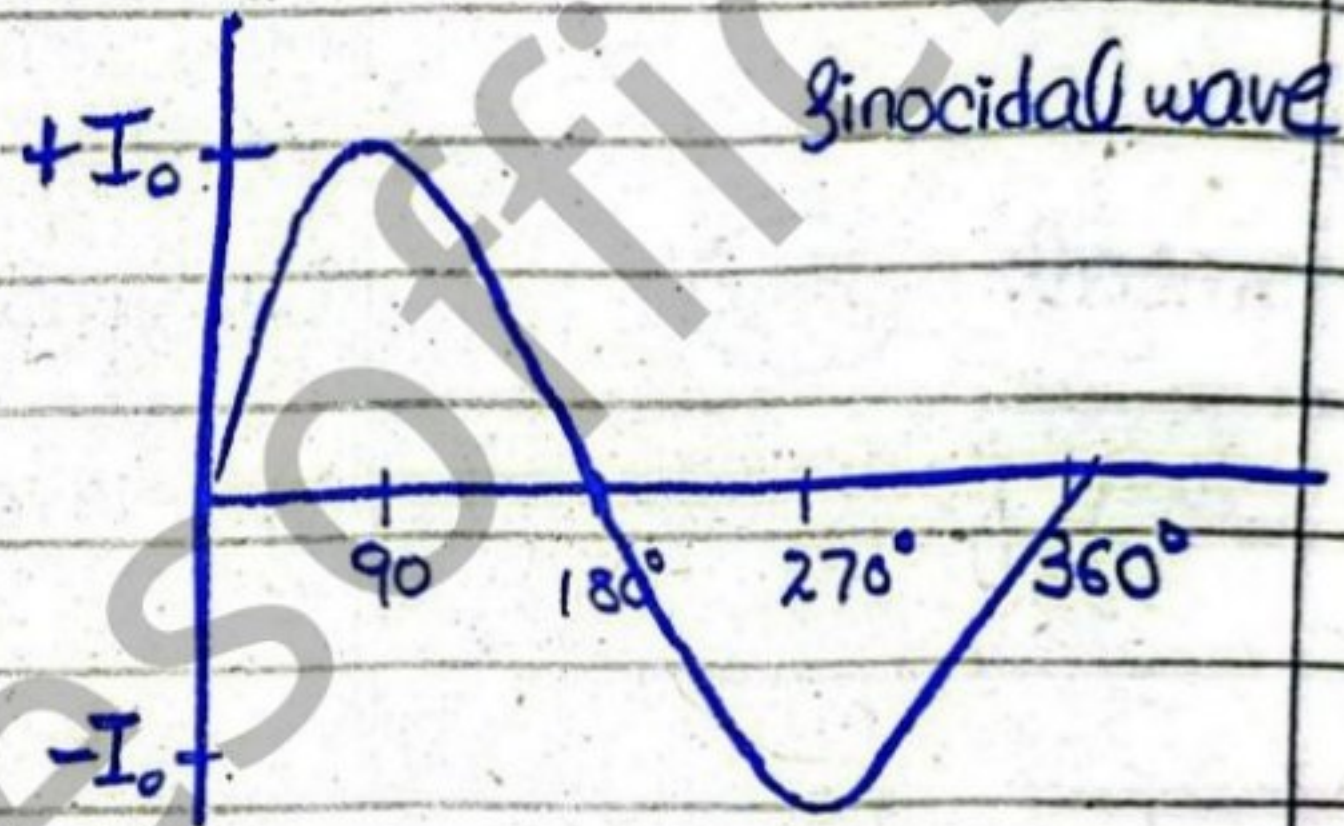
⇒ Equation for alternating voltage:-

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

instantaneous voltage. max voltage phase angle.

Graph:-

ω	I	V
0°	0	0
90°	$+I_0$	$+V_0$
180°	0	0
270°	$-I_0$	$-V_0$
360°	0	0

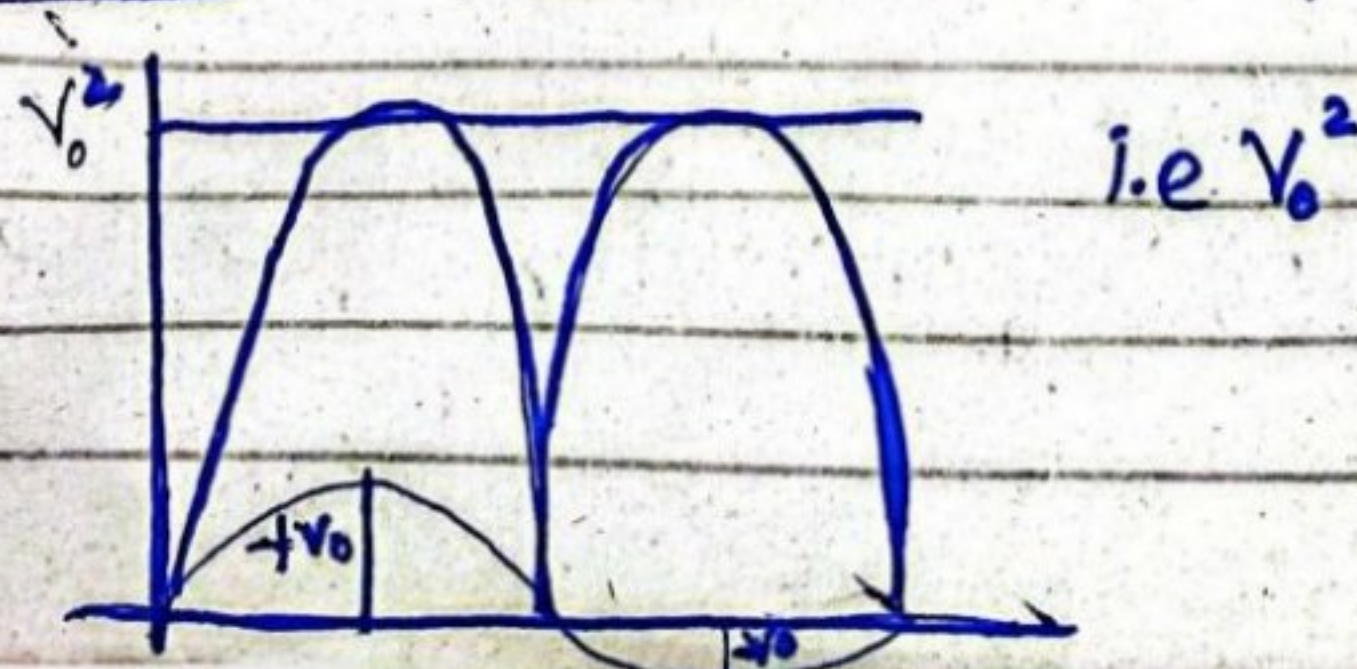


R.m.s value of AC: The effective value of AC over a cycle is called r.m.s value of AC

The value of AC while passing through a resistor R produce same heat as that of DC in a given time.

Calculation:

RMS-value: 1) Step 1 Take square of AC.



Step #2 - Taking mean of AC

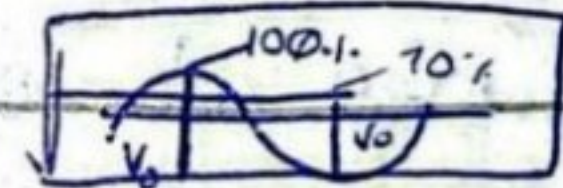
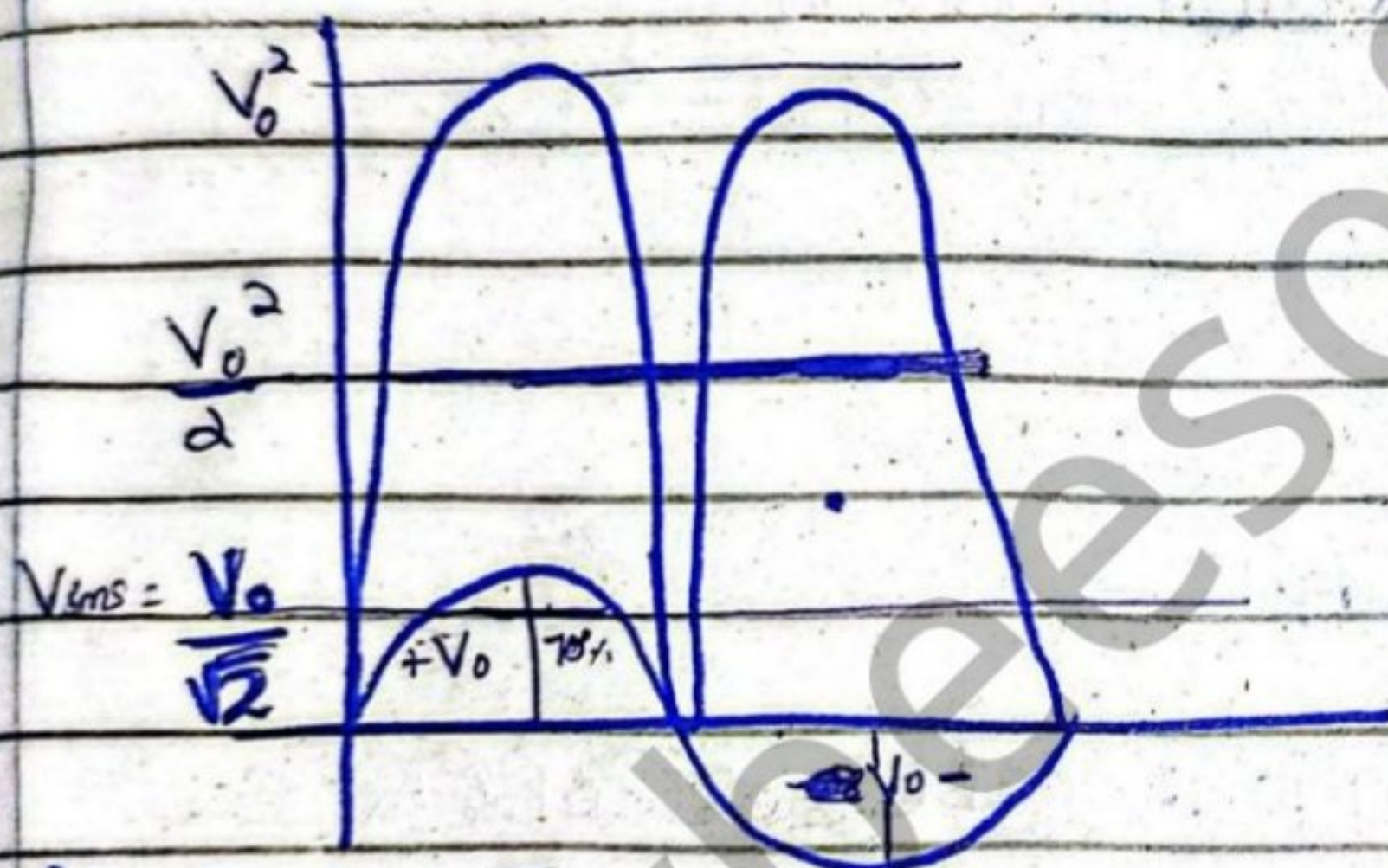
$$= \frac{\text{Minimum value} + \text{maximum value}}{2}$$

$$= \frac{0 + V_0^2}{2} = \boxed{\frac{V_0^2}{2}}$$

Step 3 - Taking square root

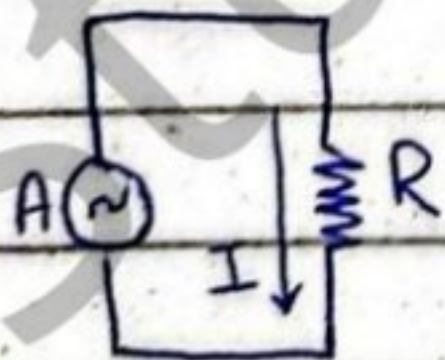
$$V_{rms} = \sqrt{\frac{V_0^2}{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}} = 0.707 V_0 = \boxed{70\% V_0}$$



Similarly $I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707 I_0 = 70\% I_0$

Maximum Power & Mean Power of AC :-



Alternating current is

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

When this current pass through resistor (R)

Power produce is

$$P = I^2 R$$

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

$$P = I_0^2 R \sin^2 \omega t$$

Max power

if $\omega t = 90$

$$P = P_0 (\max)$$

$$\boxed{P_0 = I_0^2 R}$$

max power

mean power

$$\langle P \rangle = I_0^2 R \langle \sin^2 \omega t \rangle$$

$$\langle P \rangle = I_0^2 R \left(\frac{1}{2} \right)$$

$$\boxed{\langle P \rangle = \frac{I_0^2 R}{2}}$$

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

$$\sqrt{\frac{1}{2}}$$

MCA.

$$\textcircled{1} \langle P \rangle = \frac{P_0}{2}$$

Reason: $\langle P \rangle = \frac{I_0^2 R}{2} = \frac{P_0}{2}$

$$\textcircled{2} P_0 = 2 \langle P \rangle$$

Reason: $\langle P \rangle \times 2 = I_0^2 R \Rightarrow P = 2 \langle P \rangle$

Acad

Rectification

AC into DC is called rectification.

Rectifier: Device used for rectification is called rectifier.

Diode is used as a rectifier.

Types of rectification: 2 types of rectification

1) Half wave rectification: ~~Rectification~~

2) Full wave rectification:

1) Half wave rectification: ^{efficiency 40.6%} The process in which any half cycle of AC is converted into DC is called half wave rectification.

Explanation:

- For positive half cycle: For positive half cycle diode is forward biased.
- It offers very low resistance.
- Current flows through the resistance 'R'.
- In this case, diode acts as a close switch.

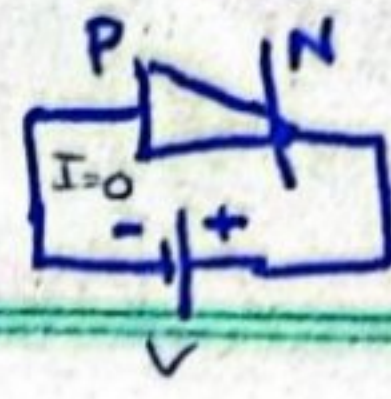
Diode:- is a unidirectional semiconductor device.

(PN junction)

Symbol of Diode:



① Forward biased (ON)
closed switch
 $R \downarrow I \uparrow$



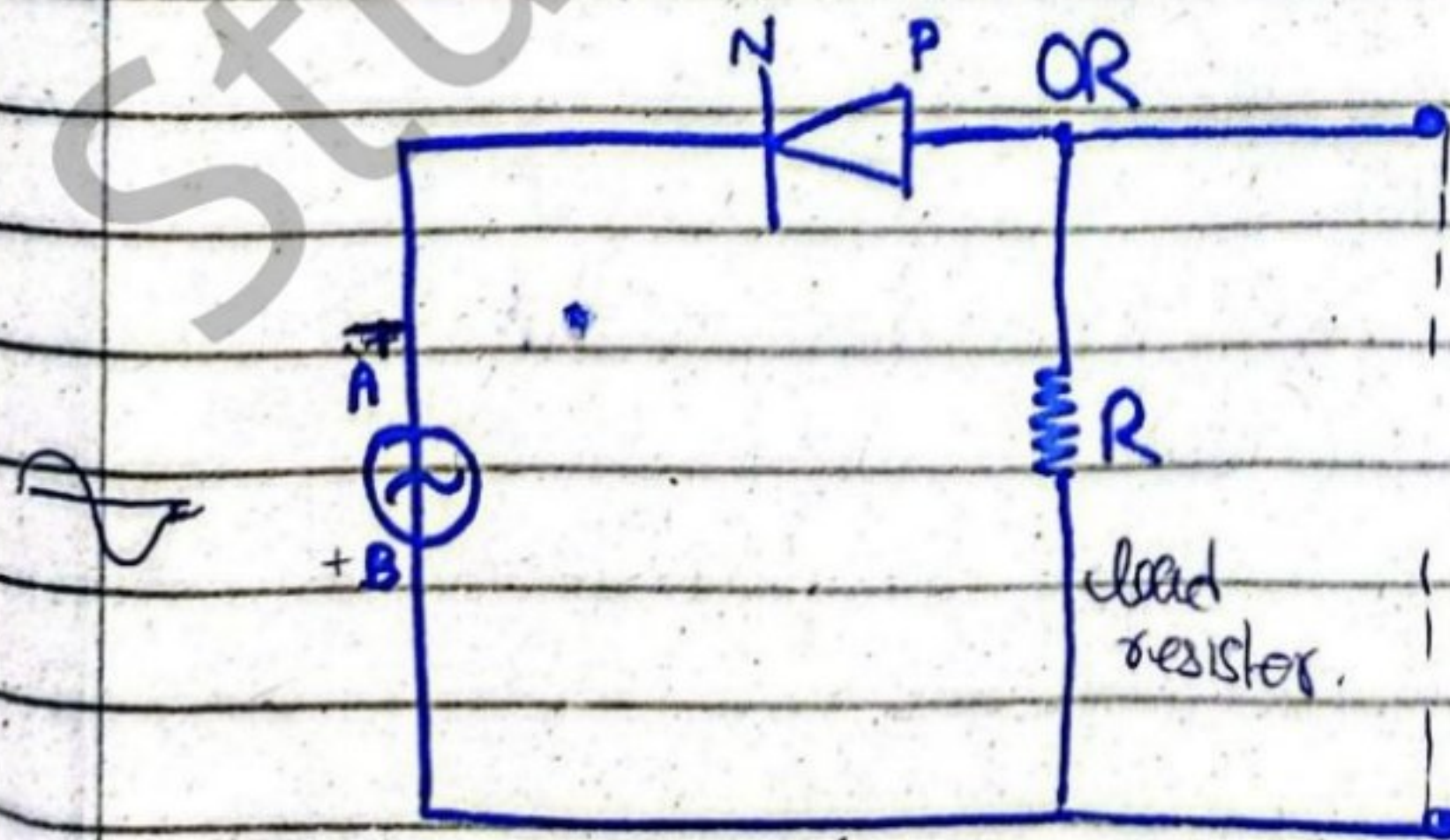
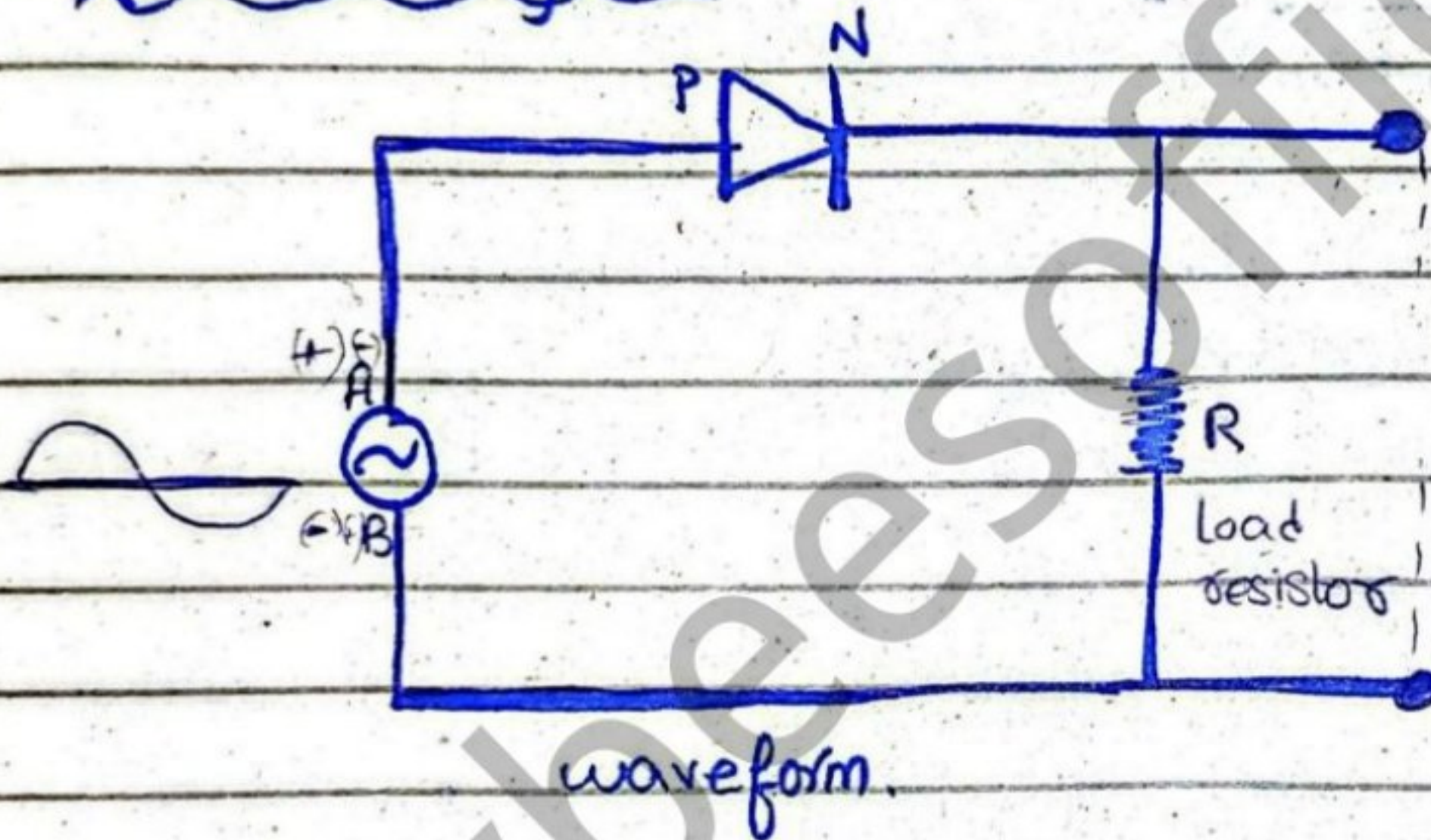
Reverse Biased (OFF)
open switch
 $R \uparrow$

2) For negative half cycle: • Diode is reversed biased

- It offers very high resistance
- Current flow through the resistor 'R'
- In this case, diode act as a open switch

Circuit Diagram:-

Half Wave Rectification



efficiency 80.2%.

Full wave Rectification:- "The process in which

complete cycle of A.C is converted to DC is called full wave rectification.

There are two waves.

- 1) Centre tapped [full wave rectification] 2 diodes are used
- 2) Bridge rectifier (4 diodes are used).

1) Bridge Rectifier:- This circuit consists of 4 diodes D_1, D_2, D_3, D_4 connected in the form of bridge.

- An A.C source
- A load resistor R

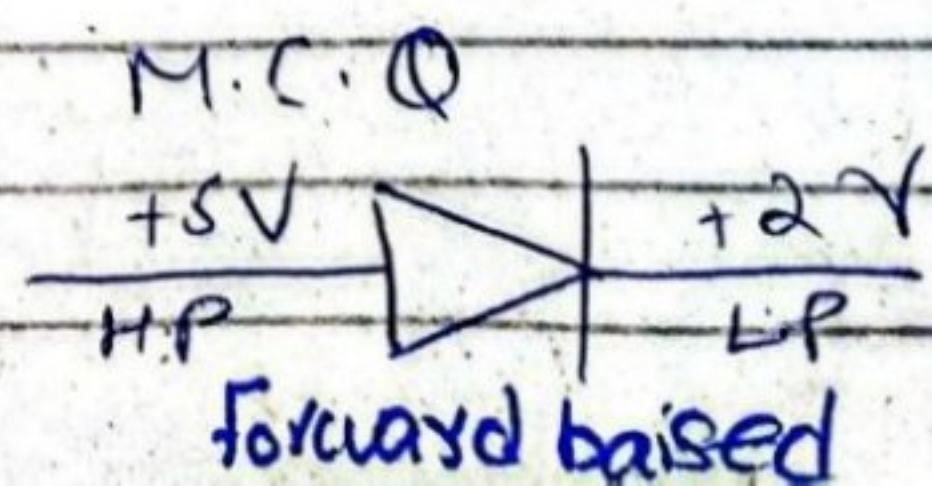
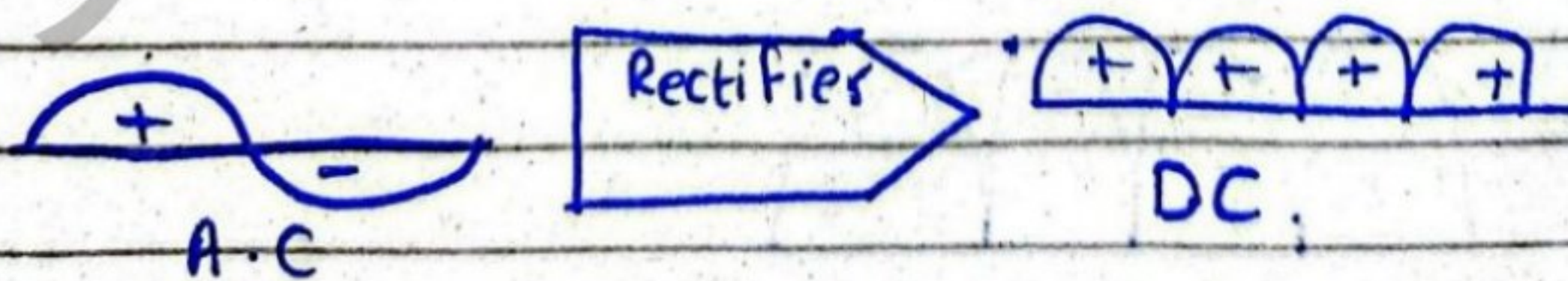
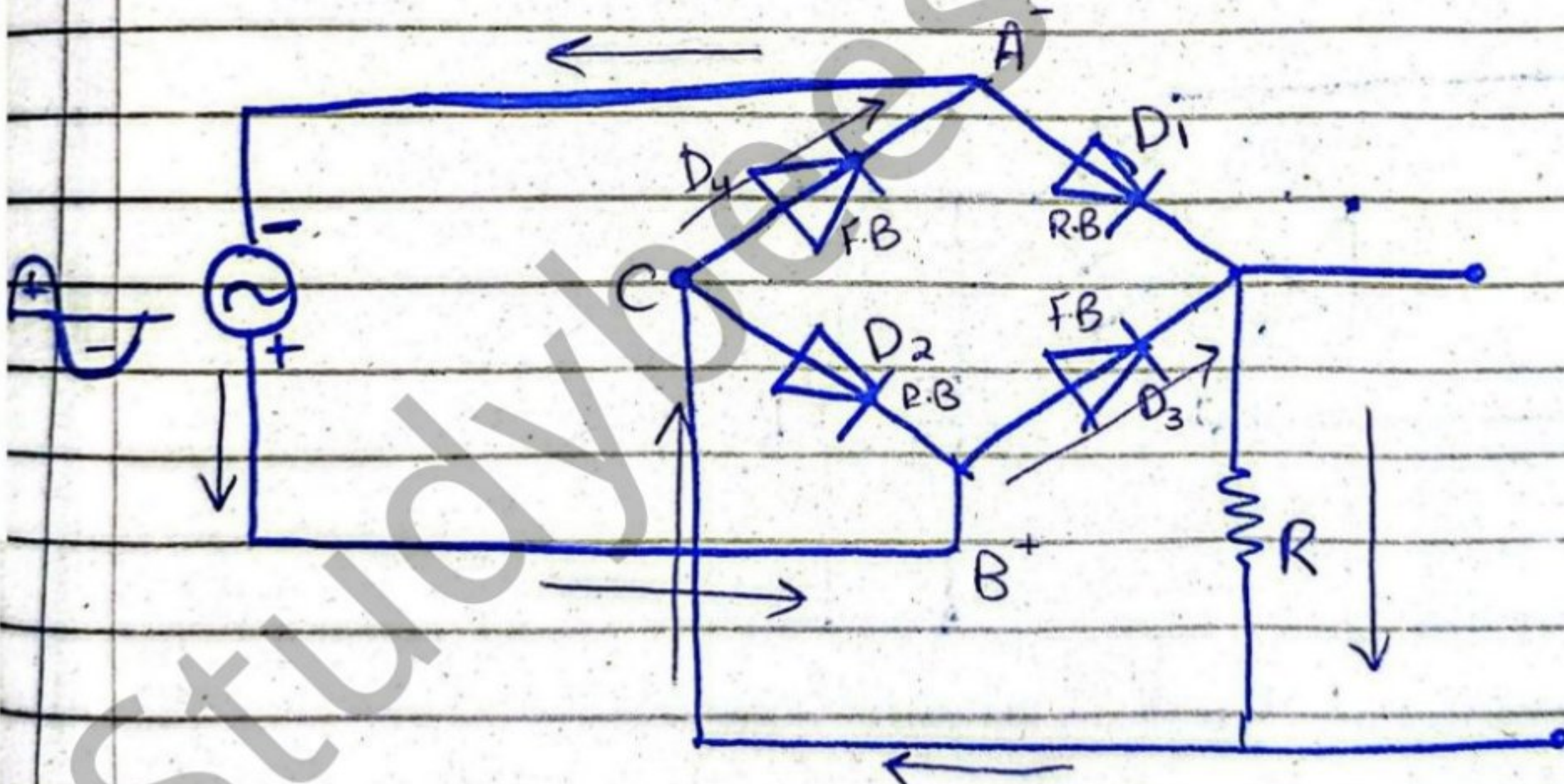
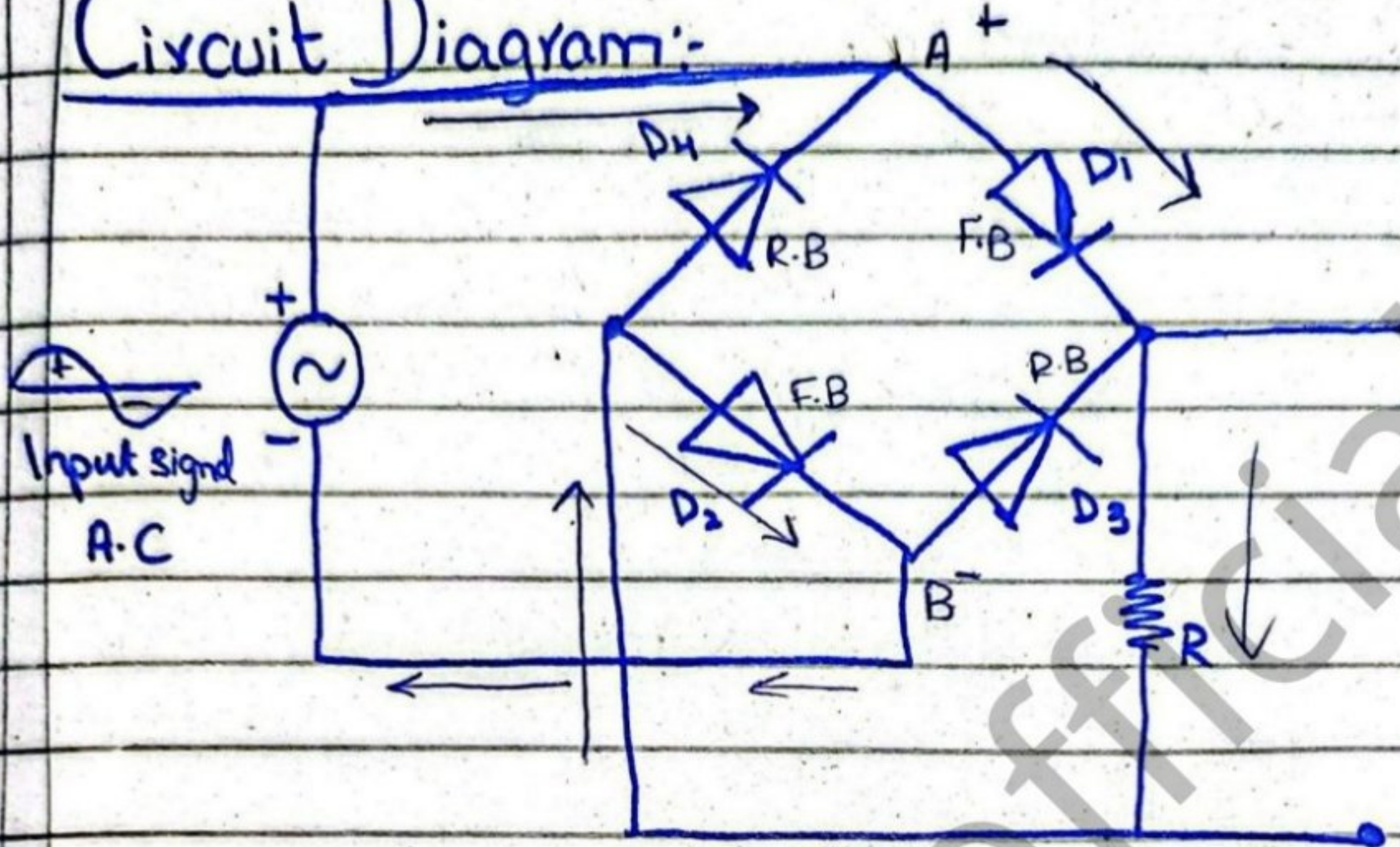
■ For positive half cycle:-

- Terminal A is positive and terminal B is negative
- Diode D_1 and D_2 are forward biased
- Diode D_3 and D_4 are reverse biased
- Hence current flows from Diode D_1 , load resistor (from top to bottom), diode D_2 and finally reaches to negative terminal.

■ For negative half cycle:

- Terminal A is negative and terminal B is positive
- Diode D_1 and D_2 are reverse biased
- Diode D_3 and D_4 are forward biased
- Hence current flows from diode D_3 , load resistor R (from top to bottom), diode D_4 and finally reaches to negative terminal.

Circuit Diagram:-



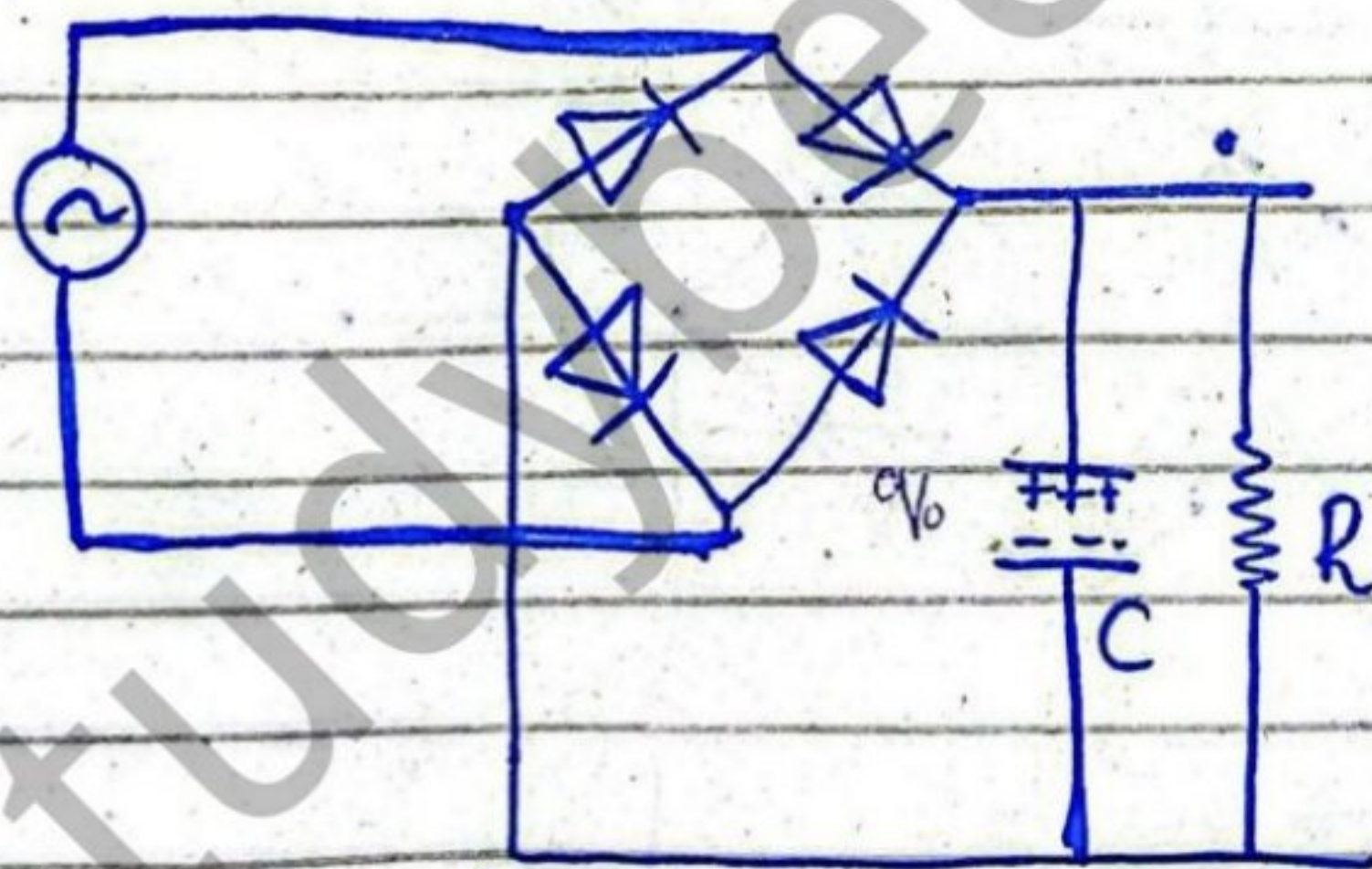
• filtering:- The process of using a capacitor to convert a pulsating DC into smooth and constant DC is called filtering.

1) When voltage rises to peak of input wave form, capacitor charges to peak voltage.

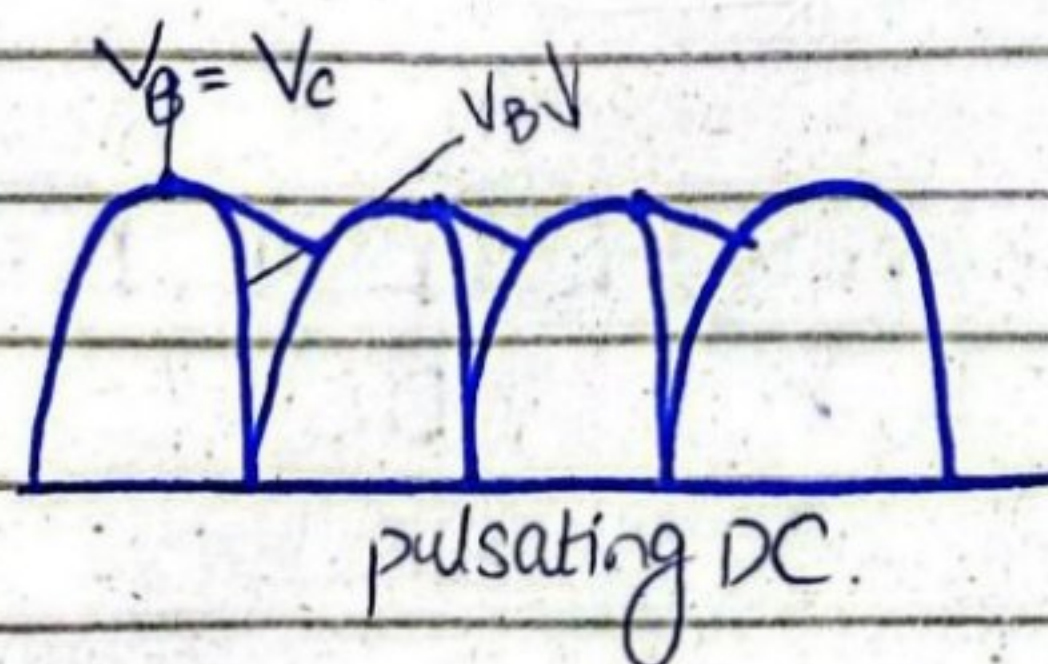
2) When input voltage drops but capacitor discharges slowly by supplying charges to load resistor.

3) This discharge of capacitor helps to fill the gap between peaks of rectified wave form.

4) In this way fluctuating voltage can be converted into smooth and constant DC.



$\uparrow t = RC \uparrow$ slow discharging



Self-Induction:- Defination: The process in which changing current induces an emf in the coil itself is called self induction.

Explanation:-

1) Consider a coil of N -turns, rheostat (variable resistor) and a battery connected in series.

2) When current in the coil changes with the help of variable resistor then magnetic flux through the coil also changes.

* Faraday law:- The emf induced in a coil is directly proportional to negative rate of change of magnetic flux.

formula: $\mathcal{E} = -N \frac{\Delta \phi}{\Delta t}$

$$\mathcal{E} = -\frac{\Delta(N\phi)}{\Delta t} \quad (1)$$

But,

$$N\phi \propto I$$

$$N\phi = LI \text{ put in (1)}$$

$$\mathcal{E} = \frac{\Delta(LI)}{\Delta t}$$

$$\boxed{\mathcal{E} = -L \frac{\Delta I}{\Delta t}}$$

i.e. $\mathcal{E} \propto \frac{\Delta I}{\Delta t}$

Self Inductance (L) constant

Symbol: L

formula: $L = \frac{\mathcal{E}}{\frac{\Delta I}{\Delta t}}$

Defination: Ratio of induce emf in a circuit to a ratio of change of current in itself.

Unit: Henry (H)

$$1H = \frac{1V}{AS}$$

Factors:- ① No of turns of coil.
 $L \propto N^2$

② Area of coil
 $L \propto A$

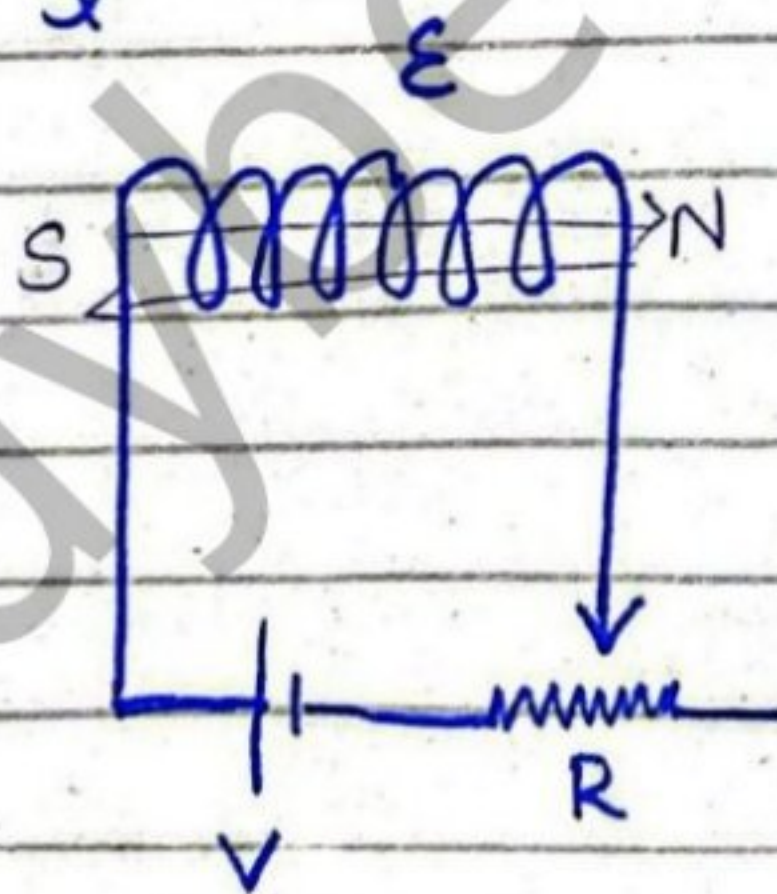
$$\therefore L = \frac{\mu_0 N^2 A}{l}$$

③ Core-material.
 $L \propto \mu_0$ (permeability)

$$\therefore \mu_0 = \frac{4\pi \times 10^{-7} \text{ wbA}^{-1}\text{m}^{-1}}$$

④ length of coil
 $L \propto \frac{1}{l}$

Diagram:



MCQs.

- 1) Self Induced emf is also called back emf because according to Lenz's law it oppose applied emf
- 2) Solenoid is also called inductor (**choke**) due to self-induction. Inductor is used to store energy in magnetic field

③ In AC circuit, Inductor is used as a resistor.

Topic: Mutual Induction

Defination: The process in which change of current in one coil induces an emf in another coil is called mutual induction.

Explanation: The circuit of mutual induction consist of two coils

1) Primary coil, 2) Secondary coil.

• Primary Coil:- It consist of battery and variable resistor (rheostat).

• Secondary coil:- such a coil that consist of only galvanometer.

• Derivation:- When current in primary coil change the help of variable resistor, then emf induced in secondary coil.

According to Faraday law, the induced emf in secondary coil is

$$\epsilon_s = -N_s \frac{\Delta \phi}{\Delta t}$$

$$\epsilon_s = -\Delta \frac{N_s \cdot \Delta \phi}{\Delta t} \quad \text{--- (1)}$$

Here $N_s \phi \propto I_p$

$$N_s \phi = M I_p$$

putting in (1)

$$\epsilon_s = -\Delta \frac{M I_p}{\Delta t}$$

$$\boxed{\epsilon_s = -M \frac{\Delta I_p}{\Delta t}}$$

Mutual Inductance:- Symbol: M

Formula: $M = \frac{E_s}{\frac{\Delta I_p}{\Delta t}}$

Definition:- It is the ratio of induced emf in secondary to rate of change of current in primary coil.

Unit: Henry H

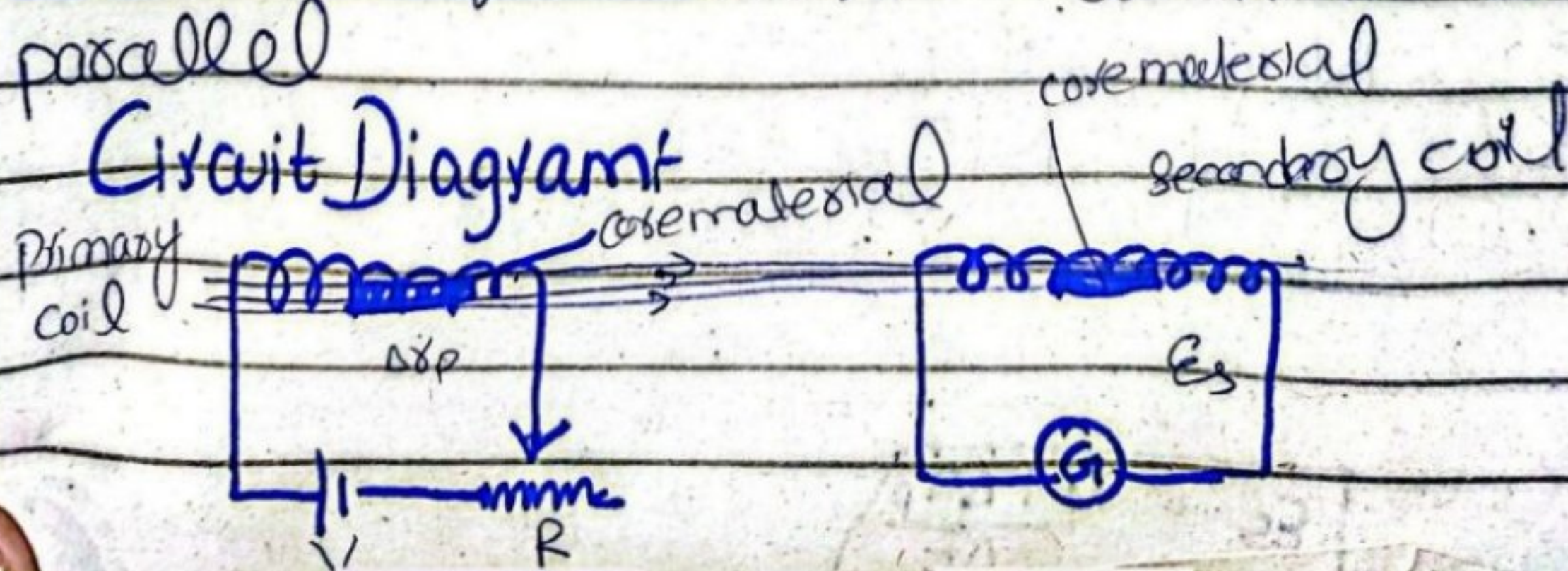
$$1H = \frac{1V}{1AS^{-1}}$$

$$H = VsA^{-1}$$

Factors affecting mutual-inductance

- ① No of turns of coils:- $M \propto N_s$
- ② Area of coil:- $M \propto A$
- ③ Closeness of coil:- Two coils must be close to each other.
- ④ Core material of coils:- It increases when core material is put b/w coils
- ⑤ Orientation of coils:- Two coils must be parallel

Circuit Diagram

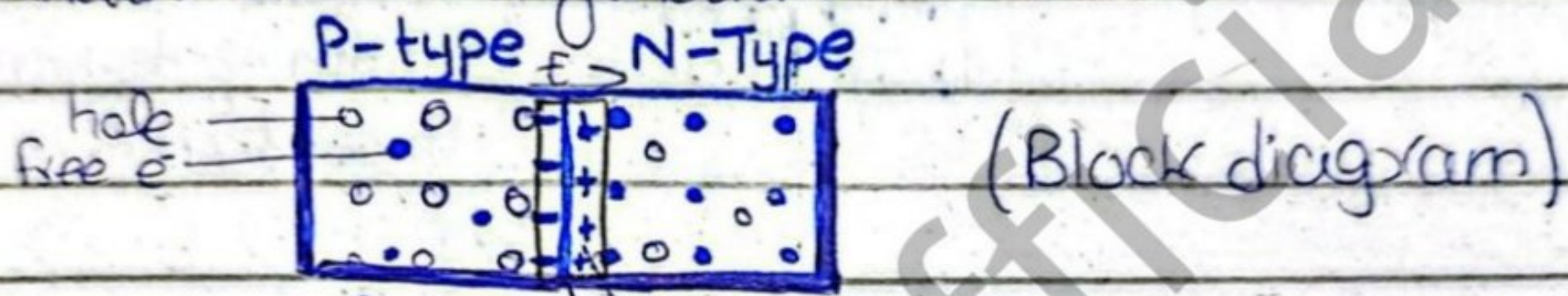


Ch#20

CLG.

•• hole seems to be move but actually it does not move e^- moves

PN Junction:- If we add pentavalent impurity at one side of pure semiconductor and trivalent impurity at other side of pure semiconductor this type of combination is known as PN junction.

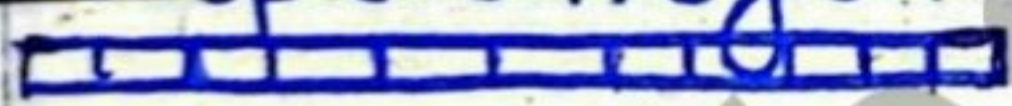


P.N. $\Rightarrow$ Potential barriers

Si $\Rightarrow$ 0.7V (Knee voltage)

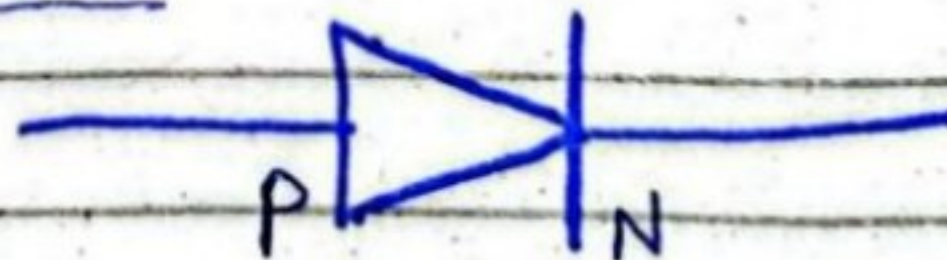
Ge $\Rightarrow$ 0.3V (Knee voltage)

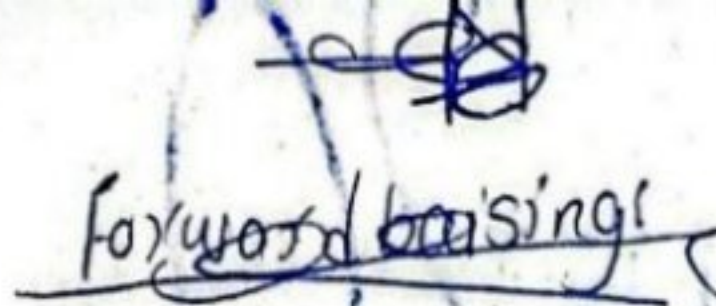
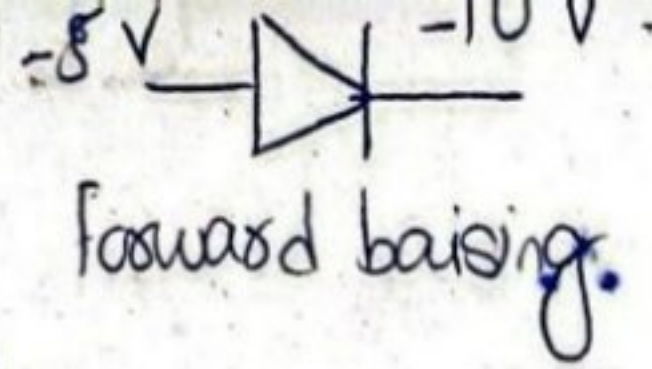
Depletion region:-



Just after the formation of junction, electron start diffusing from n type to p-type. After some time a charge less region is developed across the junction that stop the further diffusing of electron from N-type to p-type this region is also called depletion region and its potential is known as a potential barrier.

Symbol of Diode:-



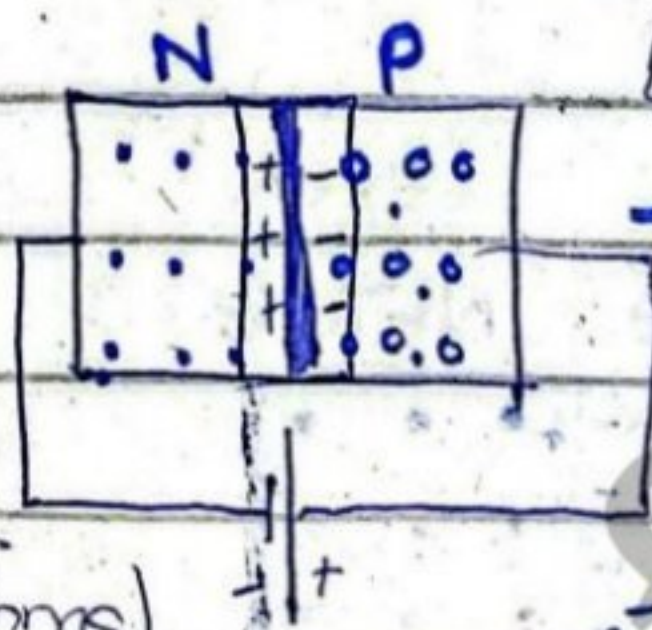
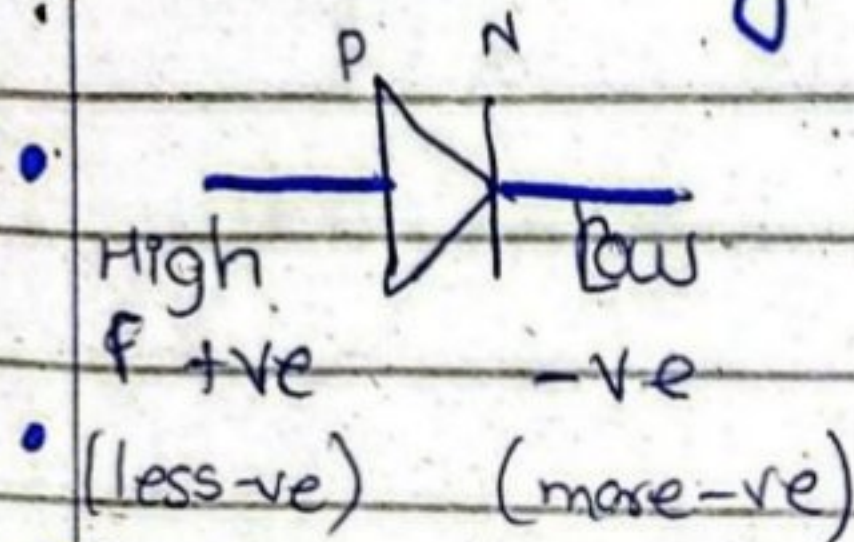


PTB

Biasing: To apply a p.d across PN junction is called biasing.

Types

1) Forward Biasing: • True connection



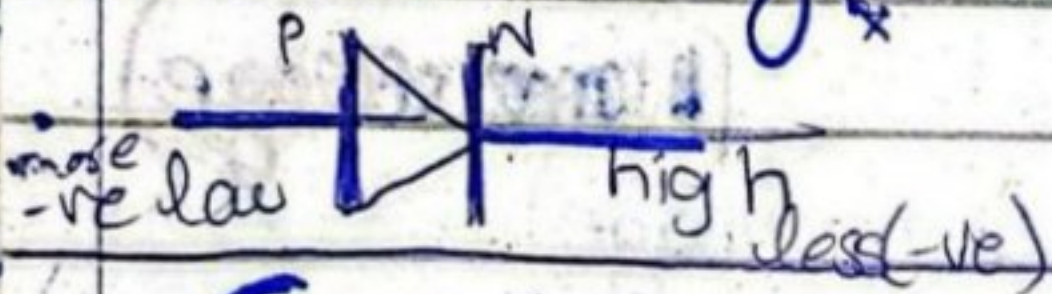
block diagram

→ In forward biasing width of depletion layer decreases.

→ I flows (mA)

→ Resistance decreases (few ohms)

2) Reverse Biasing: • False connection



→ Diode behave as short circuit.

Ch#20

Acad.

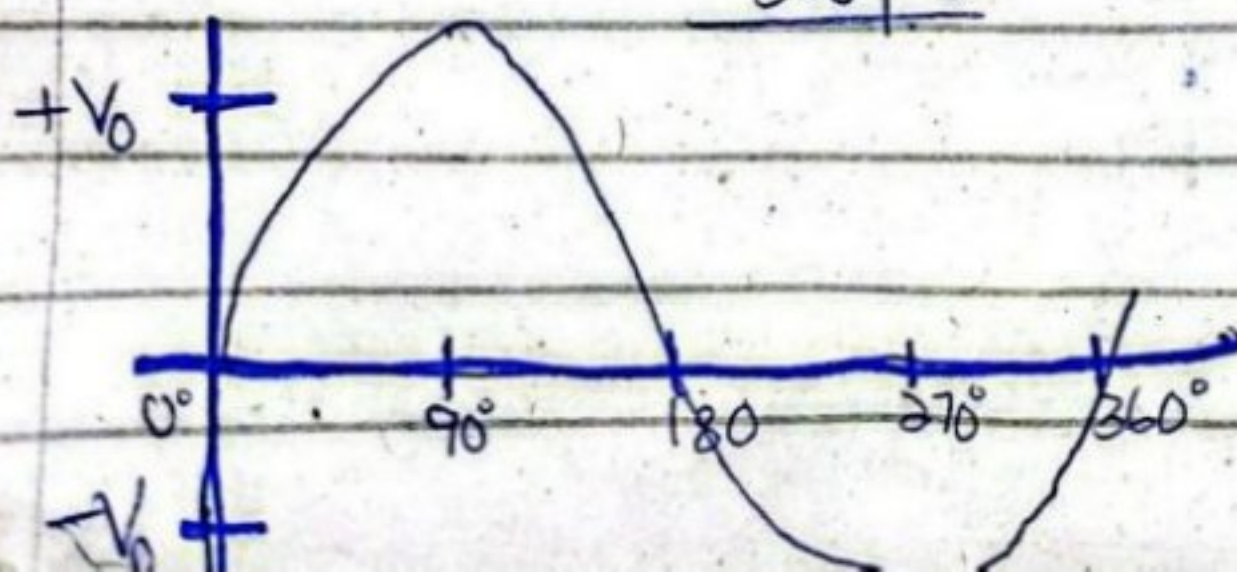
Phase of AC:

The angle ϕ = wt which describes the instantaneous value of alternating quantity.

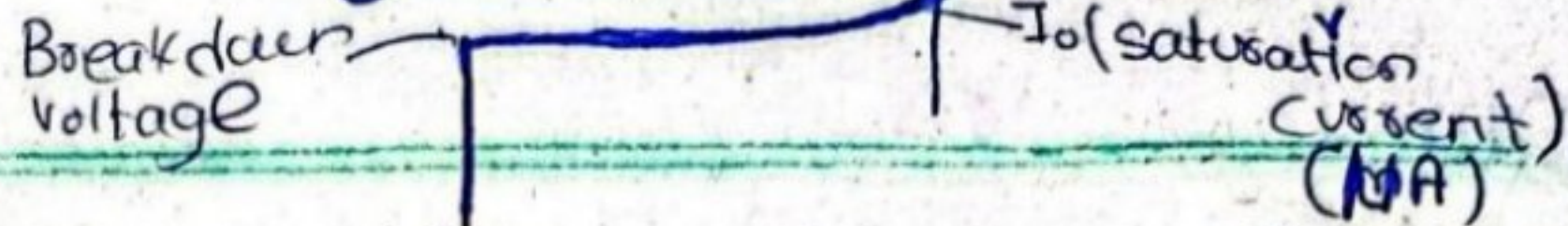
$$V = V_0 \sin \phi$$

ϕ	V
0°	0
90°	$+V_0$
180°	0
270°	$-V_0$
360°	0

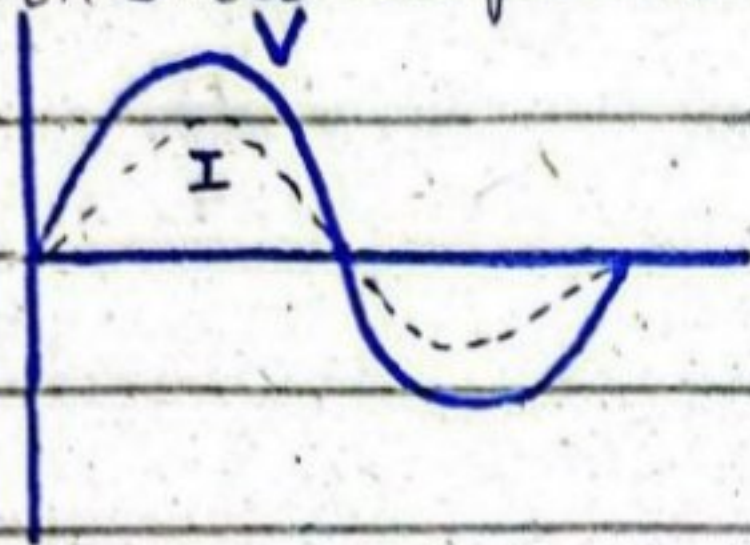
Q.1.



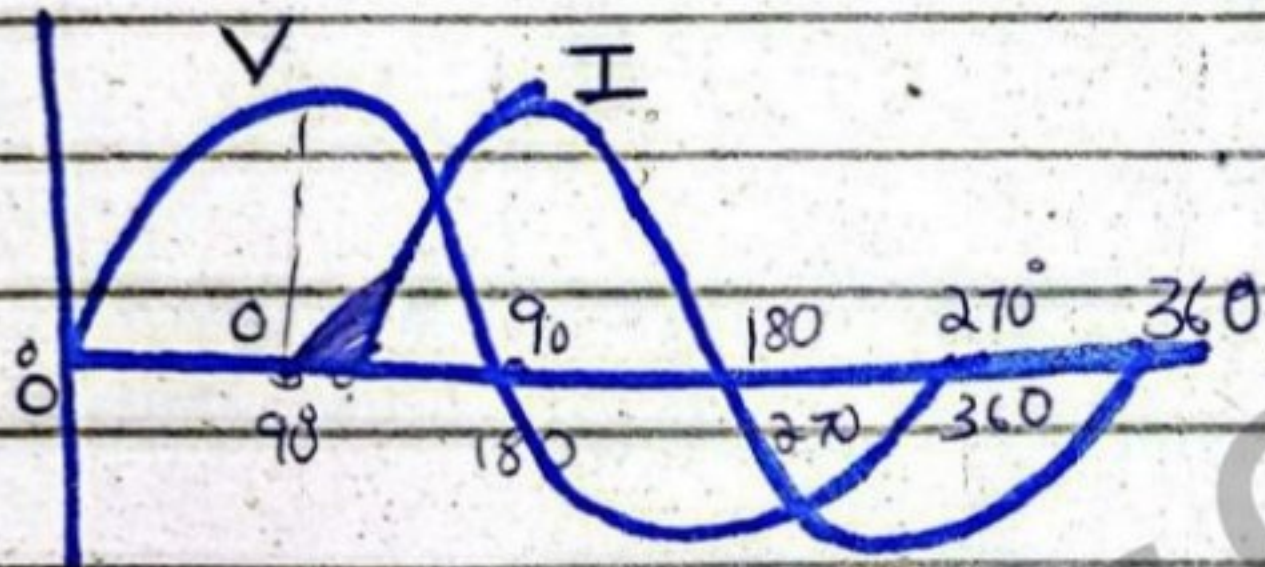
Reverse biasing:



Phase difference: Phase difference b/w two alternating quantities at a point give phase **lead** or phase **lag**



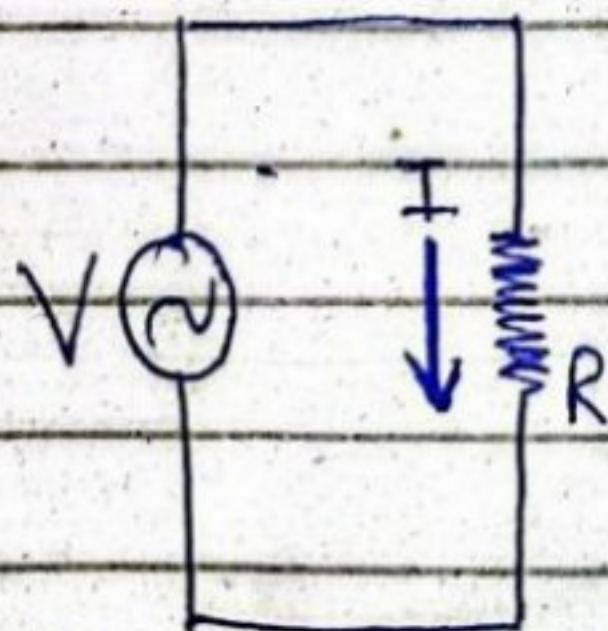
- starting same.
- phase diff zero.
- No lead or No lag.
- In phase.



- diff starting point
- phase diff $= 90^\circ$
- V lead I by 90°
- I lag V by 90°

A.C through Resistor:-
(Resistive circuit)

Circuit Diagram:-



Voltage across resistor:
 $V = V_0 \sin \omega t$ — (1)

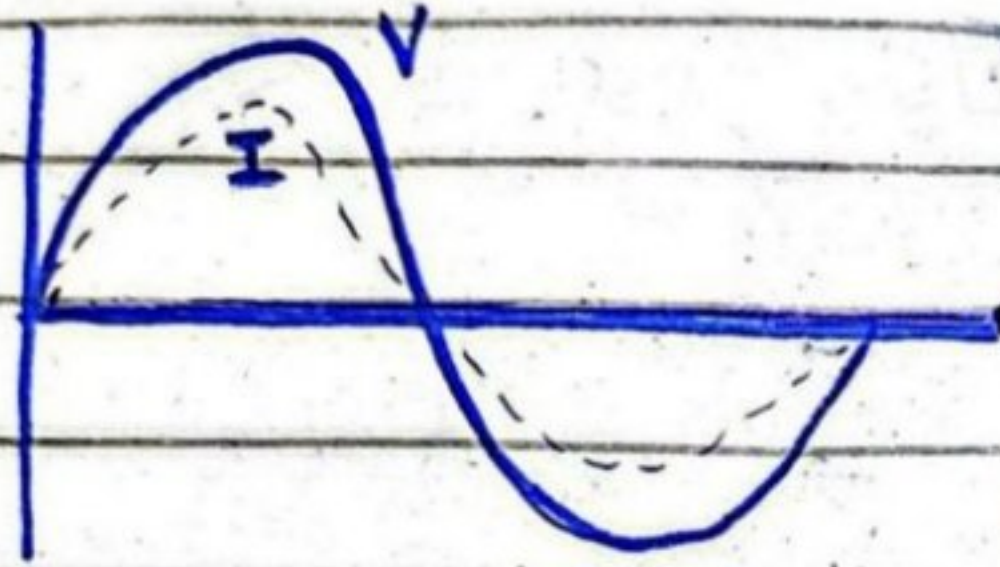
Ohm law:- $V = IR$

$$I = \frac{V}{R}$$

$$I = \frac{V_0 \sin \omega t}{R}$$

$$I = I_0 \sin \omega t \quad (2)$$

Phasor Diagram:



Conclusion:- $\rightarrow$ same starting point

- $\rightarrow$ phase diff = zero
- $\rightarrow$ No lead or lag
- $\rightarrow$ V & I are in phase in case of resistor

Vector diagram:-



Power:-

$$P = VI \cos \phi$$

ϕ = phase angle

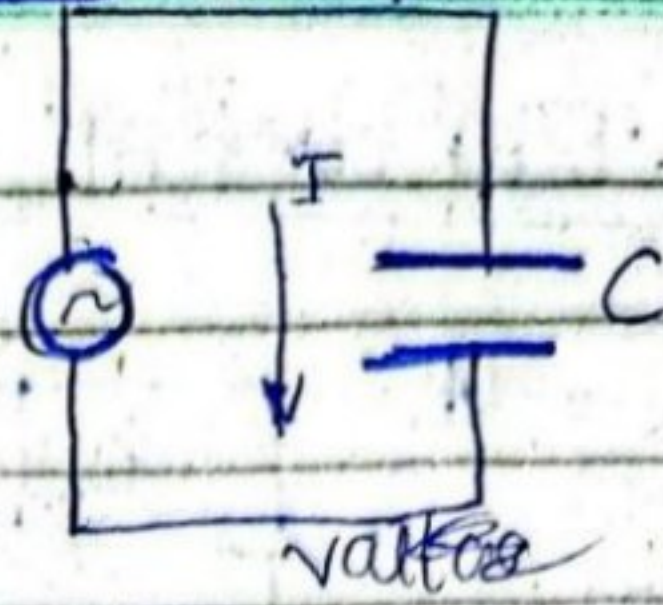
$\cos \phi$ = power factor

MCQ

- ① phase angle $= \phi = 0^\circ$
- ② Power factor $= \cos \phi = 1$
- ③ $P = VI$ same.

AC through Capacitor:- (Capacitive - Circuit)

Circuit Diagram:



Voltage across capacitor:

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

For Capacitor:

$$Q = CV$$

$$Q = C V_0 \sin(\omega t)$$

Now,

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = \frac{\Delta (C V_0 \sin(\omega t))}{\Delta t}$$

$$I = C V_0 \frac{\Delta \sin(\omega t)}{\Delta t}$$

$$I = C V_0 \frac{\Delta \sin(\omega t)}{\Delta t}$$

$$I = C V_0 \cos(\omega t) \times \frac{\Delta(\omega t)}{\Delta t}$$

$$I = C V_0 \cos(\omega t) \times \omega$$

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

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

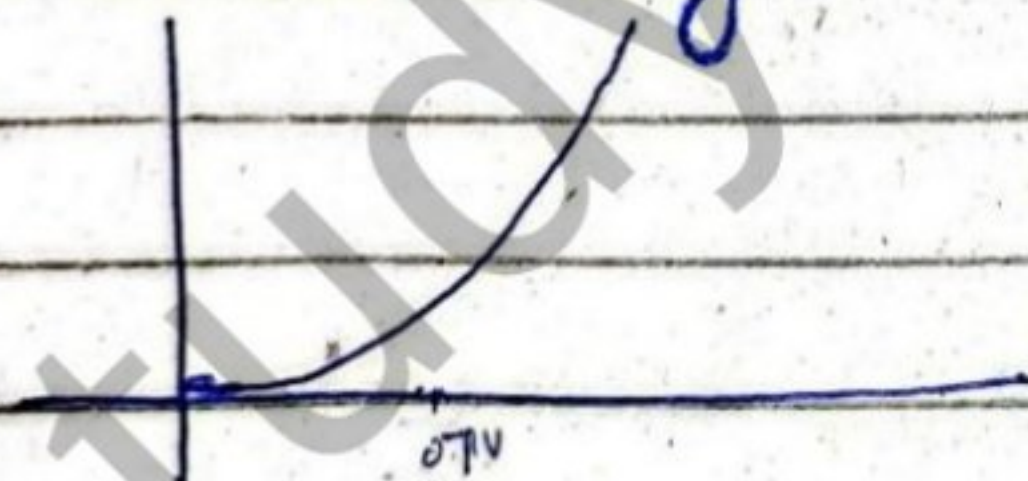
$$I = I_0 \cos(\omega t)$$

or

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

$I_0 = C V_0 \omega$
replace const with constant
 $I_0 \sin(\omega t + \frac{\pi}{2})$

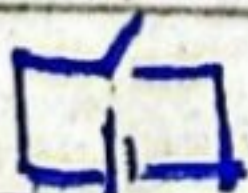
Forward biasing:



$$\text{Slope} = \frac{\Delta I}{\Delta V}$$

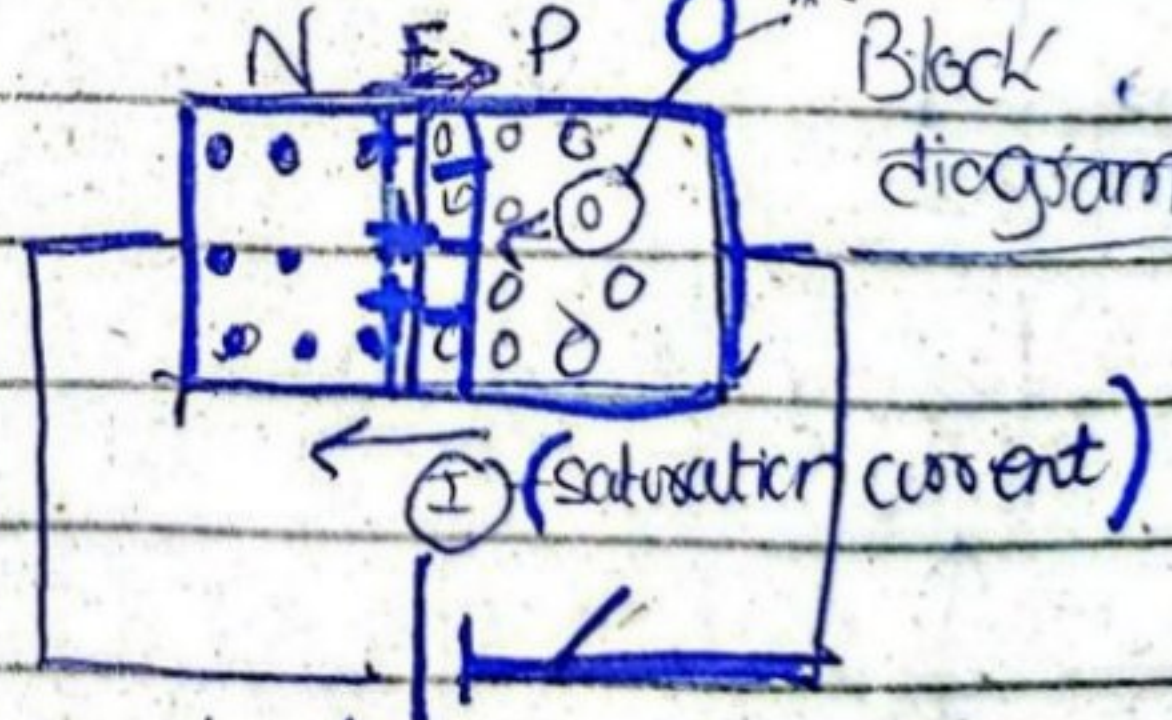
$$G = \frac{\Delta I}{\Delta V}$$

$$R = \frac{1}{G} = \frac{1}{\frac{\Delta I}{\Delta V}} = \frac{\Delta V}{\Delta I}$$



Diagram

Reverse Biasing:



Block diagram:-

→ Width of depletion layer increases (10³ to 10⁶ cm).

→ Resistance increases (Mega ohm)

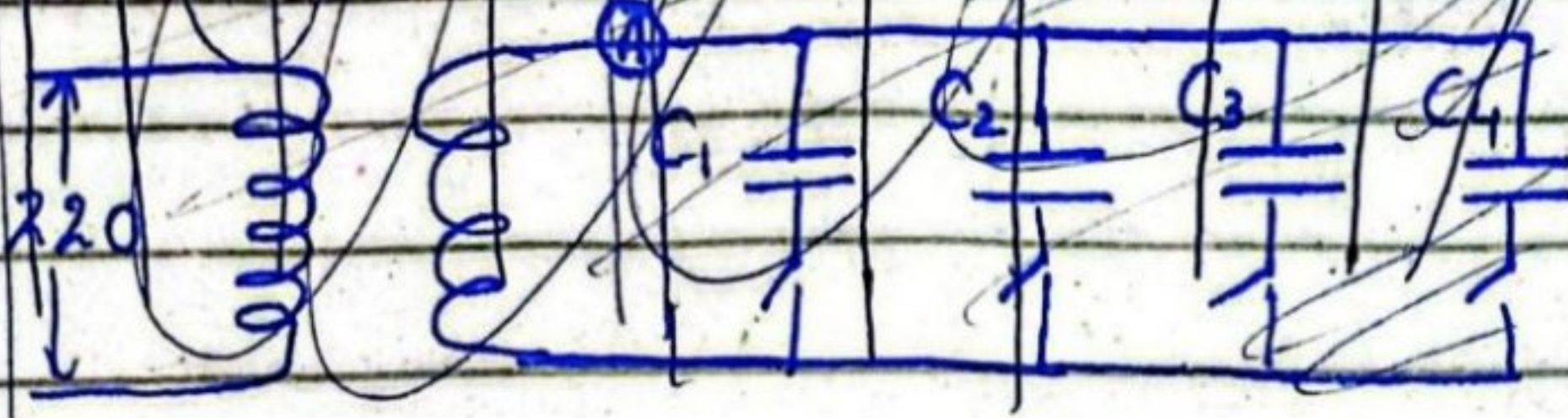
→ I flow but in (uA) it

flows due to leakage of

minority charge.

→ No current as open circuit.

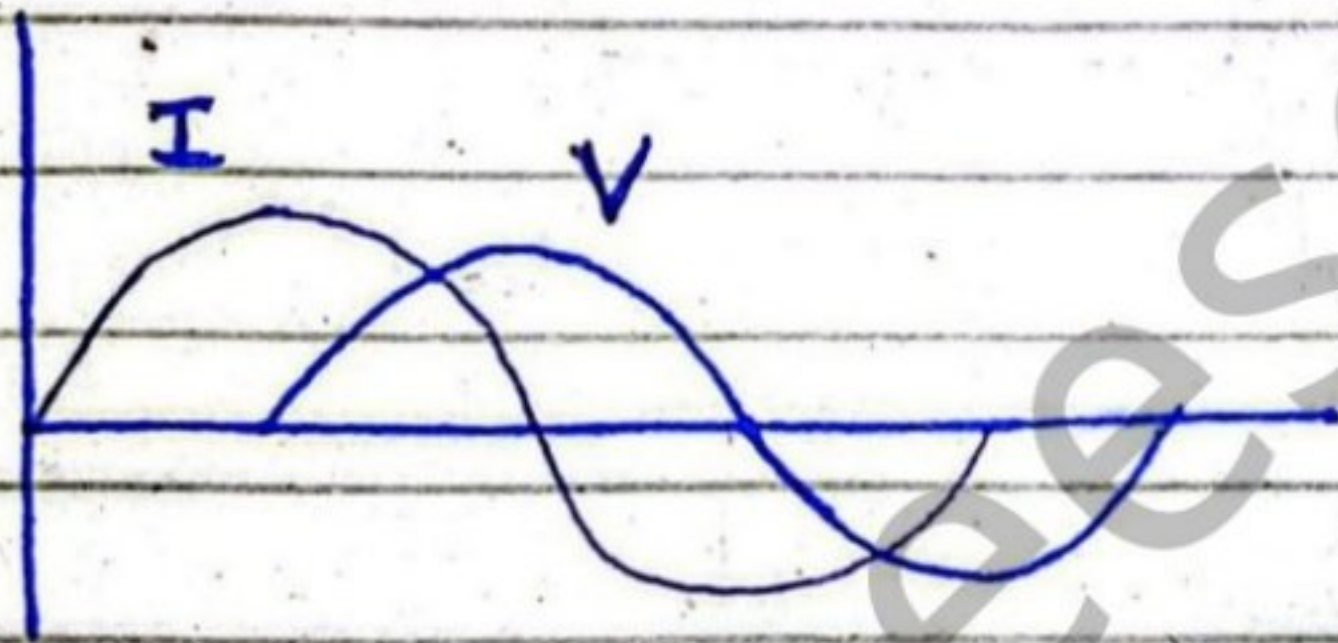
Relationship b/w current & Capacitance



Ch#20

Acad.

Phasor Diagram:- $I = I_0 \cos \phi$

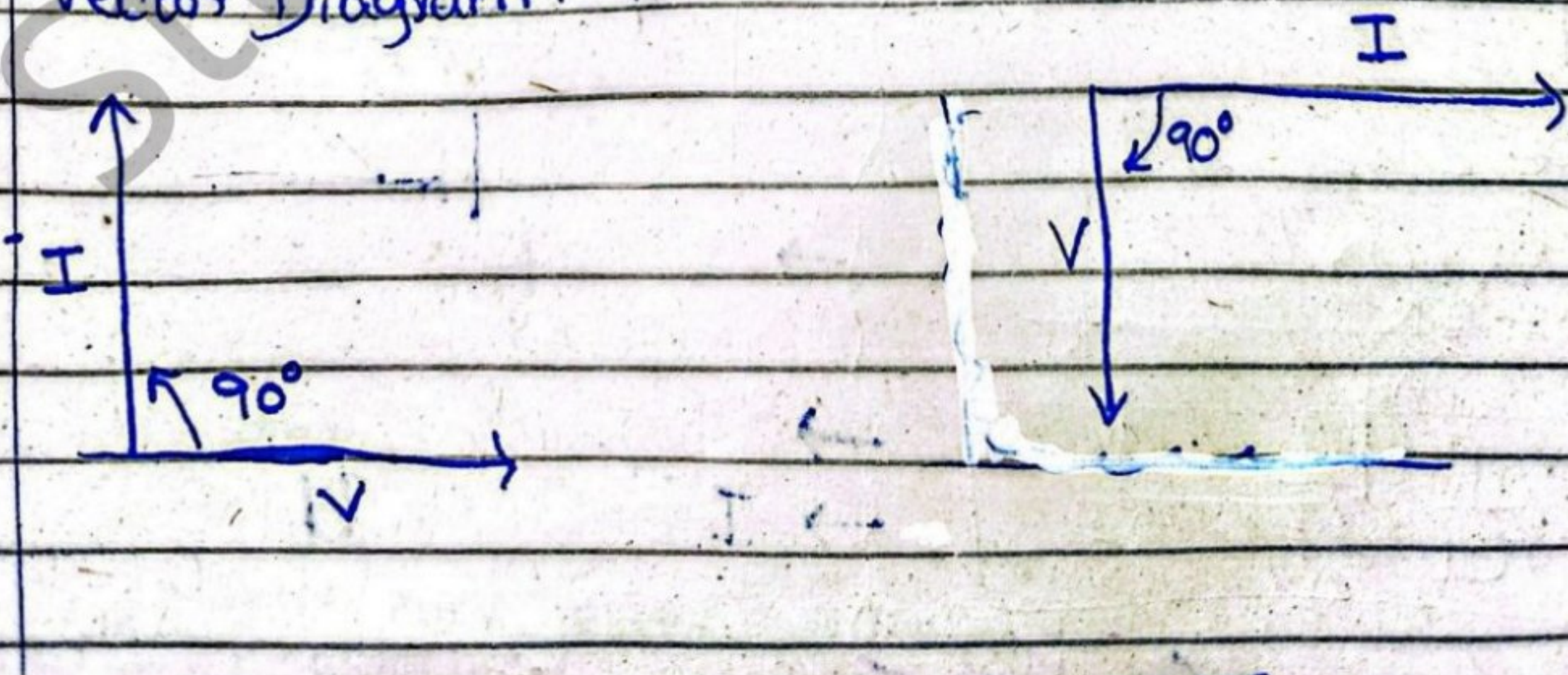


Conclusion:- $\rightarrow$ Different starting point

$\rightarrow$ phase diff = 90°

$\rightarrow$ I lead V by 90° or $\frac{\pi}{2}$

Vector Diagram:



$$V = IR$$

resistor

$$V = I X_C$$

capacitor

$$V = I X_L$$

inductor

Reactance of Capacitor / Capacitive reactance

Defination: Opposition to flow of charge by capacitor is called reactance of capacitor.

Symbol: X_C

Formula: $I_0 = C V_0 \omega$

$$\frac{V_0}{I_0} = \frac{1}{\omega C}$$

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

But $\omega = 2\pi f$

$$X_C = \frac{1}{2\pi f C} \quad \text{or} \quad X_C \propto \frac{1}{f}$$

Unit: (Ω) ohm

$\therefore$ MCC: ① For DC $f = 0$
 $X_C = \frac{1}{0} = \infty$

Power: (In case of capacitor)

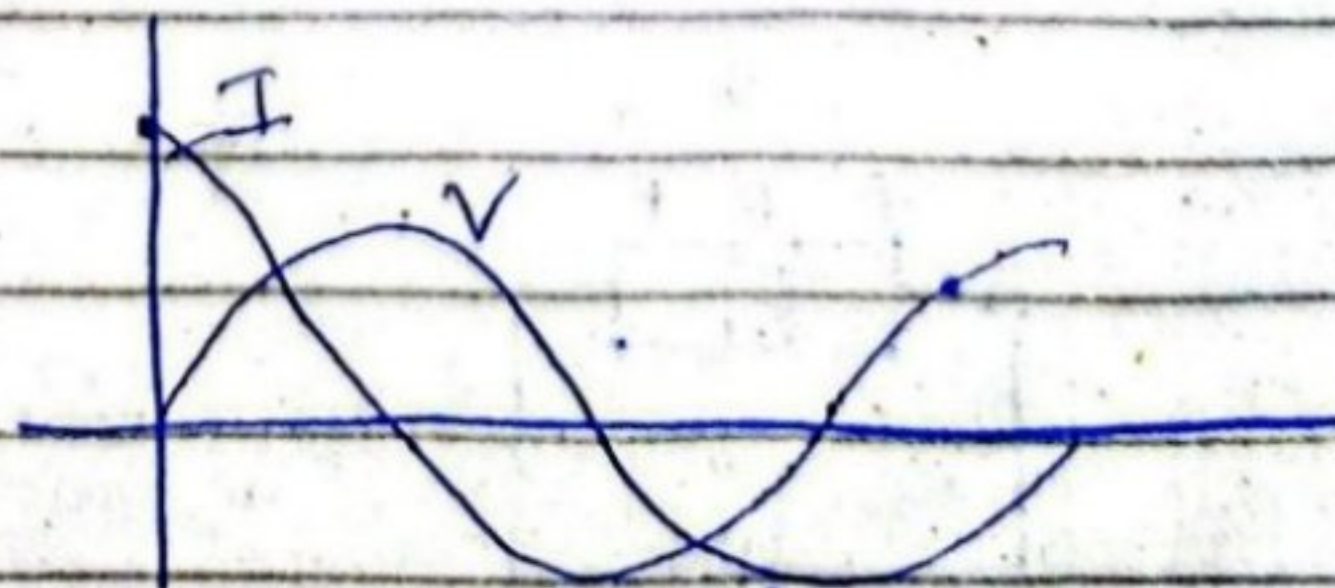
$$P = VI \cos \phi$$

$$P = VI \cos(90^\circ)$$

$$P = 0 \quad \text{powerless} \rightarrow 0$$

$$V = V_0 \sin \phi$$

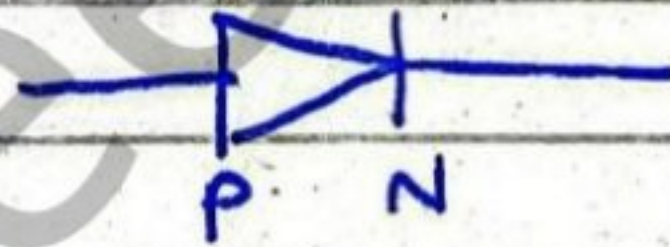
$$I = I_0 \cos \phi$$



PN-Junction: If the crystal of germanium or silicon grow in such a way that its one half is doped with trivalent impurity and other half is doped with pentavalent impurity PN junction is formed.

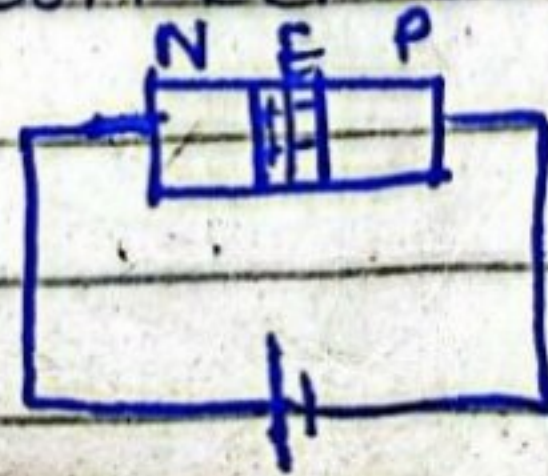
At the junction electron from N-type fill the empty spaces in P region thus negative and positive ions are produced. These ions create electric field from N to P type region. It stops further diffusion of electrons and holes.

Forward Biasing:-



When P type region is connected with positive potential with respect to N-type region and potential drop is increased slowly the junction barrier height increases at one point called a knee voltage majority.

Charge carriers across the junction and the current flows the current known as forward current.



Reverse biasing: If P-type region is made negative with respect to N-type no majority charge carriers across the junction and hence there is no current. A small amount of current flows due to minority charge carriers. The biasing is called reverse biasing. The current is called reverse current.

Knee voltage: The forward voltage at which current through PN junction starts increasing rapidly. It is also called cut-in-voltage or threshold voltage. The knee voltage for Si is 0.7V & for germanium is 0.3V.

Saturation Current: For a diode in reverse bias the current is very small and is called reverse saturation current. It increases with Temp.

Zener effect: In reverse bias if voltage is increased due to available energy, covalent bond break & large number of electrons is released. This causes sudden inc in current.

Rectification: A process

that convert AC voltage into DC voltage is called rectification. (2025 NUMS)

Device used rectifier.

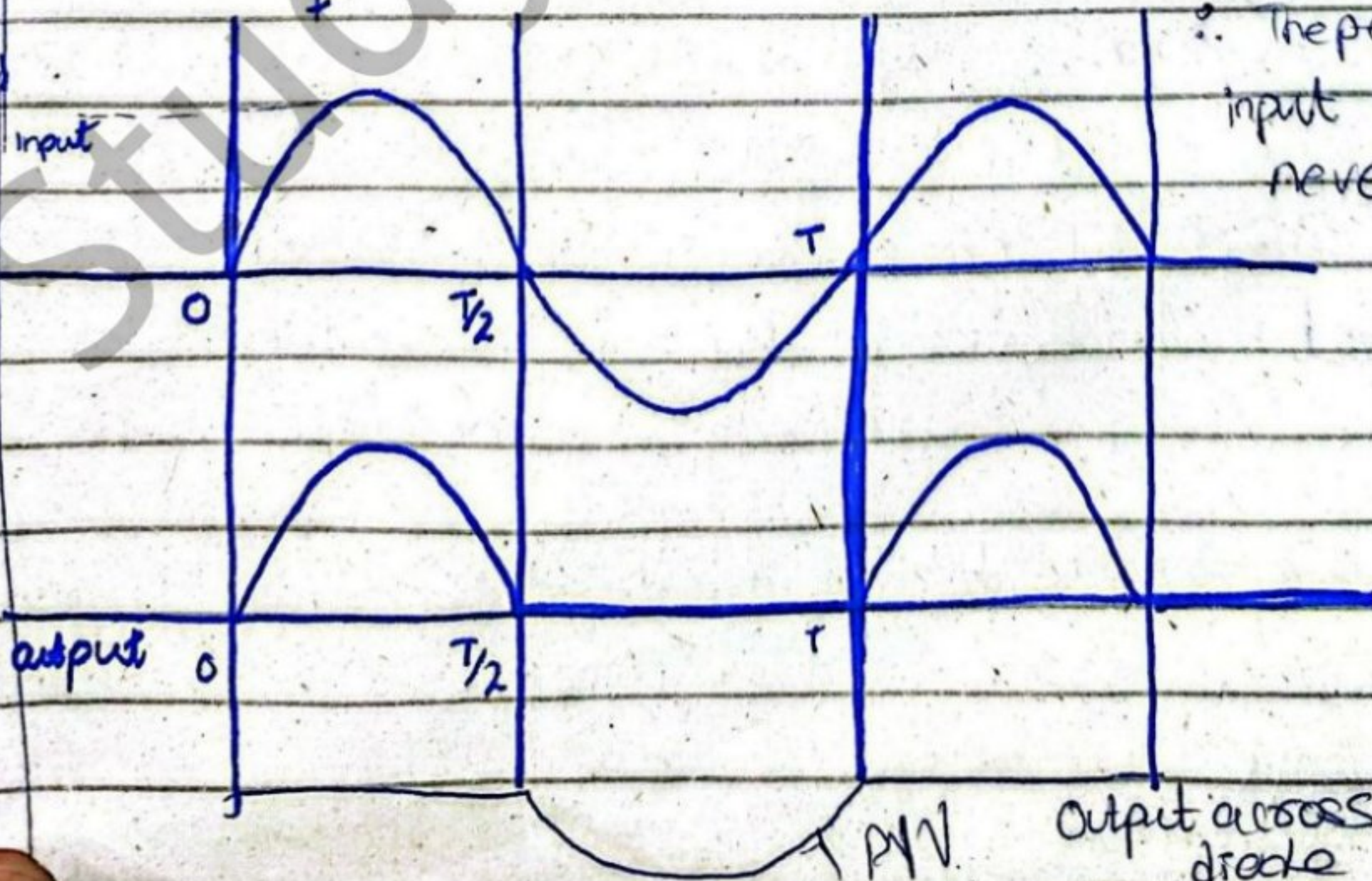
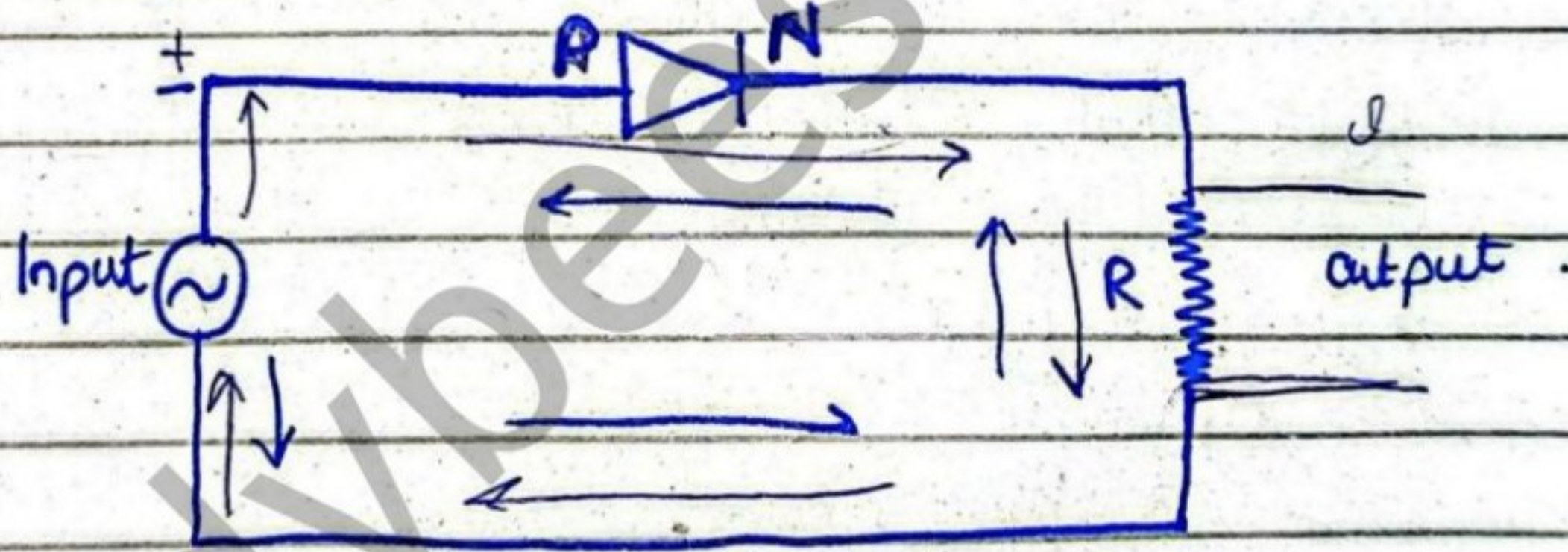
(2025 NUMS)

∴ Device to convert DC into AC called alternator.

Rectifier:- A device that convert AC voltage to DC voltage is called rectifier.

Half Wave Rectification:- A process that convert half of AC signal into pulsating DC is called half wave rectification.

Explanation:-



∴ The peak of input & output never equal.

from time period 0 to $\frac{T}{2}$ diode conduct forward bias

from time period $\frac{T}{2}$ to T diode become (Reverse biased) will not conduct.

MCO MDCAT

• Its efficiency 40.6% ($\eta = 40.6\%$)

• $T_{input} = T_{output}$

• $f_{input} = f_{output}$

• Ripple factor: Concentration of AC in rectified DC. for half wave rectification ripple factor $= 1.21$
pure DC has 0 ripple factor

• PIV (Peak Inverse voltage)

The voltage that is drop across ~~diode~~ ^{diode} during reverse biased mode is called PIV. $PIV = V_{input} = V_{output}$.

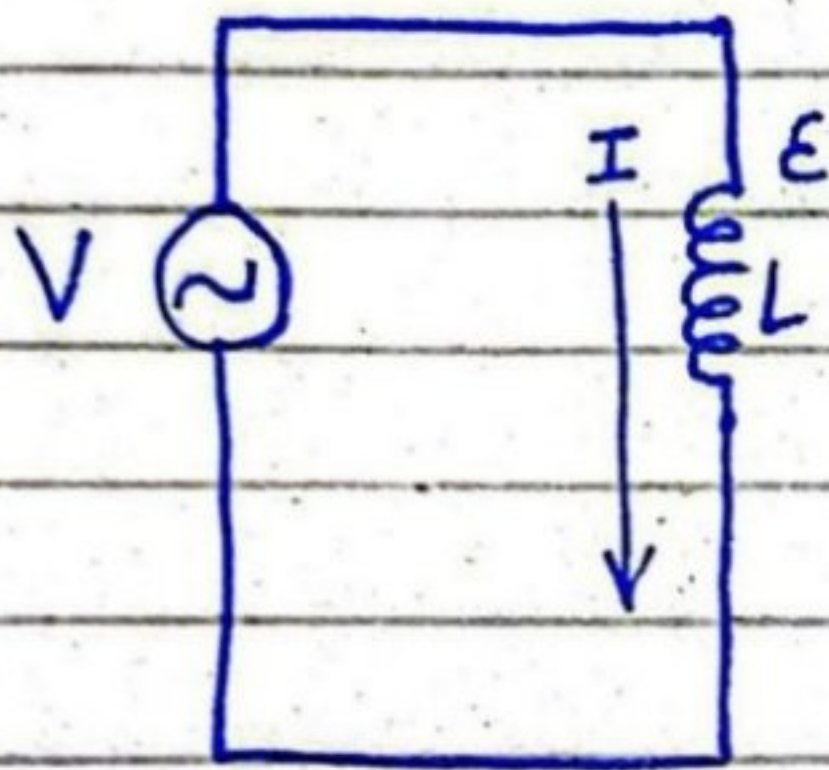
$I = 0$

Ch# 20

Acad

AC through Inductor:- (inductive current -)

Circuit Diagram: ~~Algebra~~



Alternating current passing through inductor

$$I = I_0 \sin \omega t \quad \text{--- (1)}$$

By process of self Induction:-

$$\boxed{\mathcal{E} = -L \frac{\Delta I}{\Delta t}}$$

for ideal Inductor:- (no resistance) no loss of energy

Applied e.m.f = - Back emf
 $V = -\mathcal{E}$

$$V = - \left(-L \frac{\Delta I}{\Delta t} \right)$$

$$V = L \frac{\Delta I}{\Delta t}$$

$$V = L \frac{\Delta (I_0 \sin \omega t)}{\Delta t}$$

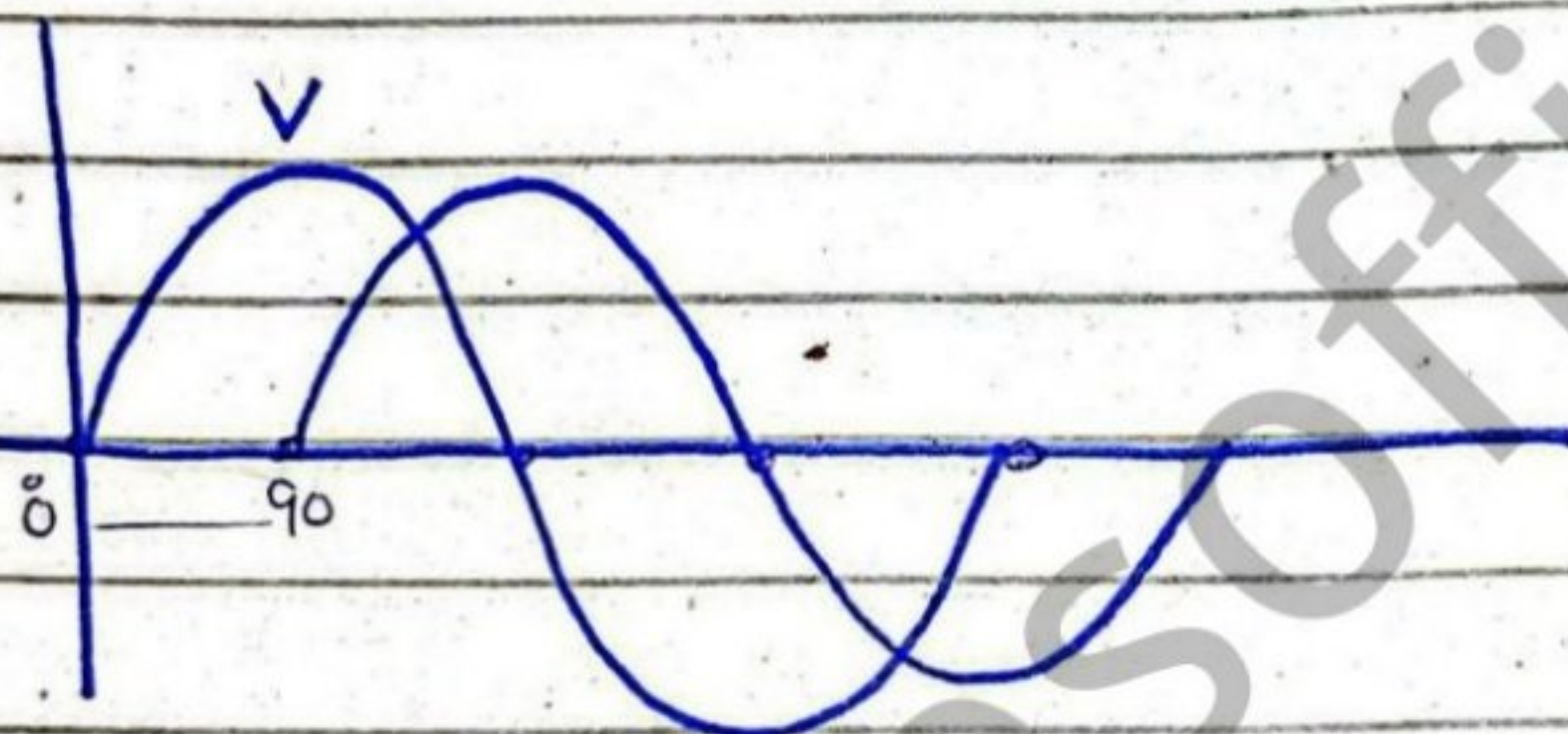
$$V = \frac{L I_0 \Delta \sin \omega t}{\Delta t}$$

$$V = L I_0 \cos \omega t \times \frac{\Delta(\omega t)}{\Delta t}$$

$$V = L I_0 \omega \cos \omega t \times \frac{\Delta t}{\Delta t}$$

$$V = V_0 \cos \omega t \quad \text{or} \quad V = V_0 \sin(\omega t + 90^\circ) \quad \text{--- (1)}$$

Phasor diagram:-

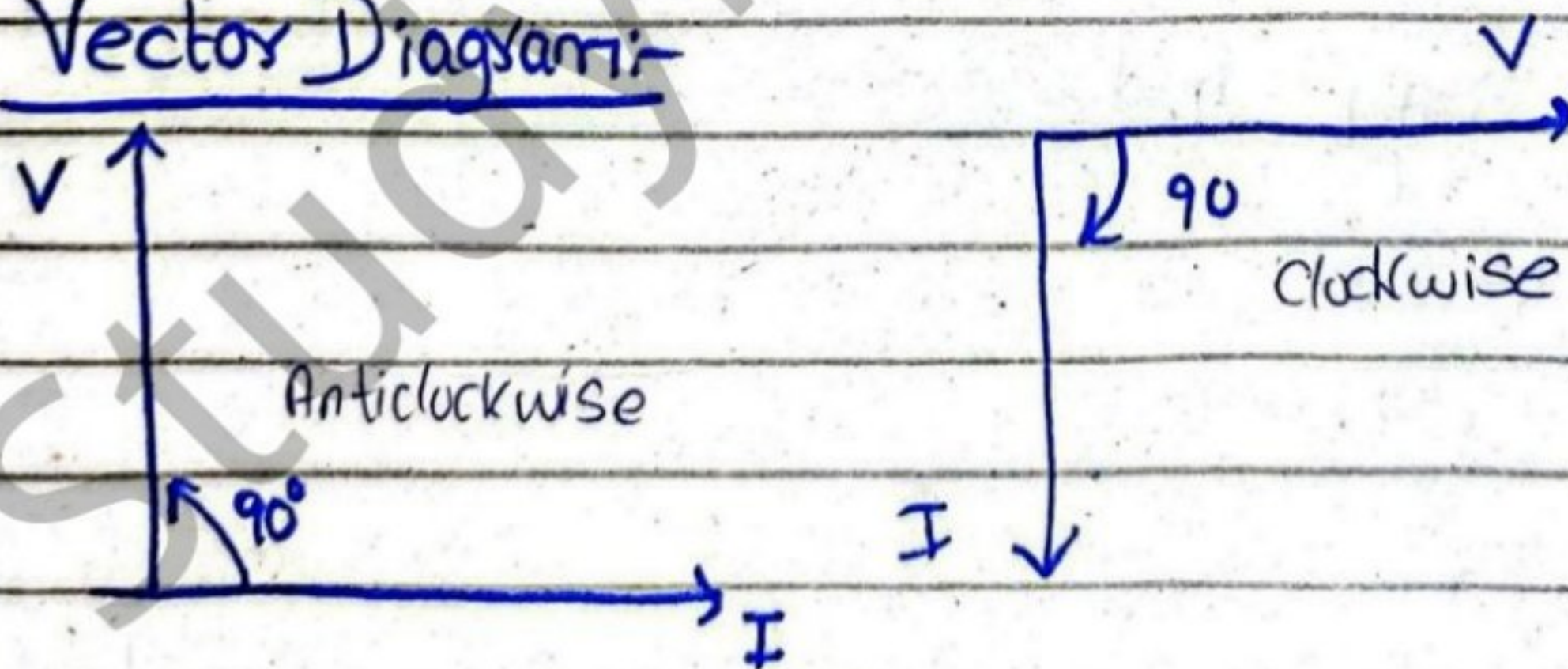


Conclusion:- 1) Different starting point

2) Phase difference is 90°

3) Voltage leads I by 90° or $\frac{\pi}{2}$

Vector Diagram:-



Power: $P = VI \cos 90^\circ$

$$P = 0$$

Reactance of inductor: (Inductive reactance)

Def:- Opposition to flow of charge by inductor is called ^areactance of inductor.

Symbol: X_L

Formula: $V_o = L I_o \omega$

$$\frac{V_o}{I_o} = \omega L$$

$$X_L = \omega L$$

$$X_L = 2\pi f L$$

$$X_L \propto L$$

Short Q. IMP

Q) If frequency of AC is doubled what is effect on reactance of inductor and reactance of capacitor?

Ans) $X_L = 2\pi f L$ Inductor

$$X'_L = 2\pi f' L$$

$$X'_L = 2\pi (2f) L$$

$$X'_L = 2X_L \text{ doubles}$$

$$\frac{dX_L}{df} = \frac{d}{df} (2\pi f L)$$

Capacitor: $X_C = \frac{1}{2\pi f C}$

$$X'_C = \frac{1}{2\pi f C} \Rightarrow X'_C = \frac{1}{2\pi (2f) C} \Rightarrow X'_C = \frac{1}{2} X_C$$

halves.

Ques

Impedence: The combine opposition of resistor or inductor (x_L) and capacitor (x_C) to flow of current in AC circuit is called Impedence

Symbol: Z

formula: $Z = \frac{V_{r.m.s}}{I_{r.m.s}}$

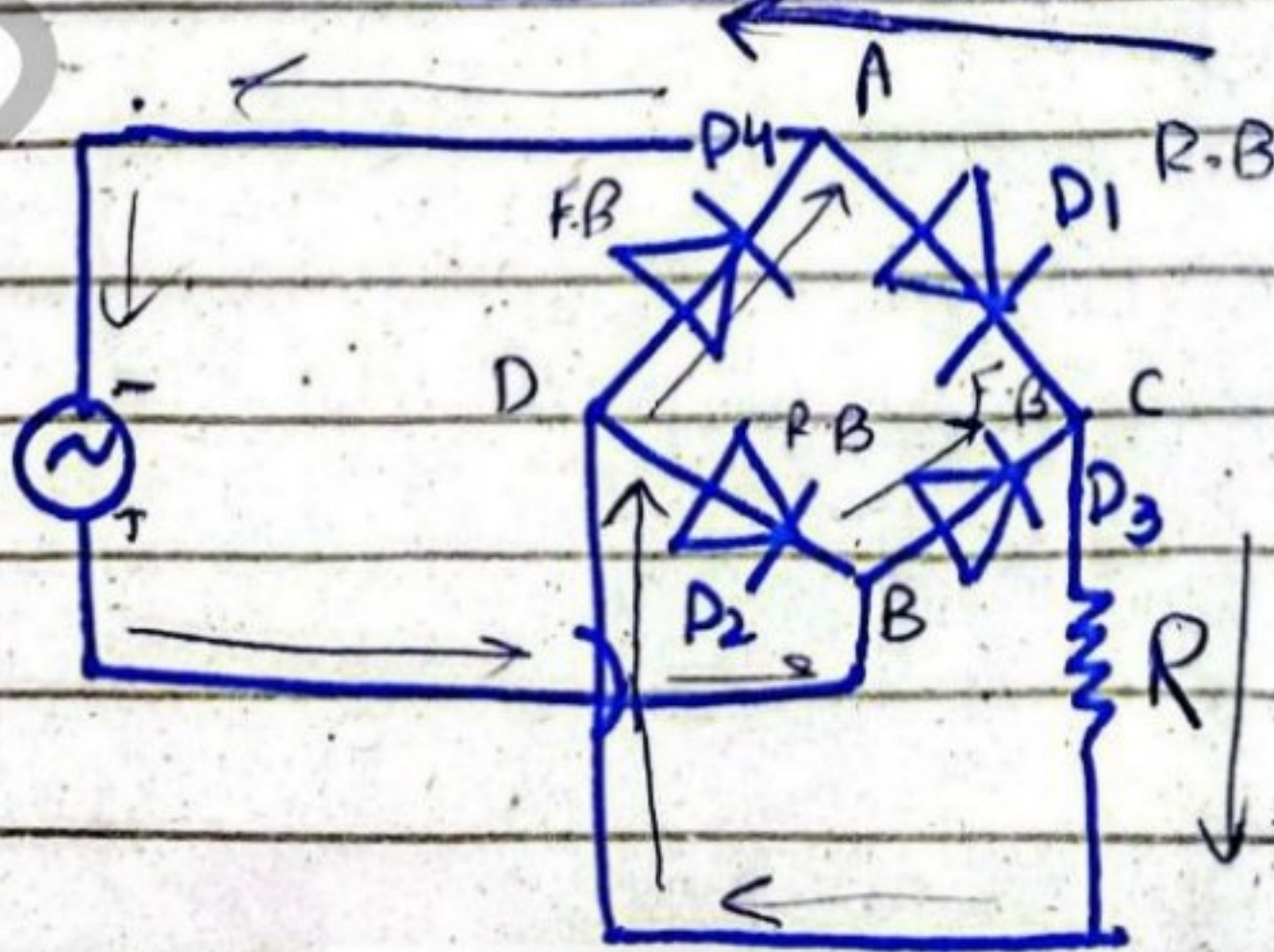
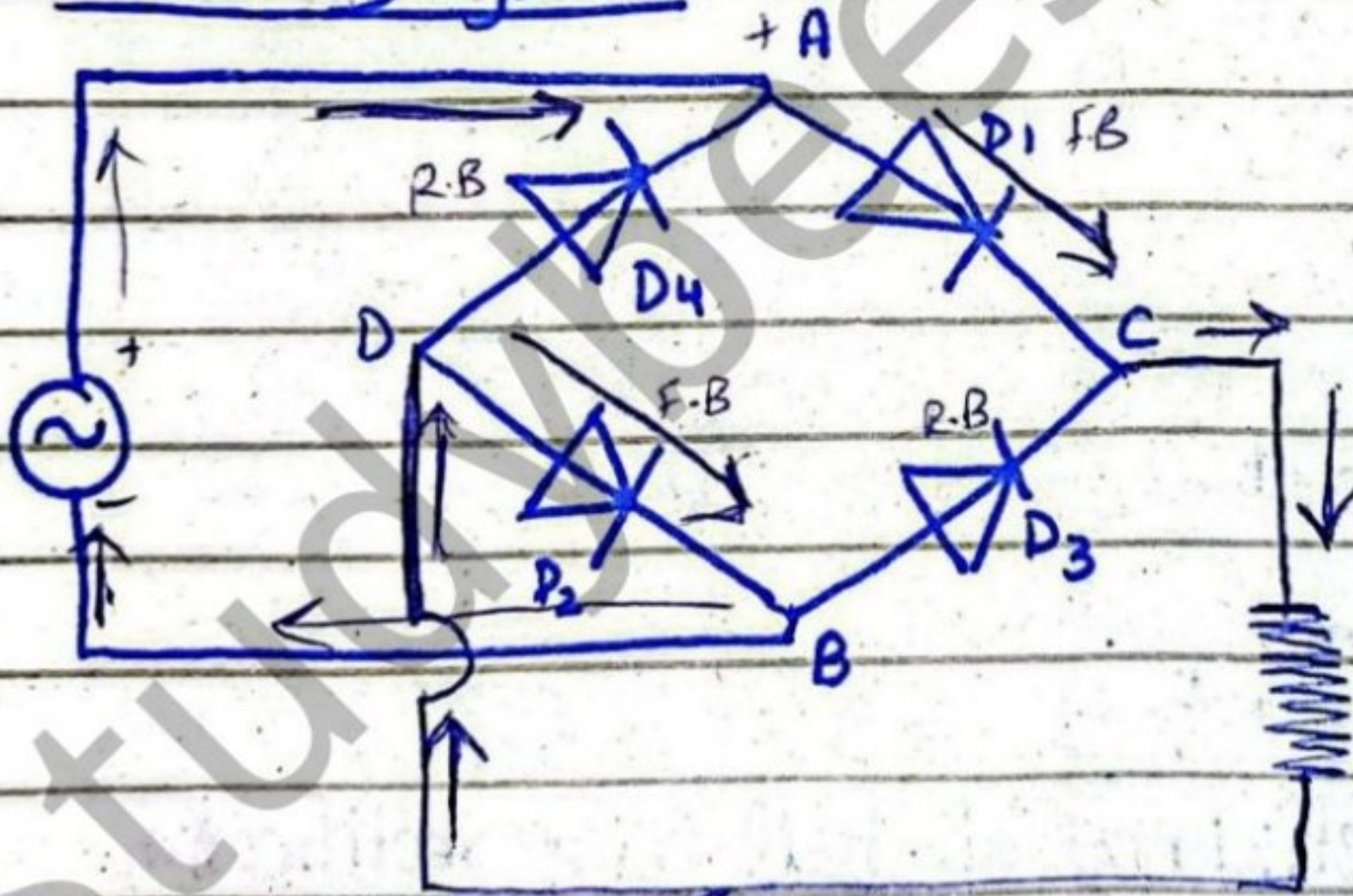
Unit: Ω (ohm)

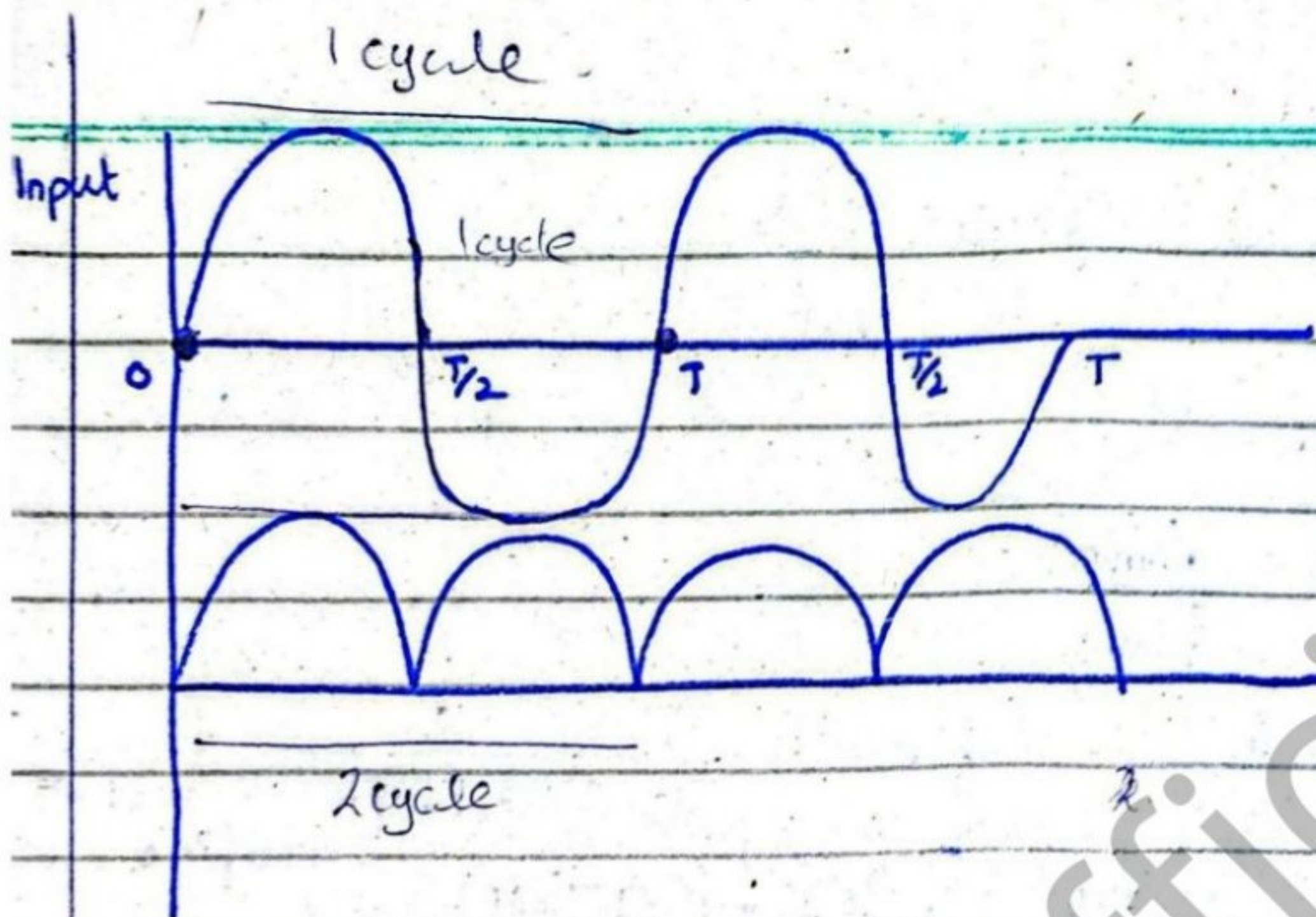
Full Wave Rectification

Bridge rectifies CIG

"A process in which complete AC ^{signal} is converted into pulsating DC."

- Circuit Diagram:-





• From time period 0 to $T/2$ (+ve)

D_1	D_2	D_3	D_4
F.B	F.B	R.B	R.B

• From time period $T/2$ to T (-ve)

D_1	D_2	D_3	D_4
R.B	R.B	F.B	F.B

$$f_{\text{output}} = 2 f_{\text{freq input}}$$

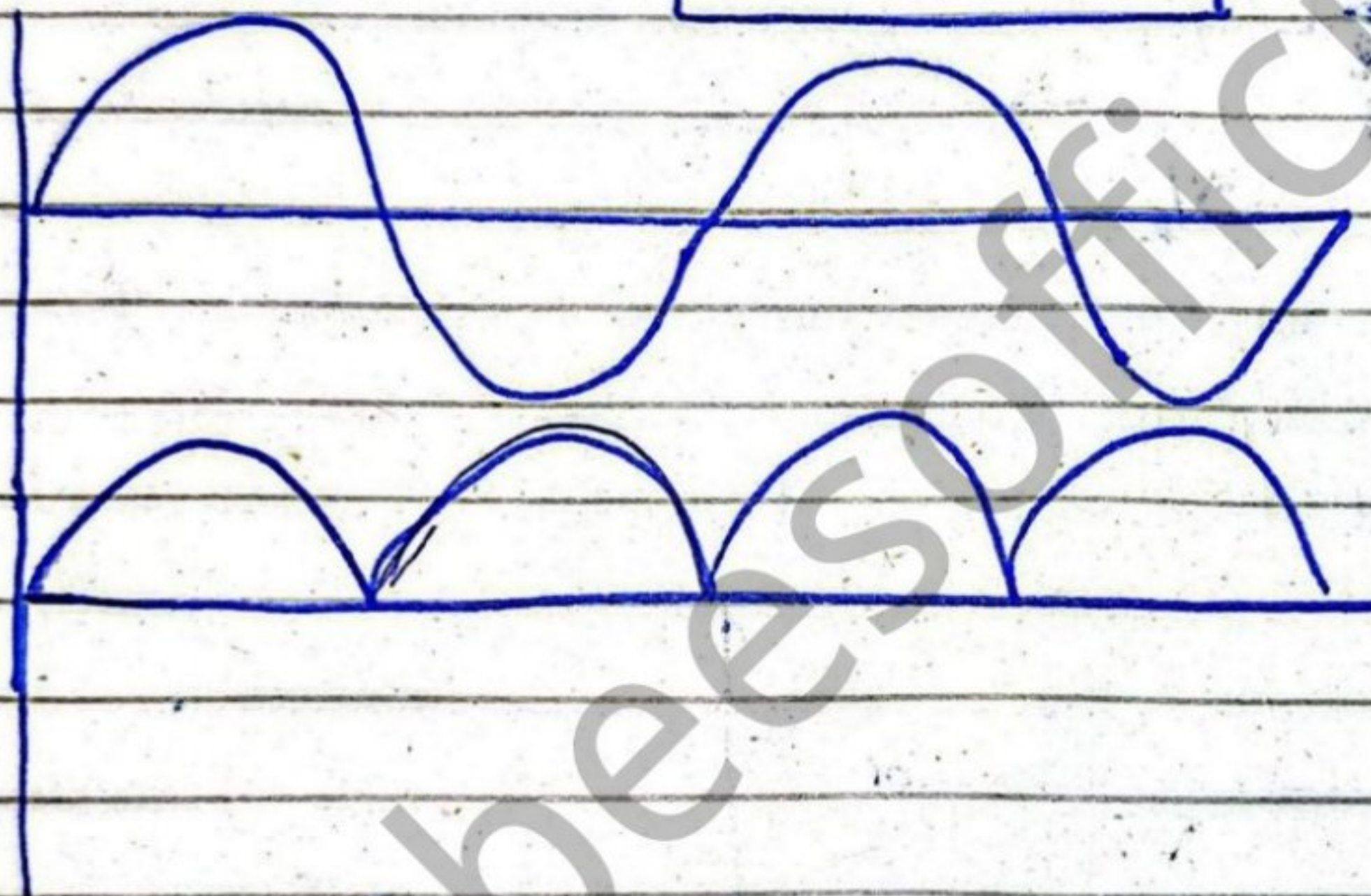
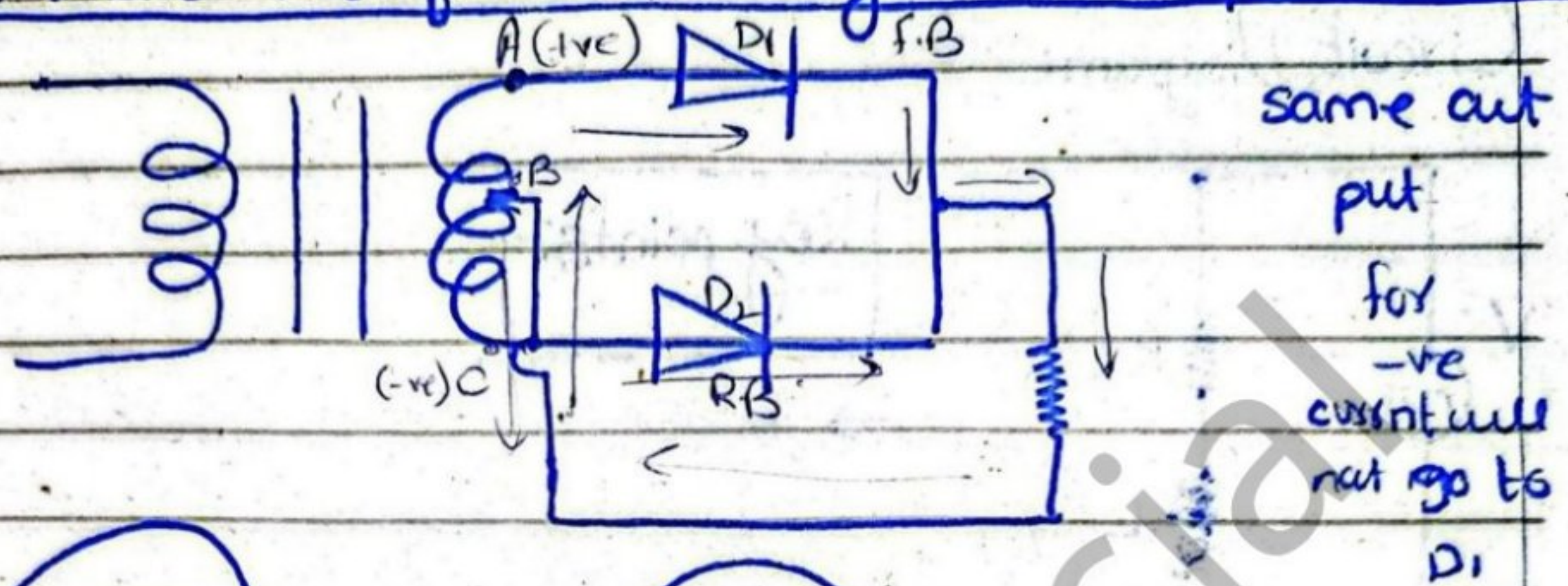
$$\text{Time output} = \frac{1}{2} \text{Time input}$$

$\eta = 81.2\%$ efficiency of full wave rectification

Ripple factor: 0.48

$$PIV = V_{\text{max}} (\text{max voltage})$$

Full Wave Rectification using centre tap transformer



From 0 to $T/2$

D_1 D_2
F.B R.B

from $T/2$ to T

D_1 D_2
R.B F.B

PIV (In case of centre tap full wave rectifier)

$$PIV = 2 V_m$$

* Min no of diode for full wave rectifier = 2

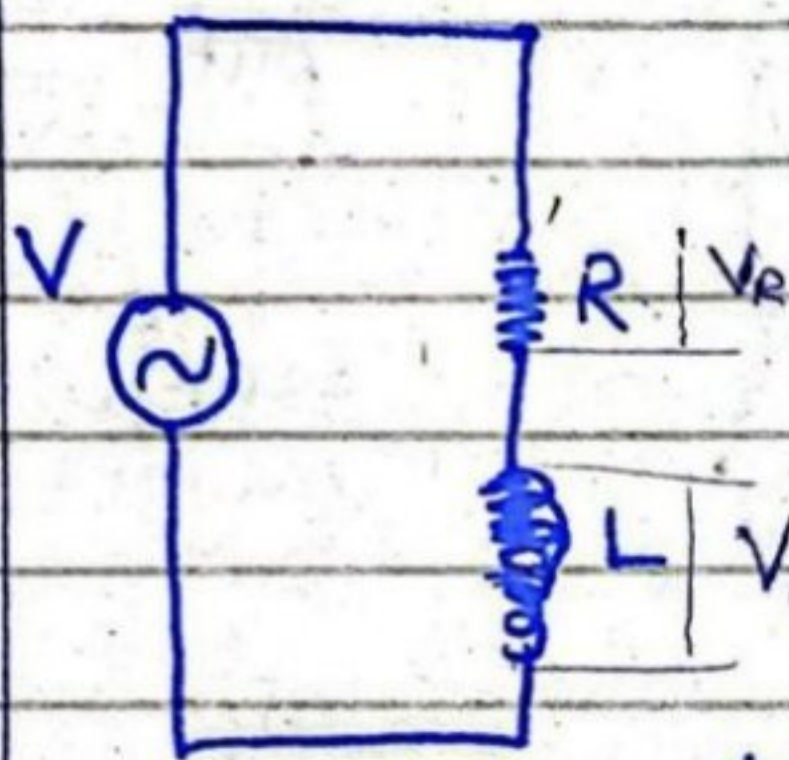
" " " " " bridge " = 4

note: In case of RL series circuit V lead I by ϕ where $0^\circ < \phi < 90^\circ$

Acad

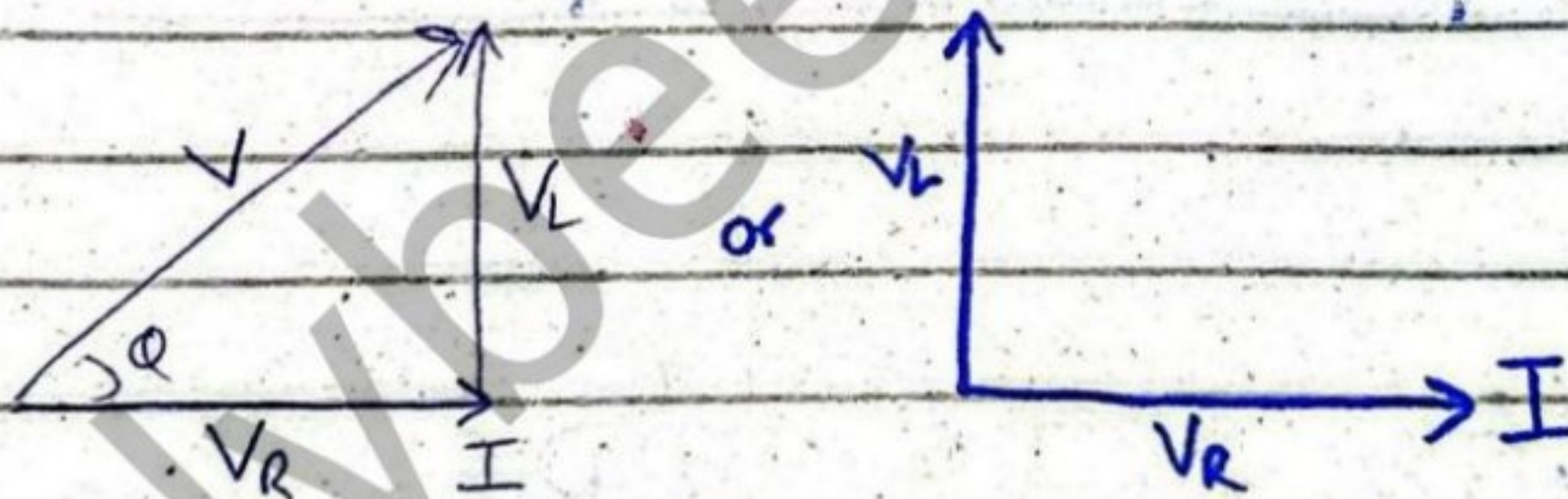
RL-Series Circuit:-

Circuit Diagram:



Key points:-

- In series, I remain same, so it is taken along X-axis (reference)
- In case of resistor I and V are in phase so V_R also taken along X-axis.
- In case of inductor V lead I by angle of 90° or $\frac{\pi}{2}$ so V_L taken along Y-axis
- Using head to tail rule at V_R and V_L



By pythagorus theorem

$$V^2 = V_R^2 + V_L^2$$

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

$$\because V_R = IR, V_L = IX_L$$

$$V = \sqrt{(IR)^2 + (IX_L)^2}$$

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

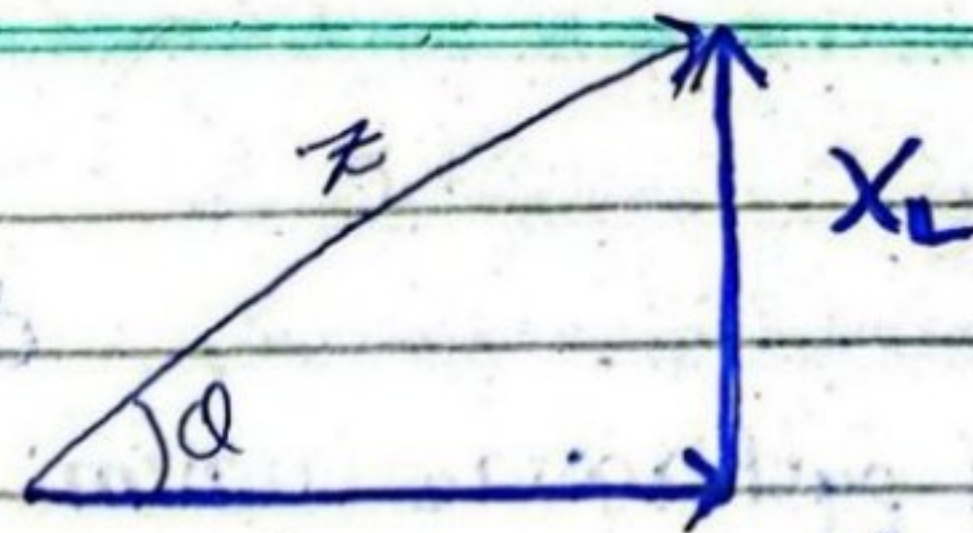
$$V = \sqrt{I^2 (R^2 + X_L^2)}$$

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

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

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

Impedance diagram:-



In case of RL series circuit Z lead R by ϕ where $0^\circ < \phi < 90^\circ$

Phase angle ϕ

$$\tan \phi = \frac{P_{\text{exp}}}{\text{Base}}$$

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

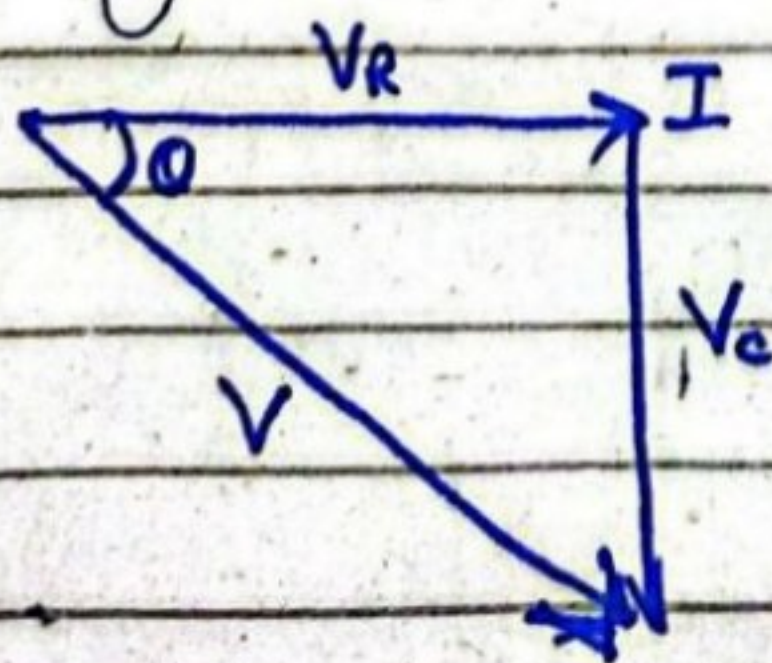
• RC-Series Circuit

Circuit diagram:-



Key-point:-

- 1) In case of series circuit current remain same so it is taken along x-axis (reference axis).
- 2) In case of resistor current and voltage are in phase so V_R taken along x-axis.
- 3) In case of capacitor voltage lag the current by 90° so V_C taken along -ve y-axis.
- 4) Using head to tail rule add V_R and V_C .



In case of RC series circuit voltage lags I by ϕ where $0^\circ < \phi < 90^\circ$.

Using Pythagoras theorem:

$$V^2 = V_R^2 + V_C^2$$

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

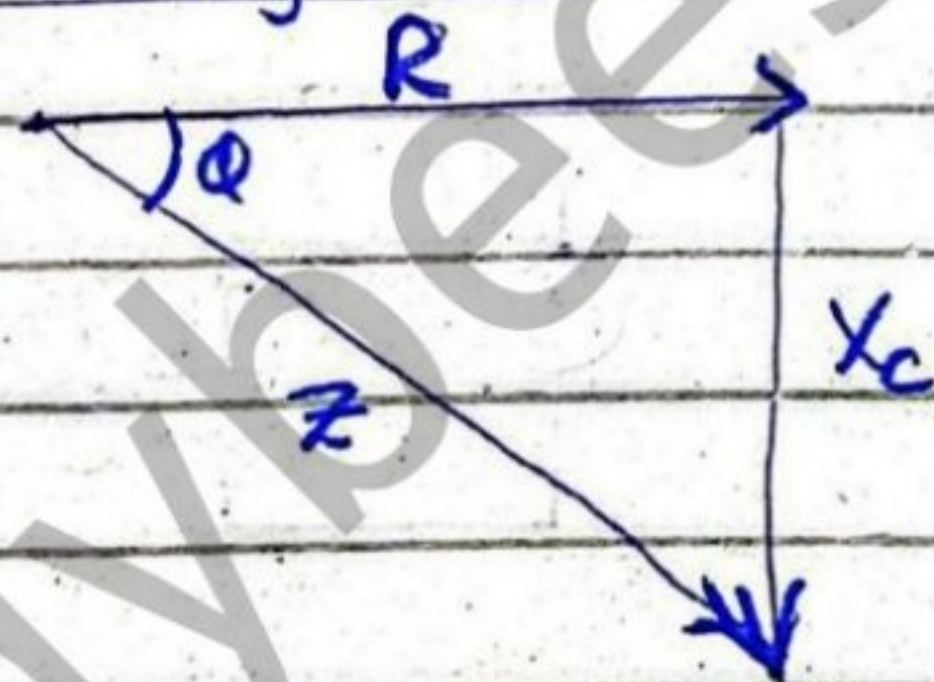
$$\therefore V_R = IR, V_C = IX_C$$

$$V = \sqrt{I^2 R^2 + I^2 X_C^2}$$

$$V = I \sqrt{R^2 + X_C^2}$$

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

Impedance diagram:-



(Z) lags the resistance by ϕ where $0^\circ < \phi < 90^\circ$

Phase angle:-

$$\tan \phi = \frac{\text{Perp}}{\text{Base}} = \frac{X_C}{R}$$

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

Ch# 20

Flux linkage:-

The product of no. of turns of coil and flux linking to the coil is called flux linkage.

$$\text{Flux linkage } \mathcal{E} = N\Phi$$

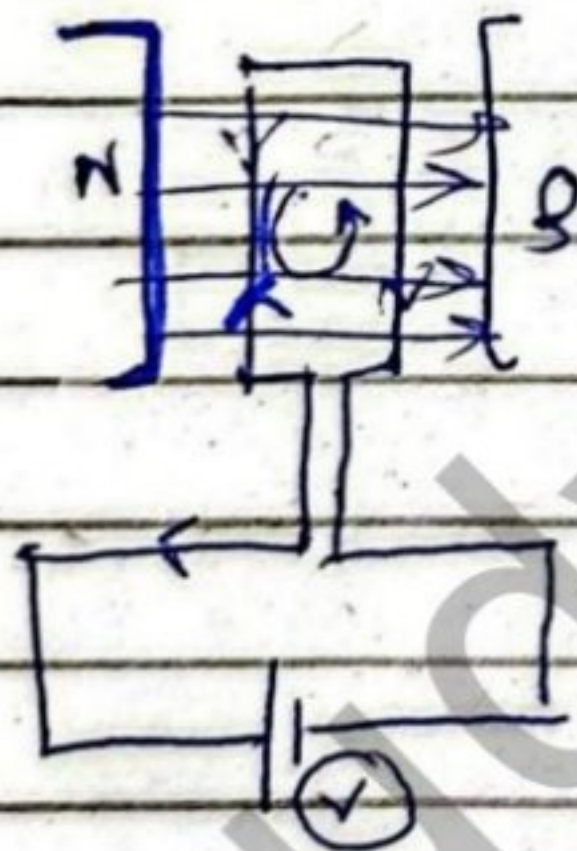
$$\therefore B = \mu_0 n I$$

$$\Phi = BA \cos \theta$$

$$\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$$

$$V_{\text{net}} = V - \mathcal{E}$$

$\therefore$ if current inc. emf will decrease current vice versa



Torque on a current carrying placed in Magnetic field.

$$\tau = N I A B \cos \theta$$

($\mathcal{E}$) back emf

$$V_{\text{net}} = V - \mathcal{E}$$

$$IR = V - \mathcal{E}$$

$$I = \frac{V - \mathcal{E}}{R}$$

Motor starting $\Rightarrow \mathcal{E} = 0$ $I = \text{max}$

Motor running $\Rightarrow \mathcal{E} = \text{inc}$ $I = \text{decrease}$

- motor overloading I (very large) ϵ ^{Induced emf} $\rightarrow$ very small

Numericals Ch#20

(1)

Data: $V_{rms} = ?$

$$V_0 = 300V$$

Solution $V_{rms} = \frac{V_0}{\sqrt{2}} = \frac{300}{\sqrt{2}} = \boxed{212V}$

(2)

Data: $L = 100 \times 10^{-6} H$

$$L = 10^{-4} H$$

$$I = 10 \times 10^{-3} A \Rightarrow \boxed{I = 10^{-2} A}$$

$f = ?$

ohm law:-

$$V = I (X_L) \quad \text{or } \omega L$$

$$V = I (2\pi f L)$$

$$f = \frac{V}{2\pi L I}$$

$$f = \frac{6.3}{2\pi (10^{-4})(10^{-2})}$$

$$\boxed{f = 10^6 Hz}$$

③

Data: $L = 318 \times 10^{-3} \text{ H}$

$$R = 75 \Omega$$

$$V = 150 \text{ V}$$

$$f = 50 \text{ Hz}$$

$$Z = ?$$

Sol: For RL-series circuit

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

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

$$Z = 125 \Omega$$

④

Data: $R = 30 \Omega$

$$C = 79.5 \times 10^{-6} \text{ F}$$

$$f = 50 \text{ Hz}$$

$$V = 100 \text{ V}$$

$$Z = ?$$

for RC series circuit:-

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

$$Z = \sqrt{R^2 + \left(\frac{1}{2\pi fC}\right)^2}$$

$$Z = \sqrt{30^2 + \frac{1}{(2 \times 3.14 \times 50 \times 79.5 \times 10^{-6})^2}}$$

$$Z = 80 \Omega$$

Short Qs.

(2)

Q1 $\epsilon = L \frac{\Delta I}{\Delta t}$

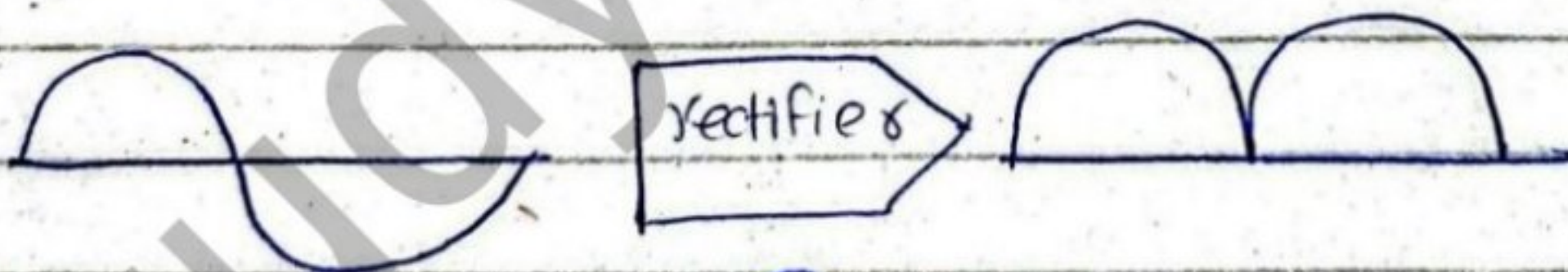
$$L = \frac{\epsilon}{\frac{\Delta I}{\Delta t}} = \frac{V}{AS^{-1}} = VSA^{-1} = H$$

Q2 $\epsilon = M \frac{\Delta I_p}{\Delta t}$

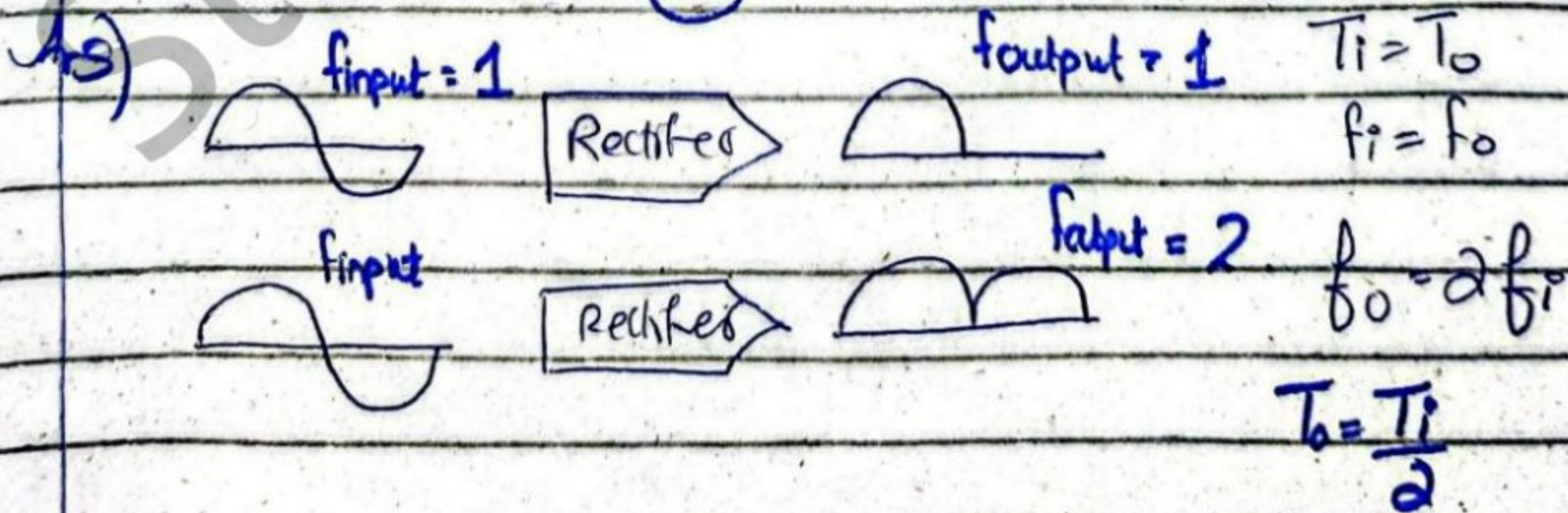
$$M = \frac{\epsilon_s}{\frac{\Delta I_p}{\Delta t}} = \frac{V}{AS^{-1}} = VSA^{-1} = H$$

(5)

Self Half wave



(6)



$$\therefore f \propto \frac{1}{T}$$

Q.

Ch#20

$$f_2 > f_1$$

Q/G

Inductance: Property of coil to oppose any change of current through it.

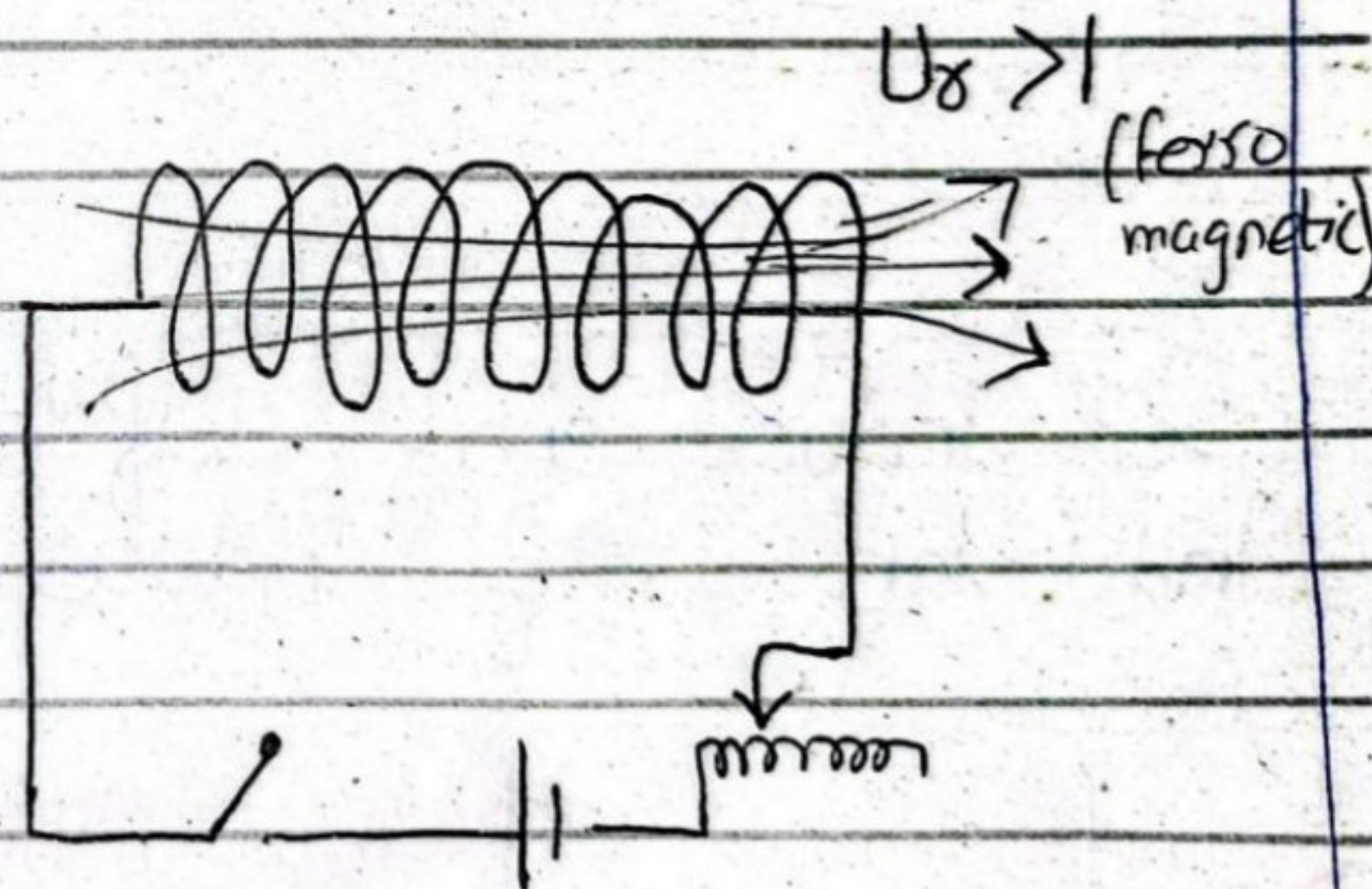
OR

Flux linkage per unit current is called inductance.

$$L = \frac{N\Phi}{I}$$

$$L = \frac{N\vec{B} \cdot \vec{A}}{I}$$

$$L = \frac{NBA \cos \theta}{I}$$



$$\theta = 0^\circ$$

$$L = \frac{NBA \cos 0^\circ}{I}$$

$$L = \frac{NBA}{I}$$

$$L = \frac{NBA}{I}$$

$$\text{As } B = \mu_0 n I$$

$$L = \frac{N(\mu_0 n I)A}{I}$$

$$= \mu_0 n N A$$

$$= \mu_0 \frac{N^2}{l} A$$

$$\therefore n = \frac{N}{l}$$

$$L = \frac{\mu_0 N^2 A}{l} \text{ or } L = \mu_0 n^2 A l$$

Factors affecting Inductance:

(1) Medium

(2) No of turns

(3) Area of cross section

(4) length of coil

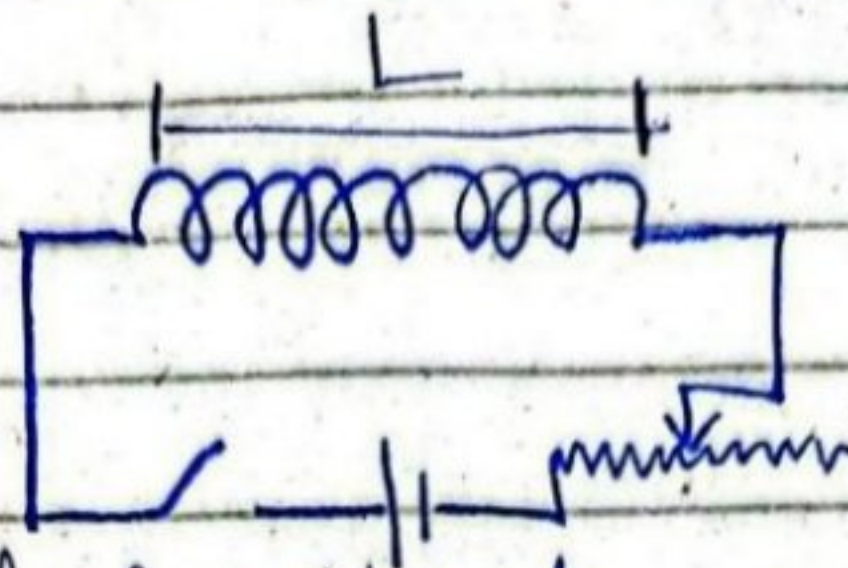
→ when we provide coil to DC source its inductance is not zero as its property of material

Unit: Henry

Self Induce emf, self Inductance, self Induction, self Induce emf:- Change in current in one coil produces an emf in itself known as self Induced

emf and this phenomenon is known as self-induction.

Explanation:



Consider a coil of length L , area of cross section is A having N -number of turns is connected with battery and rheostat. When the switch is closed, a steady current will start flowing through a coil. When a current through a coil changes with the help of rheostat. This change in current produces induced emf in same coil known as self induced emf.

Determination of induced emf: According to Faraday's law, the magnitude of induced emf is:

$$\mathcal{E} = N \frac{\Delta \Phi}{\Delta t} \quad \text{--- (1)}$$

$$\text{or } \mathcal{E} = -L \frac{\Delta I}{\Delta t} \quad \text{---ve sign shows that induced}$$

emf always opposes the cause that produce it that's why it is known as back emf.

Let Φ is the flux of one coil, then flux linkage $N\Phi$ is directly proportional to the current

$$N\Phi \propto I$$

$$N\Phi = LI$$

Apply Δ on both sides

$$\Delta(N\Phi) = \Delta(LI)$$

$$N\Delta\Phi = L\Delta I$$

put in eq (1)

$$\mathcal{E} = L \frac{\Delta I}{\Delta t}$$

From this we conclude that rate of change of current in one coil produced an induced emf in itself known as self induced emf
Here L is inductance of a coil

$$\text{As } \mathcal{E} = \frac{L\Delta I}{\Delta t}$$

$$L = \frac{\mathcal{E}}{\frac{\Delta I}{\Delta t}}$$

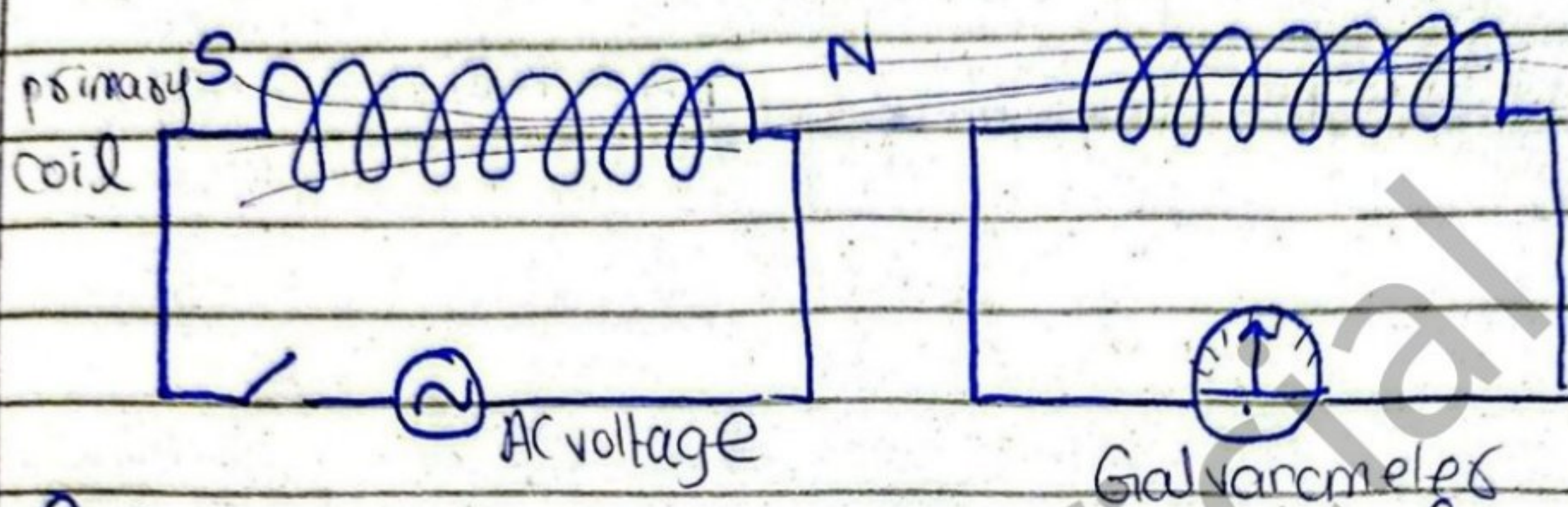
Ratio of Induced emf to rate of change of current is known as self inductance.

$$\text{Unit: } \frac{V}{A/s} = VsA^{-1} = \text{Henry} = H$$

$$1H = \frac{1V}{1A/s}$$

1 Henry: When 1A current changes in coil in one second, induces an emf of 1V. In same coil then inductance of coil will be one Henry.

• Mutual induce emf, Mutual Induction, mutual Inductance



Statement: Changing current in one coil produces an induced emf in the neighbouring coil is known as mutual induced emf and this phenomenon is known as mutual induction.

Explanation: Consider two coils placed close to each other having length L , area of cross section A , one coil is connected to a AC voltage source via a switch and connected with primary coil and other coil is connected to a galvanometer. When switch is closed a changing current passes through a primary coil. This changing current produces changing magnetic flux in the secondary coil and emf is induced in the secondary coil known as mutual induced emf. let ϕ_s is the flux of any one ~~self~~ loop of secondary coil then flux linkage $N_s \phi_s$ is directly proportional to the current of primary coil.

that is

$$N_s \phi_s \propto I_p$$

$$N_s \phi_s = M I_p$$

$\therefore M$ is constant
known as mutual
Inductance.

~~the~~ determination of emf:

According to Faraday's Law

$$\mathcal{E}_s = -N_s \frac{\Delta \phi_s}{\Delta t}$$

From eq (1)

$$\mathcal{E}_s = -M \frac{\Delta I_p}{\Delta t}$$

-ve sign shows induce emf
always opposes the cause
that produces it

Rate of change of current in the primary coil
produces induce emf in the secondary coil
known as mutual induce emf.

Here M is constant known as mutual Inductance

As,

$$\mathcal{E}_s = M \frac{\Delta I_p}{\Delta t}$$

or
property of pairs
of coil

$$M = \frac{\mathcal{E}_s}{\frac{\Delta I_p}{\Delta t}}$$

Ratio of Induce emf in the secondary coil to
the rate of change of current in the
primary coil.

Unit: $V A^{-1} \Rightarrow \text{Henry}$

$1H = \frac{1V}{1A}$ when 1V emf induced in a secondary
when 1A current changes in 1Sec in
a primary coil then mutual Inductance would be 1H

Dependence :-

- Area of cross section of both coil
- No of turns of both coil
- Separation b/w coil / closeness of coil.
- Orientation of coil.
- Medium (nature of core material)

Acad :-

Ch#20

AC circuit:- A circuit that is energized by AC power source is called A.C circuit.

~~AC circuit~~ Resistor

Phase of AC:- $V = V_0 \sin \omega t$
 $I = I_0 \sin \omega t$

while $\omega = \frac{2\pi}{T}$ that describes the instantaneous value of voltage or current.

$$V = V_0 \sin\left(\frac{2\pi}{T}t\right)$$

$$t=0$$

$$V = V_0 \sin\left(\frac{2\pi}{T} \times 0\right)$$

$$V=0$$

$$t = \frac{T}{4}; \quad V = V_0 \sin \frac{2\pi}{T} \times \frac{T}{4}$$

$$V = V_0$$

$$t = \frac{T}{2}; \quad V = V_0 \sin \frac{2\pi}{T} \times \frac{T}{2}$$

$$V=0$$

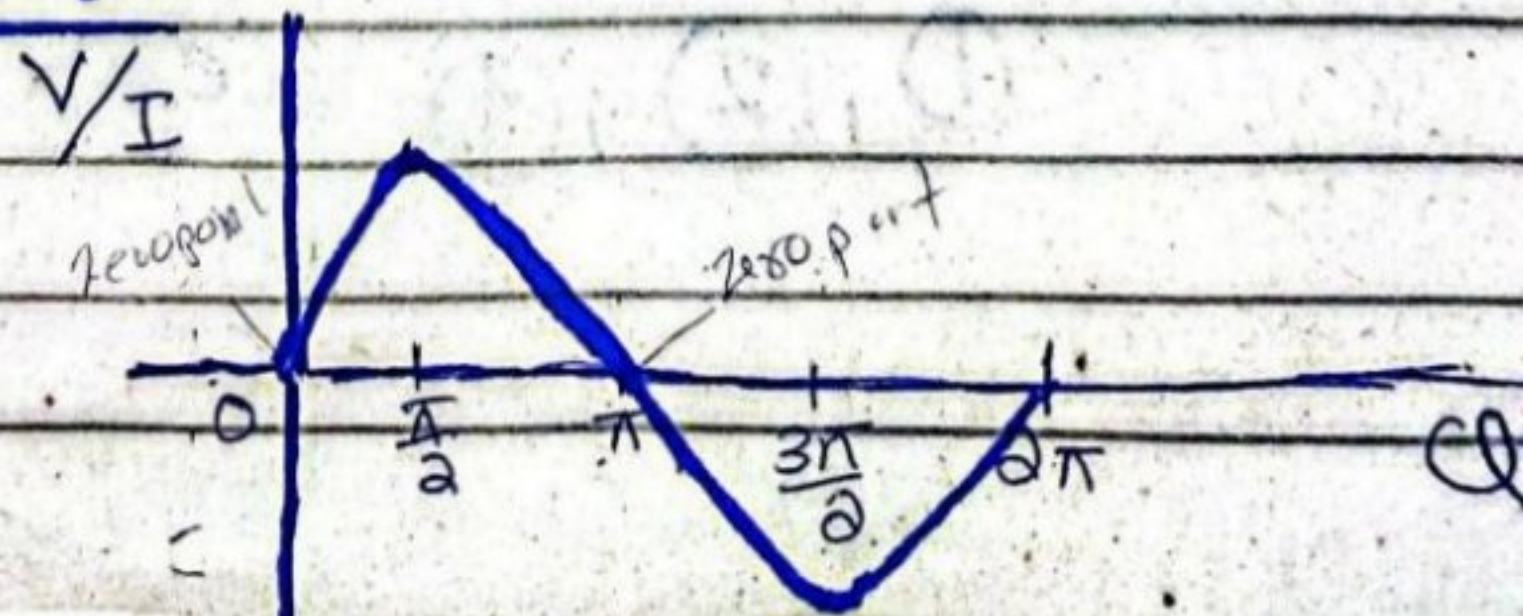
$$t = \frac{3T}{4}; \quad V = V_0 \sin \frac{2\pi}{T} \times \frac{3T}{4}$$

$$V = -V_0$$

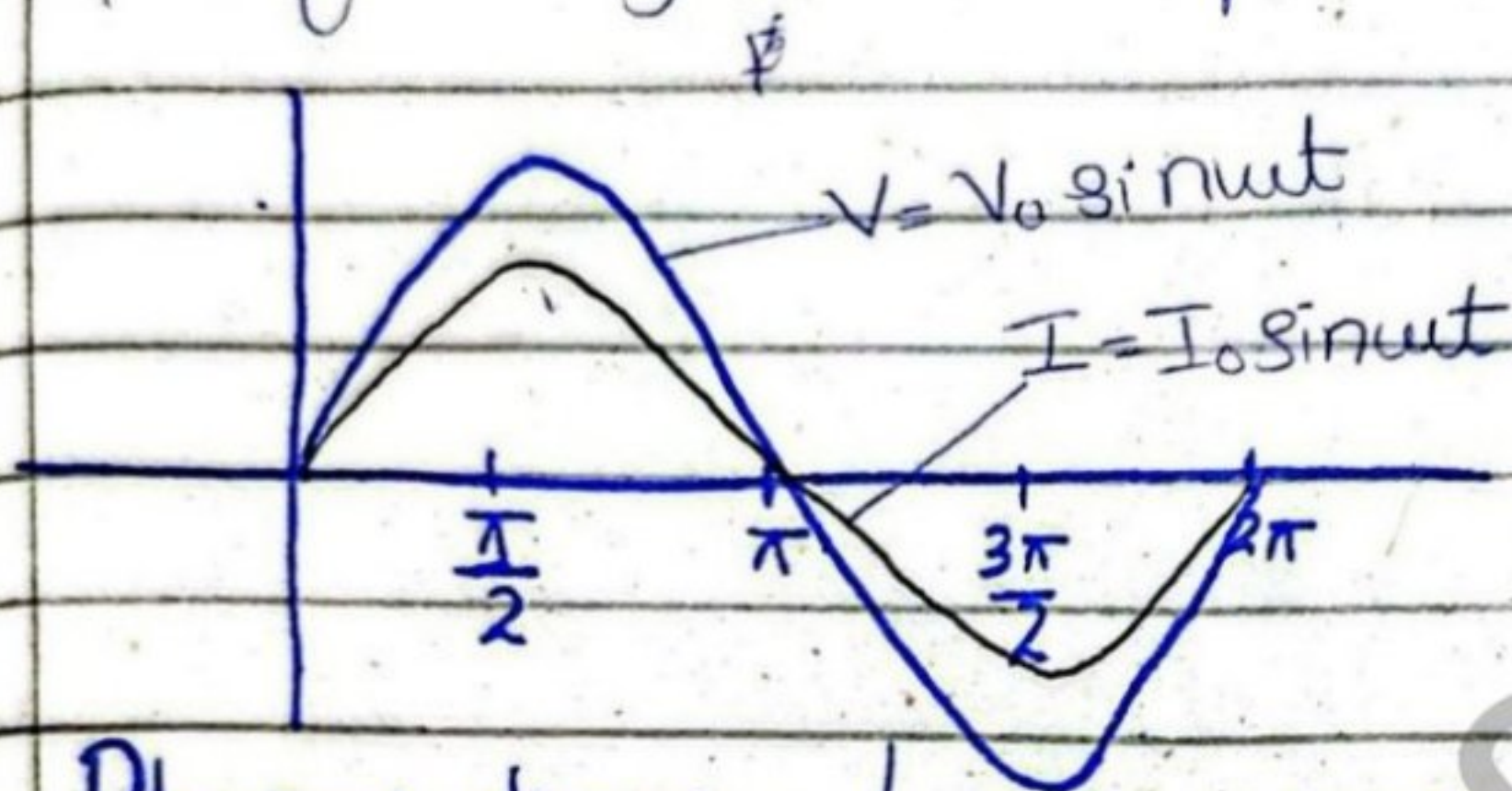
$$t = T; \quad V = V_0 \sin \frac{2\pi}{T} \times T$$

$$V=0$$

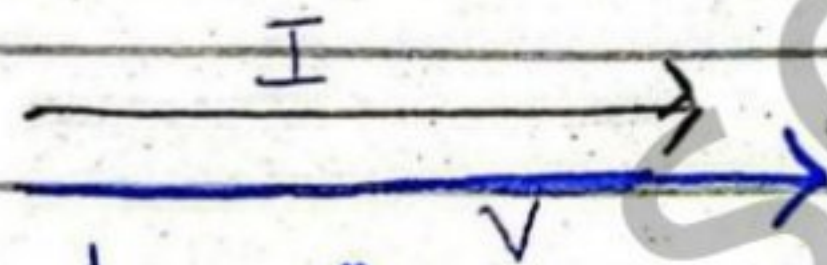
Graphical Representation:-



In Phase:- Two alternating waves are said to be in phase when they have same frequency, and passing through a zero point at same time.

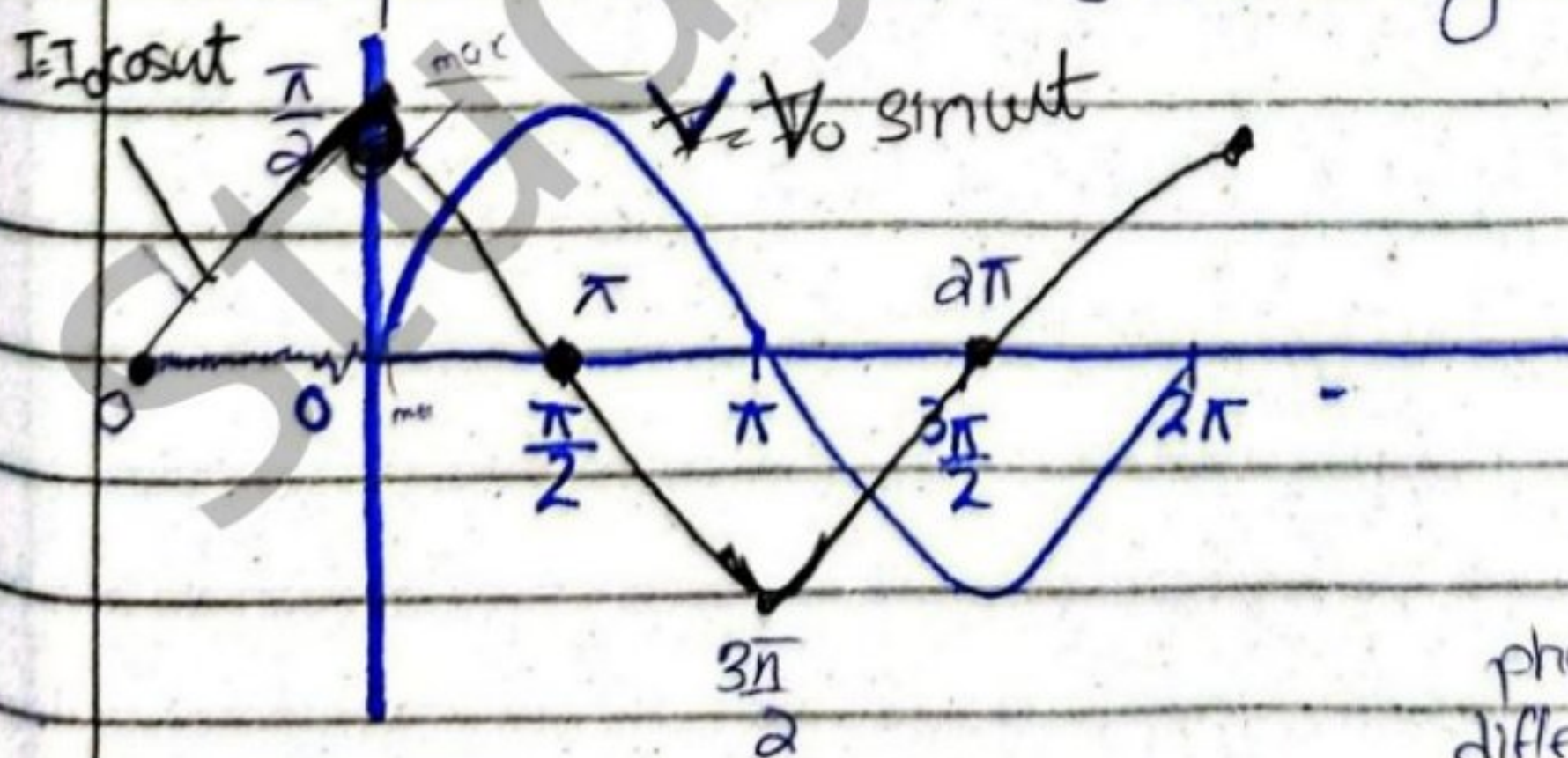


• Phasor diagram / vector representation:-



Phase lead or lag:- Two waves having same

frequency, one wave is passing through a zero point earlier than another then we can say that, the waves that passes through a zero point earlier is leading to other wave



$\Delta \phi = \frac{\pi}{2}$
phase difference

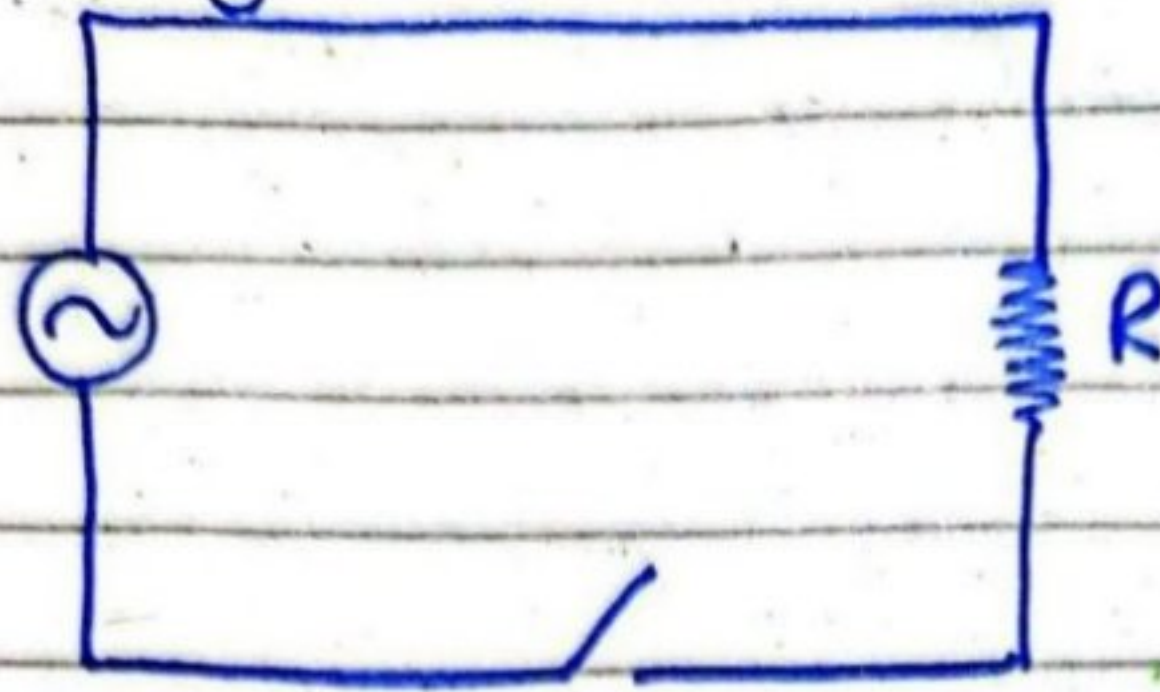
Current leads V by $\frac{\pi}{2}$

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

$$I = I_0 \cos \omega t$$

To be continue

AC Through Resistor:-



- 1) Circuit diagram
- 2) Voltage & Current equation
- 3) Graphical Rep
- 4) phasor diagram
- 5) Power loss.

Consider a resistor of resistance R connected to a AC source via switch when a switch is closed AC will start flowing through a circuit the value of instantaneous voltage is

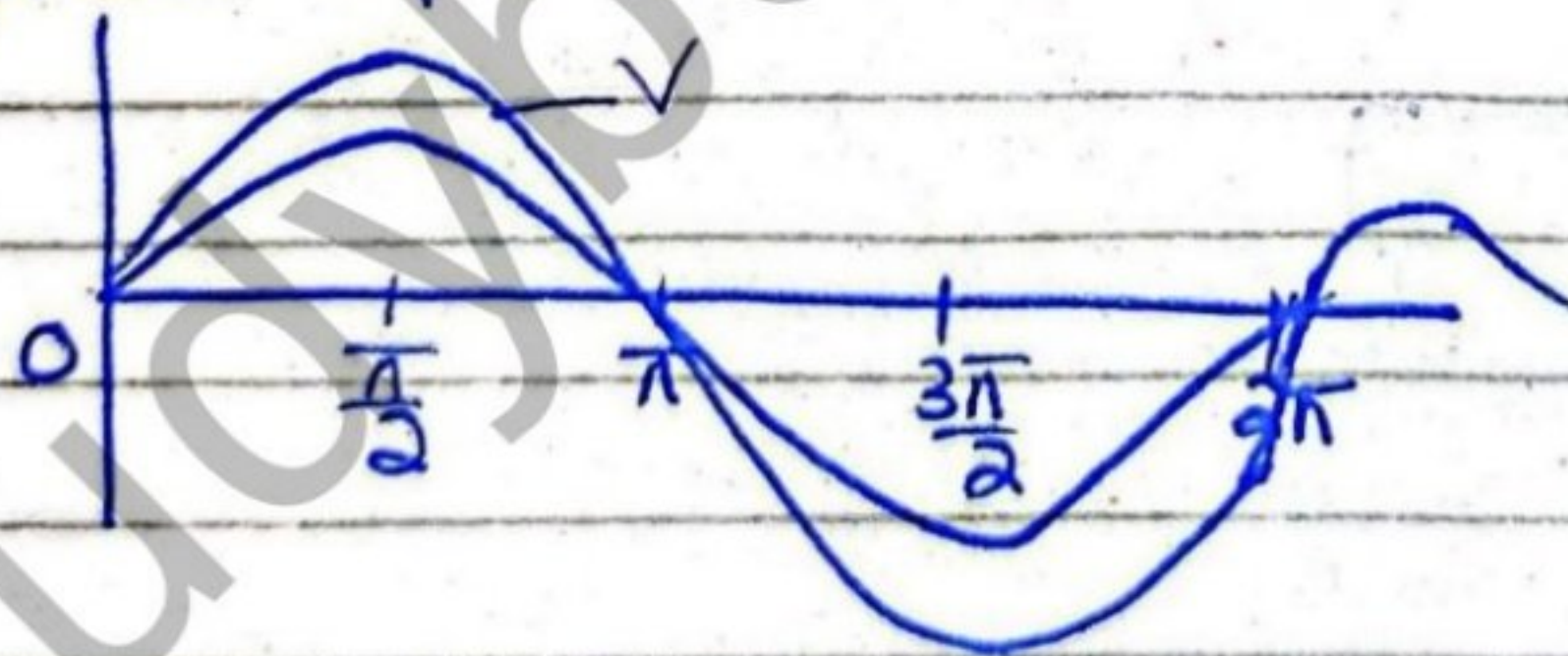
$$V = V_0 \sin \omega t$$

$\div$ by R on b/s

$$\frac{V}{R} = \frac{V_0}{R} \sin \omega t$$

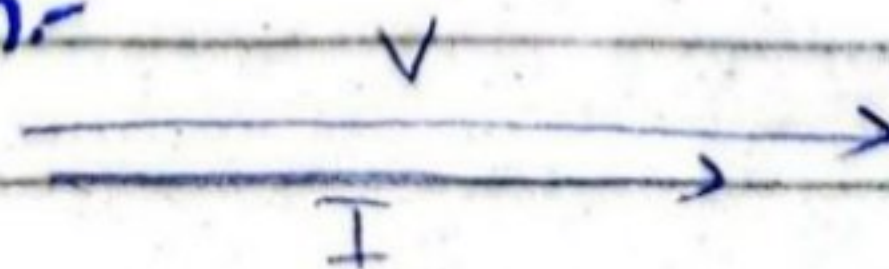
$$I = I_0 \sin \omega t$$

Graphical representation:-



from this we conclude voltage and current are in phase.

Phasor diagram:-



Power loss:-

$$P = V I$$

$$P = (V_0 \sin \omega t)(I_0 \sin \omega t)$$

$$P = V_0 I_0 \langle \sin^2 \omega t \rangle$$

$$P = V_0 I_0 \frac{1}{2}$$

$$P = \frac{V_0}{\sqrt{2}} \times \frac{I_0}{\sqrt{2}}$$

$\therefore \frac{1}{\sqrt{2}}$ can be written as $\frac{1}{\sqrt{2}}$

$$P = V_{rms} I_{rms}$$

In resistor maximum power is lost so power factor is 1

$$P = VI \cos \phi$$

$$\cos \phi = \cos 0$$

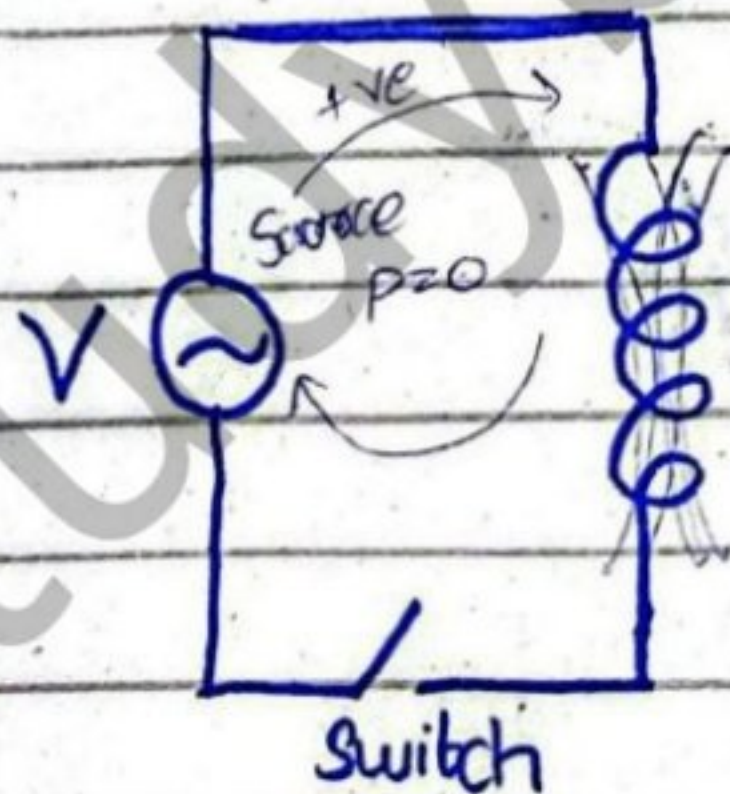
$$P = VI$$

$$= 1$$

power factor is 1

AC Through Inductor:-

long V.I.M.P



$$\mathcal{E} = L \frac{\Delta I}{\Delta t}$$

Consider a pure inductor of Inductance L . Connected to a AC power source via switch as shown. When switch is closed AC flows through a circuit. The instantaneous value of A.C. is given by:

Inductor A coil having large inductance and very small resistance. Construction: The opposite of large resistance
 $\epsilon \rightarrow \infty$ $L \uparrow$ $R=0$ $L=\infty$ } pure inductor.

$$I = I_m \sin \omega t \quad \text{--- (1)}$$

This changing current produces self induced emf in a coil known as back emf.

i.e.
$$\epsilon = -L \frac{\Delta I}{\Delta t}$$

As Inductor is pure so its resistance is zero. so we can say that back emf is equal and opposite to the applied voltage that is:

$$V = -\epsilon$$

$$V = -\left(-L \frac{\Delta I}{\Delta t}\right)$$

$$V = L \frac{\Delta I}{\Delta t} \quad \text{--- (2)}$$

from eq (1)

$$V = L \frac{\Delta(I_m \sin \omega t)}{\Delta t}$$

$$V = \frac{L I_m \Delta \sin \omega t}{\Delta t}$$

$$V = L I_m \cos \omega t \frac{\Delta \omega t}{\Delta t}$$

$$V = L I_m \omega \cos \omega t \quad \text{--- (3)}$$

For maximum voltage

$$\cos \omega t = 1$$

$$V = V_m$$

putting in eq (3)

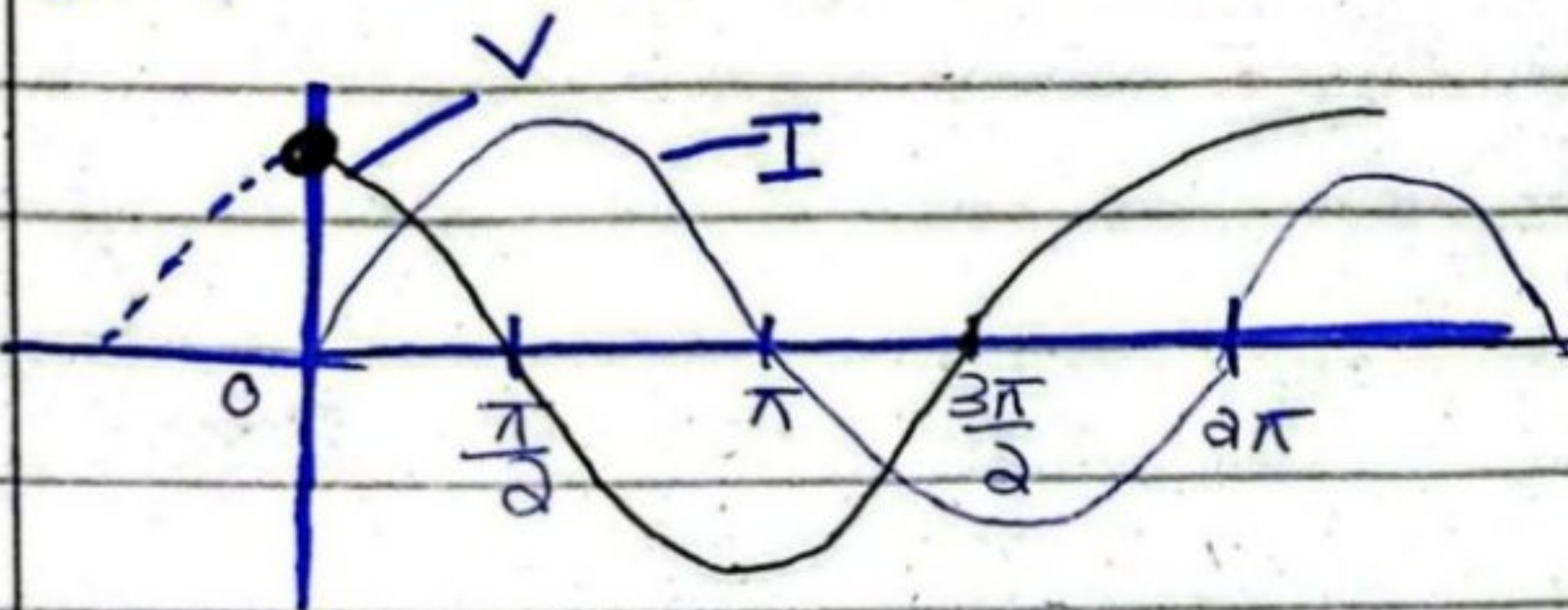
$$V_m = L I_m \omega \quad \text{--- (4)}$$

put in eq (3)

$$V = V_m \cos \omega t$$

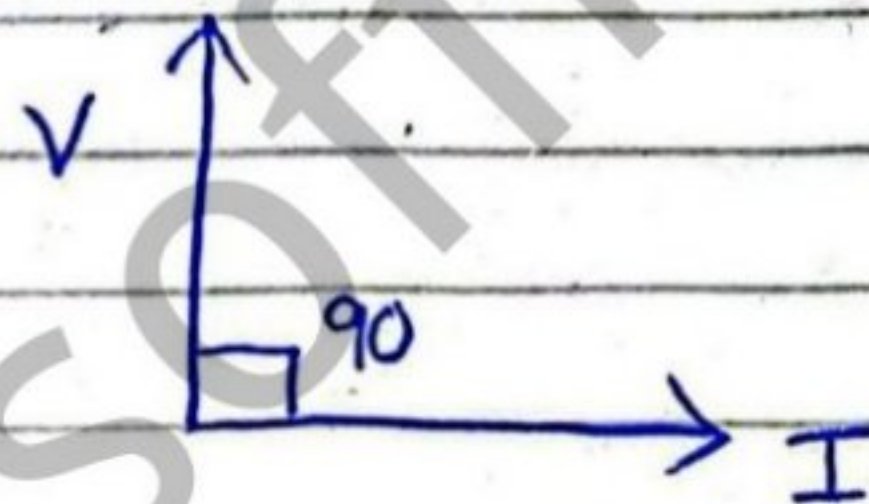
~~V = V_m \sin(\omega t)~~ $V = V_m \sin(\omega t + 90^\circ)$

Graphical Representation:-



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

Phasor Representation:-



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Inductive Reactance: opposition offered by the inductor to the flow of AC is called inductive reactance.

Represented by X_L

As,

$$V_m = I_m X_L$$

$$X_L = \frac{V_m}{I_m}$$

$$X_L = \frac{L \cdot I_m \omega}{I_m}$$

$$X_L = \omega L$$

$$X_L = (2\pi f) L$$

∞ if $f = 0$

$$X_L = 2X_L$$

for pure dc $X_L = 0$
because $f = 0$.

Induct as pass DC
|| block AC

Power loss: $P = VI$

$$P = (V_m \cos \omega t)(I_m \sin \omega t)$$

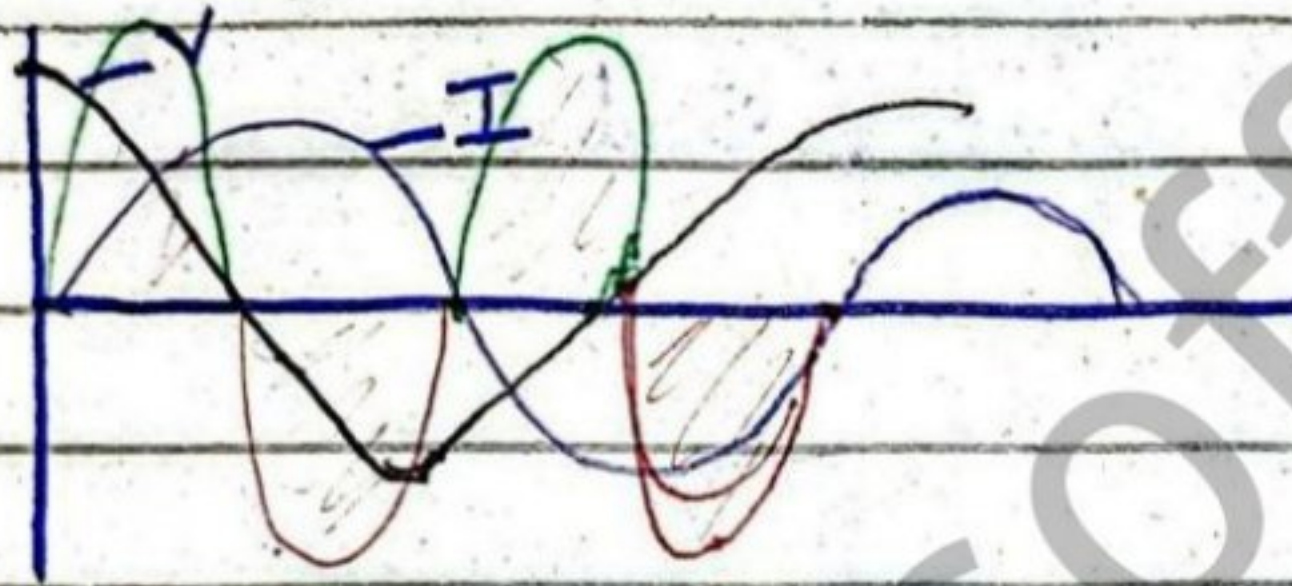
$$P = V_m I_m (\cos \omega t)(\sin \omega t)$$

$$P_{av} = V_m I_m \langle \cos \omega t \rangle \langle \sin \omega t \rangle$$

$$P_{av} = V_m I_m \times 0 \times 0$$

$$P_{av} = 0$$

Graphical Representation of power loss

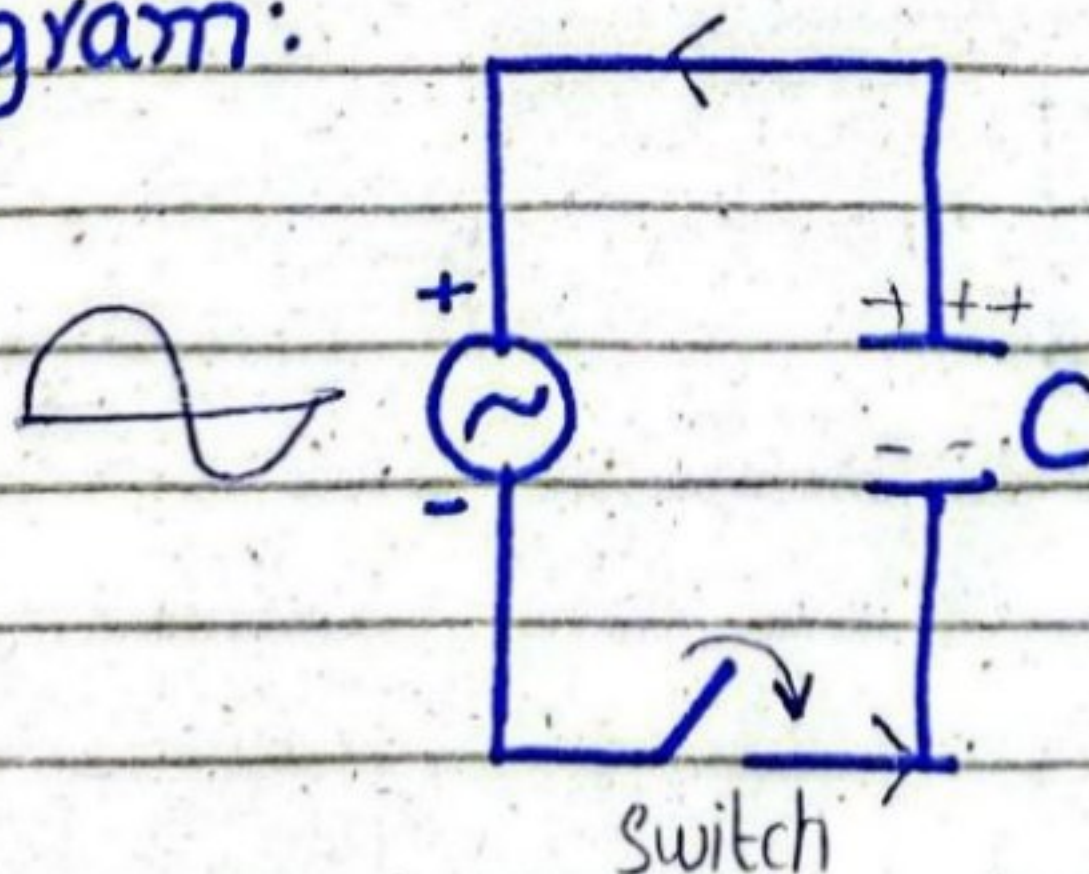


+ve (power is given to load from source)

-ve (power is going back from load to source)

AC through Capacitor.

Circuit Diagram:



Consider a capacitor of capacitance C connected

to a **AC voltage source** via switch, when switch is closed **AC** flows through a circuit because capacitor undergoes continuously charging and discharging. The instantaneous value of AC voltage is

$$V = V_m \sin \omega t \quad \text{--- (1)}$$

The instantaneous value of charge

$$q = CV$$

from eq (1)

$$q = C V_m \sin \omega t$$

~~from eq (1)~~

Now instantaneous ~~q~~ value of current is

$$I = \frac{\Delta q}{\Delta t}$$

$$I = \frac{\Delta (C V_m \sin \omega t)}{\Delta t}$$

$$I = C V_m \frac{\Delta (\sin \omega t)}{\Delta t}$$

$$I = C V_m \cos \omega t \frac{\Delta (\omega t)}{\Delta t}$$

$$I = \omega C V_m \cos \omega t \quad \text{--- (2)}$$

$$I = I_m$$

when $\cos \omega t = 1$

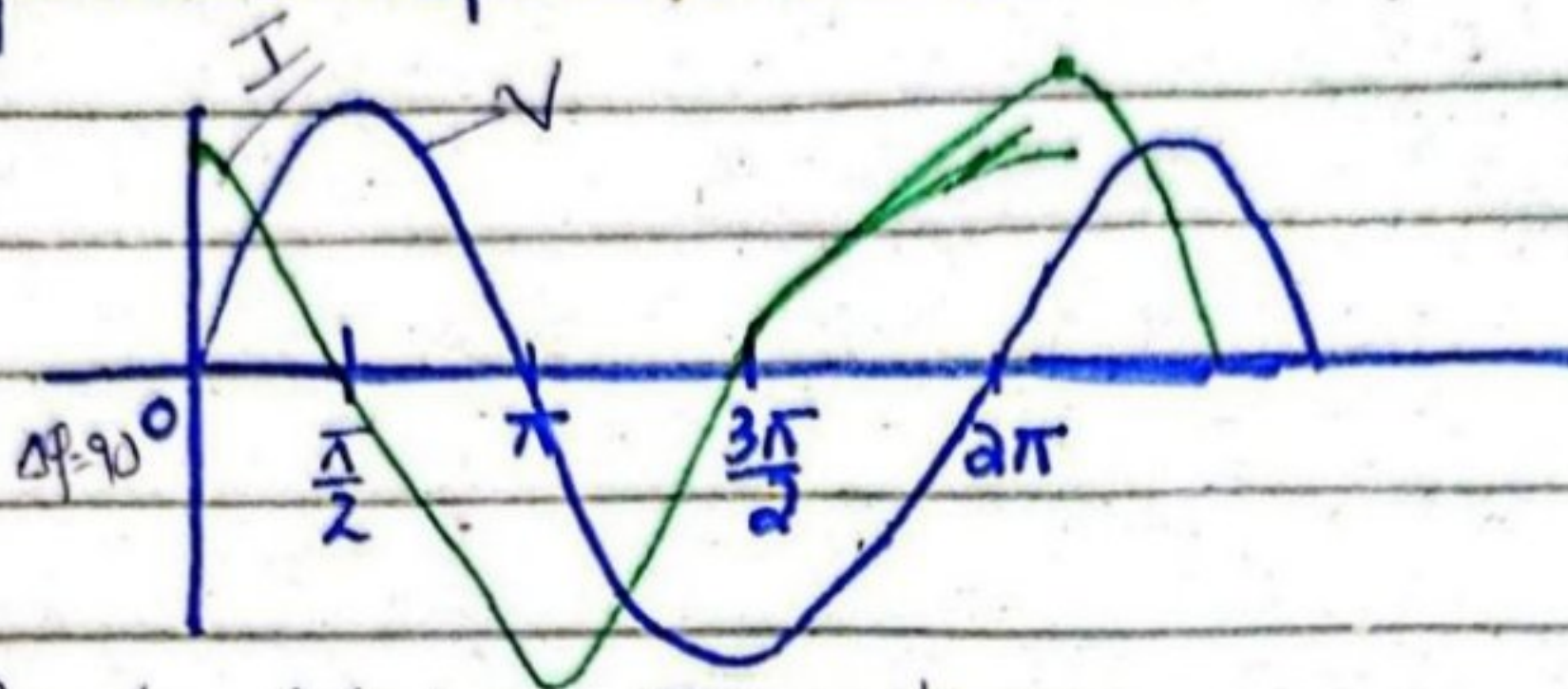
put in eq (2)

$$I_m = \omega C V_m \text{ put in (2)}$$

$$I = I_m \cos \omega t$$

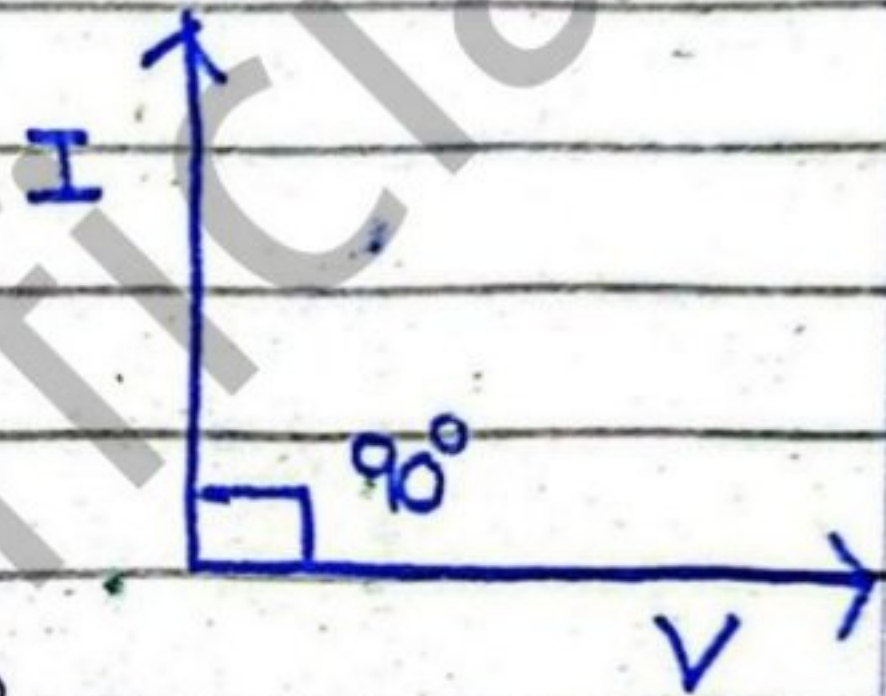
$$I = I_m \sin(\omega t + 90)$$

Graphical Representation



I leads V by $\frac{\pi}{2}$ radian.

Phasor Diagram:



Capacitive reactance:- Opposition offered by the capacitor to the flow of AC is called capacitive reactance. It is represented by X_c . It is measured in ohm (Ω).

$$V_m = I_m X_c$$

$$X_c = \frac{V_m}{I_m}$$

$$X_c = \frac{I_m X_c}{\omega C V_m} \quad \text{from eq (2)}$$

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

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

or

$$f' = 2f$$

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

Power loss: $P = VI$

$$P = (V_m \sin \omega t)(I_m \cos \omega t)$$

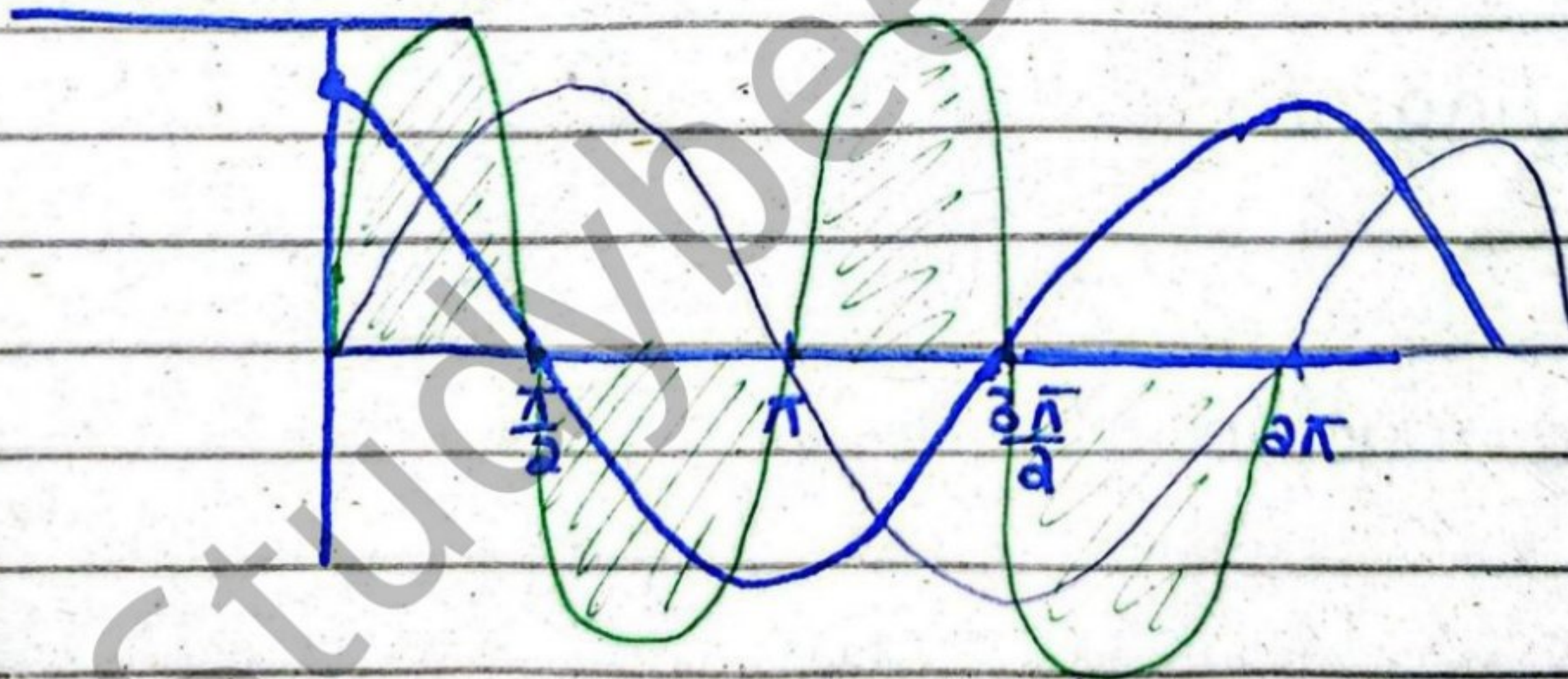
$$P = V_m I_m (\sin \omega t)(\cos \omega t)$$

$$P_{av} = V_m I_m \langle \sin \omega t \rangle \langle \cos \omega t \rangle$$

$$P_{av} = V_m I_m \times 0 \times 0$$

$$P_{av} = 0$$

Graphical rep



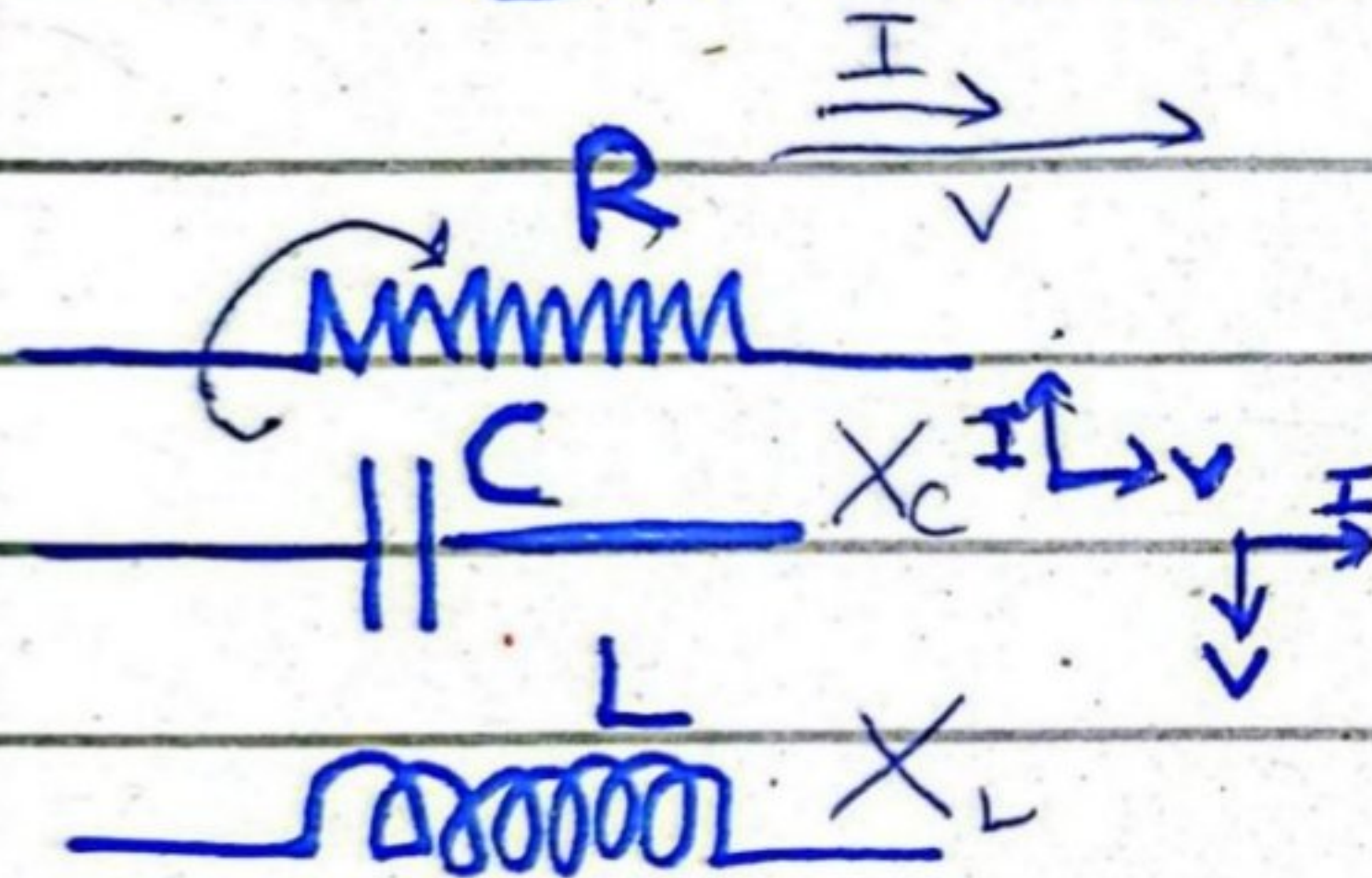
$$P = VI \cos \phi \text{ phase diff}$$

↳ power factor

$$\cos 90^\circ = 0$$

Acad

CH #20



Impedance

It is a combine effect of resistance, capacitive reactance and inductive reactance.

It is represented by Z .

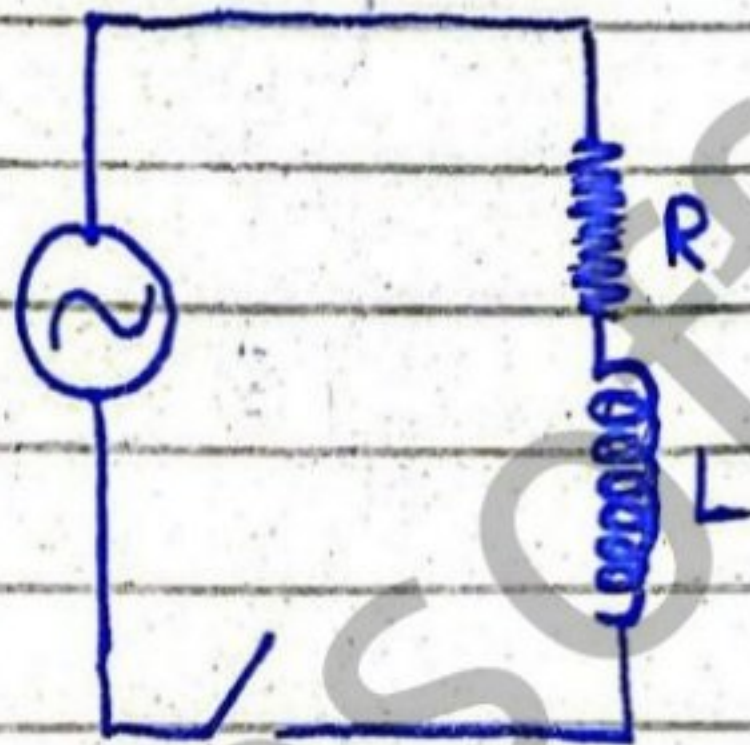
$$V = I Z$$

$$Z = \frac{V}{I} = \frac{V}{A} = \Omega$$

Admittance: Reciprocal of Impedance is called admittance. It is represented by Y , and

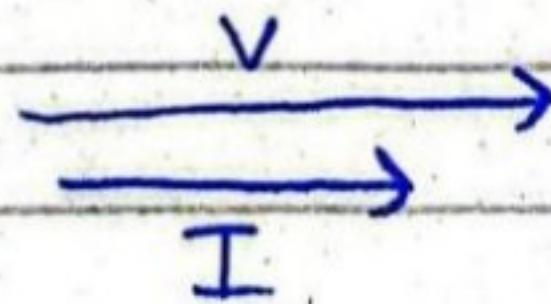
$$Y = \frac{1}{Z} = \Omega^{-1}$$

RL series Circuit:- ^{V.IMP long}

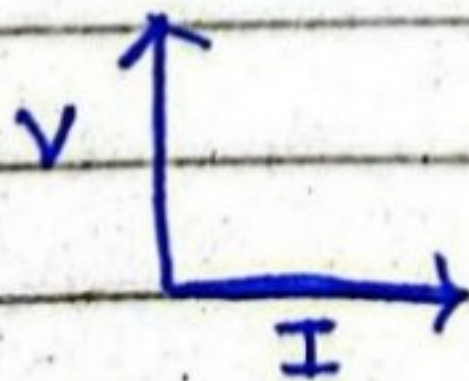


→ Consider a resistor of resistance R , and a pure inductor of inductance L are connected in series via switch.

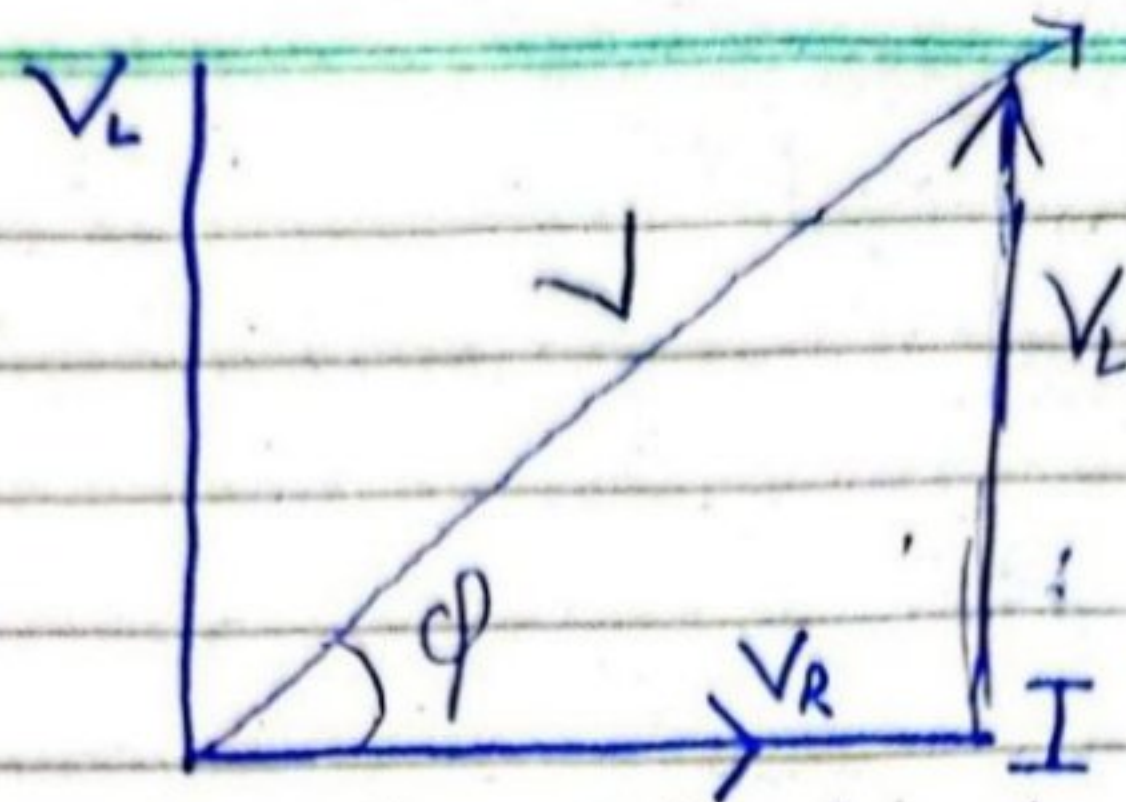
→ In resistance voltage & current are in phase.



→ In Inductor voltage leads current by $\frac{\pi}{2}$ radian.



Phasor diagram → Taking current as reference.



In RL-Series circuit V leads I by angle ϕ i.e. $0 < \phi < 90^\circ$.

Let instantaneous value of current

$$I = I_m \sin \omega t$$

Now

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

Impedance:- using pythagorus theorem in above figure:

$$V^2 = (V_R)^2 + (V_L)^2$$

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

$$V = \sqrt{(IR)^2 + (X_L I)^2}$$

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

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

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

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

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

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

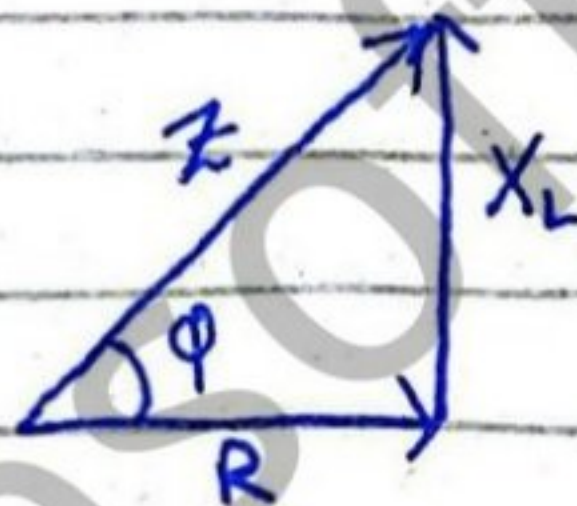
Phase Angle: $\tan \phi = \frac{V_L}{V_R} \Rightarrow$

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

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

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

Impedance triangle:-



$$Z^2 = R^2 + X_L^2$$

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

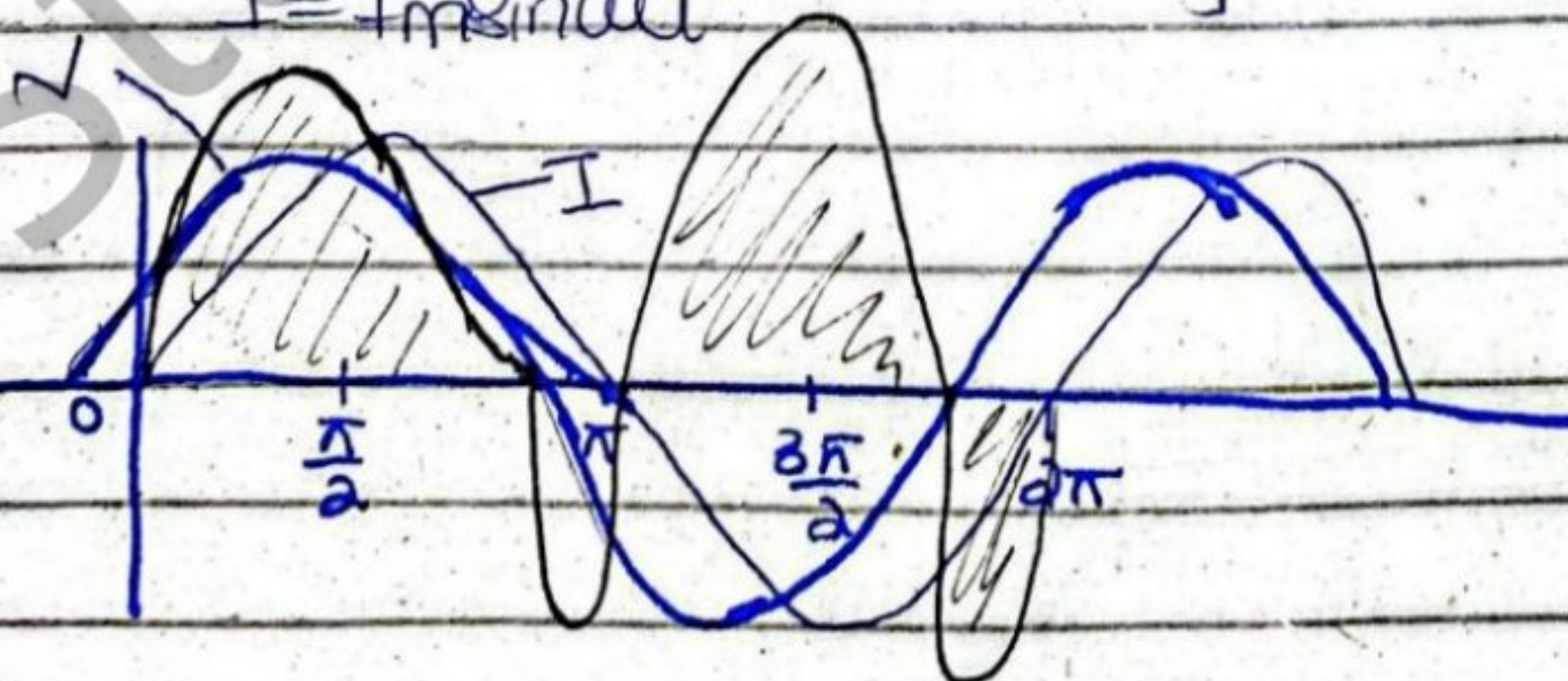
Power factor:-

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

Power loss: $P = VI \cos \phi$

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

$$I = I_m \sin \omega t$$

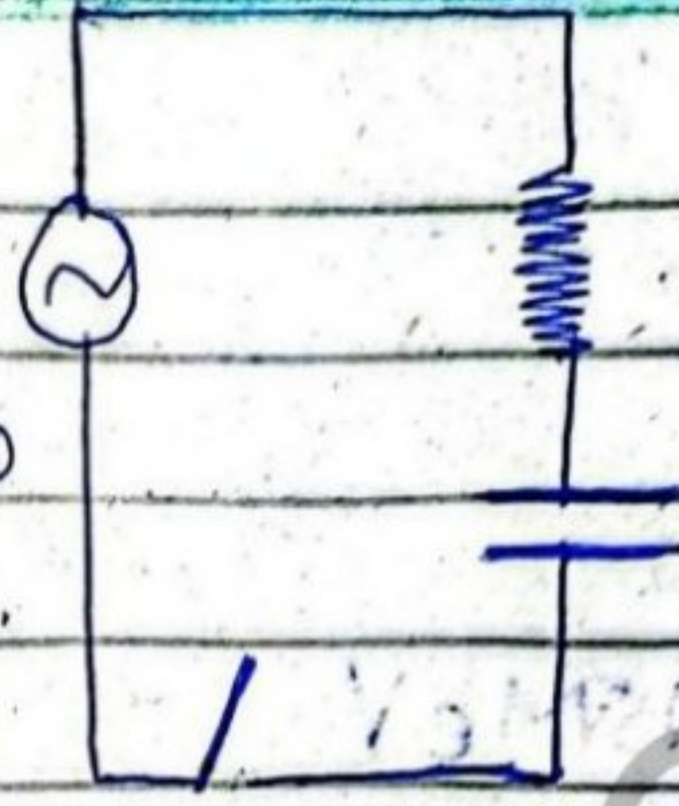


CH# 20

RC series Circuit:-

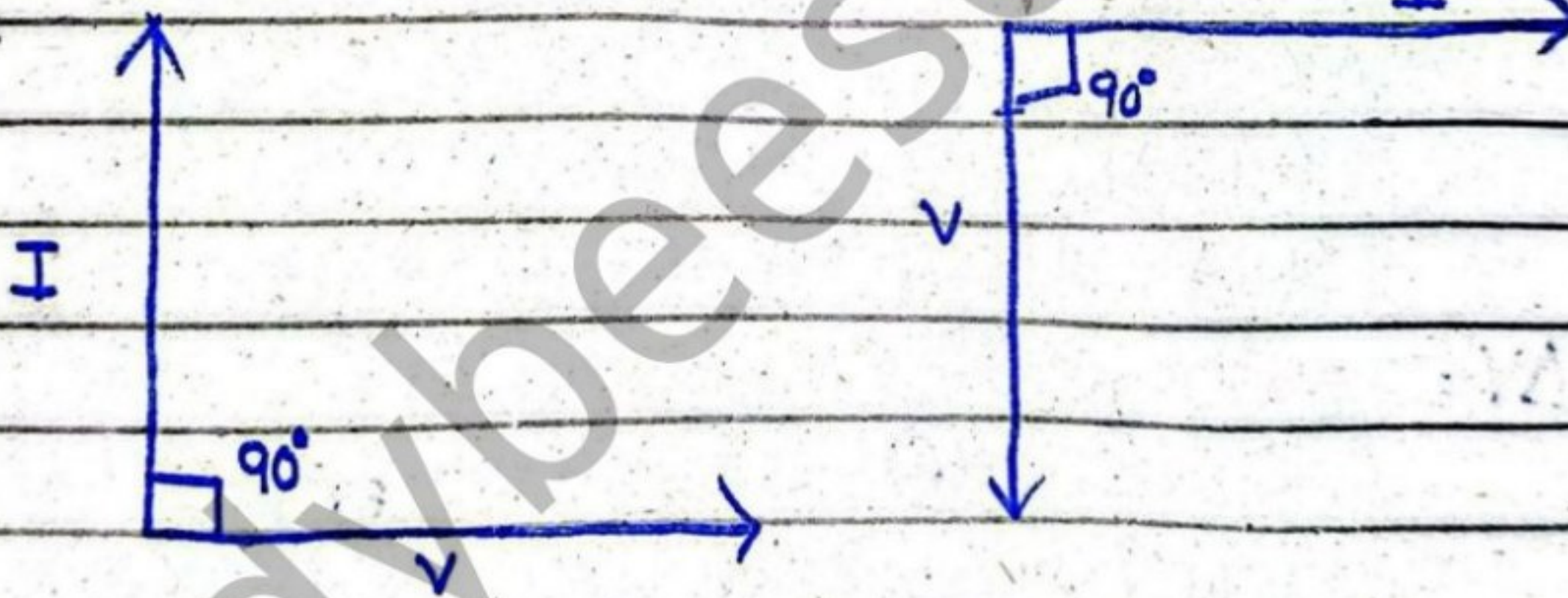
Consider a resistor of resistance R and a capacitor of capacitance C is connected in series via switch.

In resistance voltage & current are in phase.

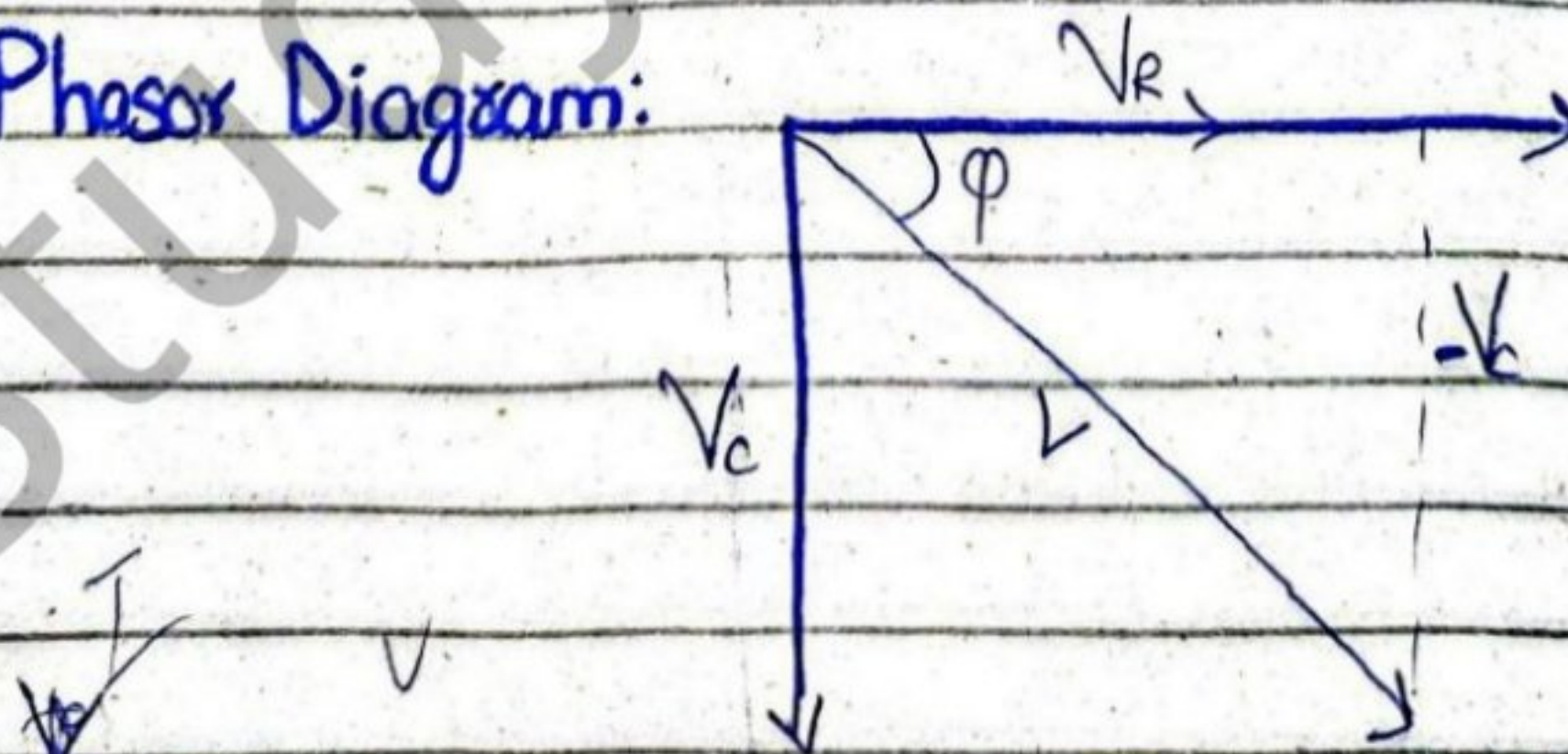


I I

In capacitor I leads V by $\frac{\pi}{2}$



Phasor Diagram:



V lags I by angle ϕ . $0 < \phi < 90^\circ$

Impedance: using pythagoras theorem $\begin{cases} V = V_0 \sin \omega t \\ I = I_0 \sin(\omega t + \phi) \end{cases}$

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

$$V = \sqrt{(IR)^2 + (-IX_c)^2}$$

$$V = \sqrt{I^2(R^2 + X_c^2)}$$

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

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

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

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

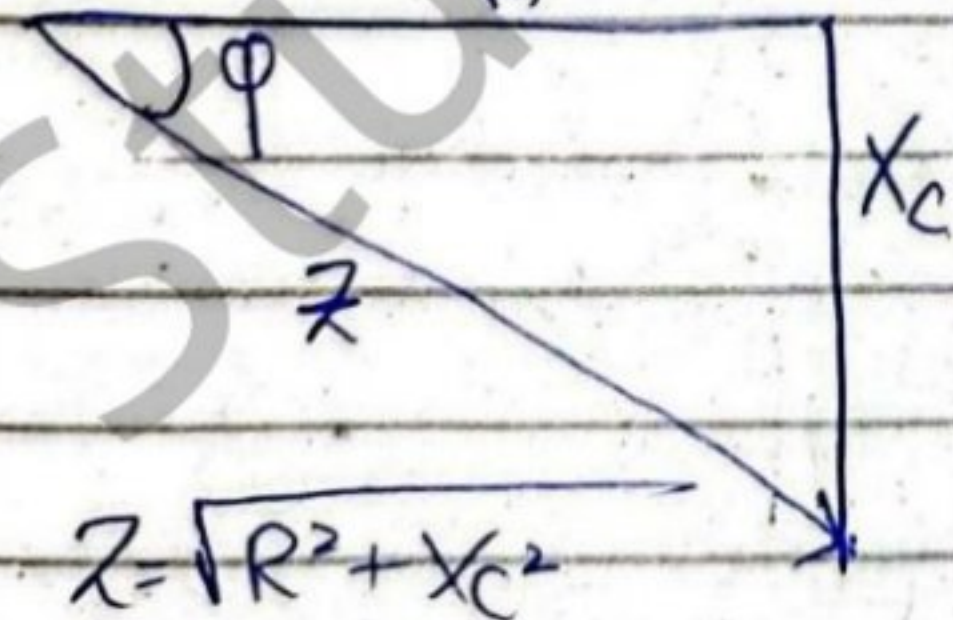
$$Z = \sqrt{R^2 + \left(\frac{1}{2\pi f C}\right)^2}$$

Phase angle: $\tan \phi = \frac{V_c}{V_R}$

$$Q = \tan^{-1} \left(\frac{IX_c}{IR} \right)$$

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

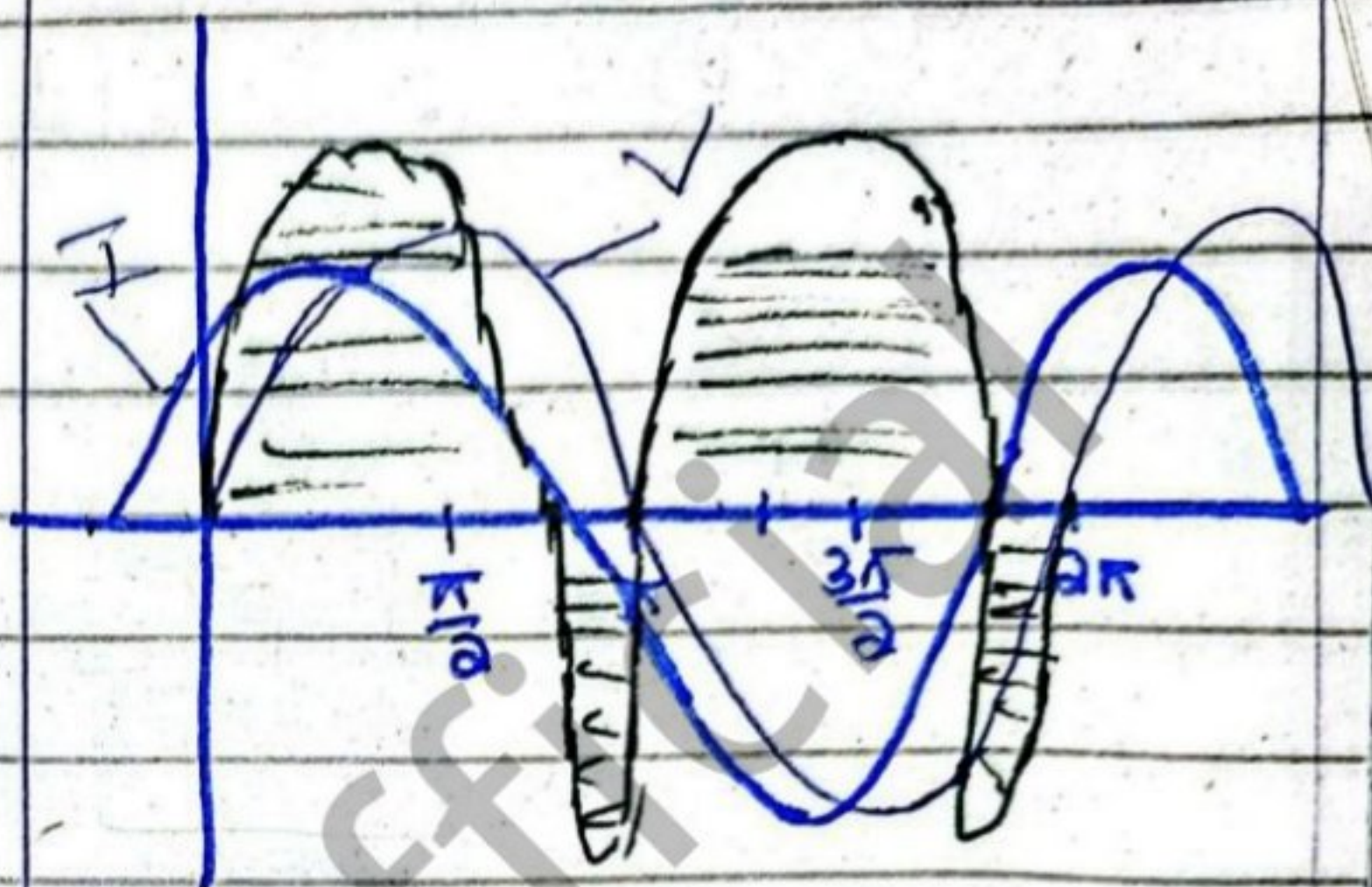
Impedance Triangle:



Power factor:

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

Power loss.

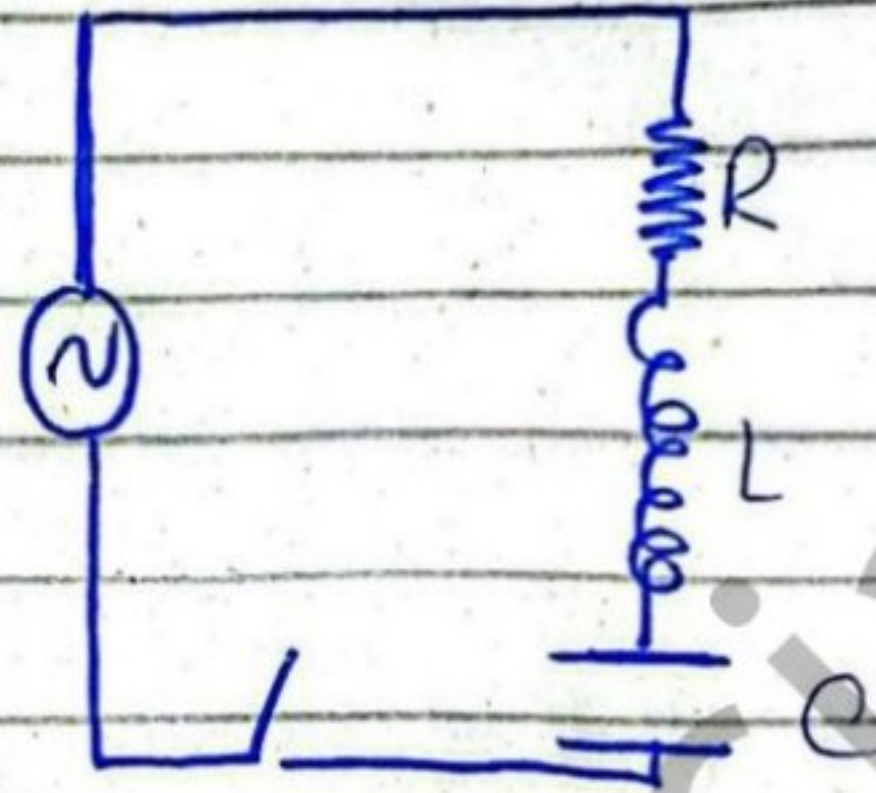


Ch# 20

RLC Series circuit:-

Circuit Diagram:-

Consider a resistor of resistance R , inductor of inductance L Inductive reactance X_L and capacitor of capacitance C , ~~ind~~ capacitive reactance X_C are connected in series via switch -



- At low freq.

$$X_C > X_L ; V_C > V_L$$

circuit behave as RC circuit

- At high frequency.

$$X_L > X_C ; V_L > V_C$$

circuit behave as RL circuit

- At resonance freq.

$X_L = X_C$ Circuit behave as resistive.

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

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

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

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

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

Ch # 20 Conceptual Questions

KPK book:- Conceptuals

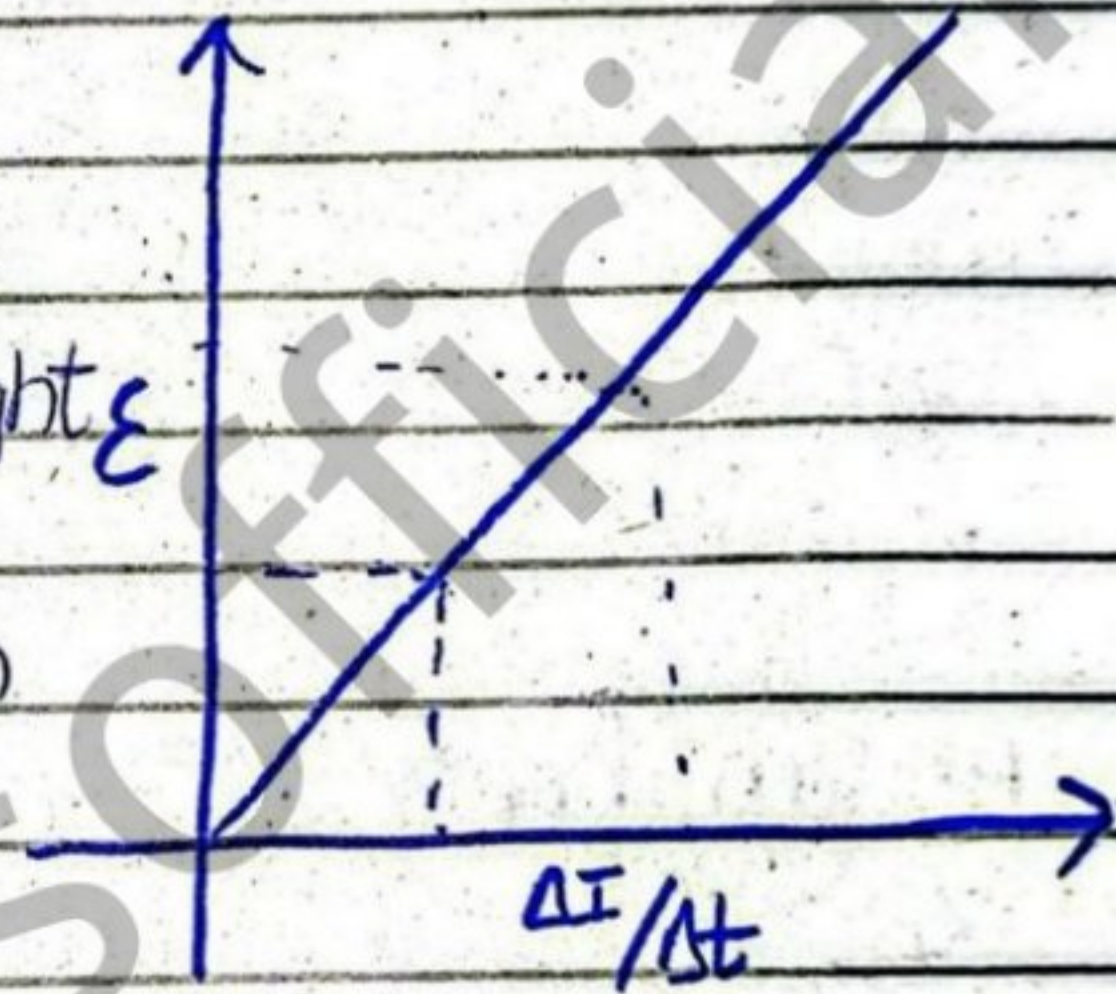
Q1) sketch a graph b/w EMF induced and rate of change of current. What is significance.

A) According to relation

$$\epsilon \propto \frac{\Delta I}{\Delta t}$$

Therefore, the graph b/w them will be a straight line as increasing rate of change of current causes an increase in emf.

$$\text{Gradient} = \tan \phi = \frac{P}{B} = \frac{\epsilon}{\frac{\Delta I}{\Delta t}}$$



This is equal to self inductance.

Q2) What determines the gradient of a graph of inductive reactance against frequency?

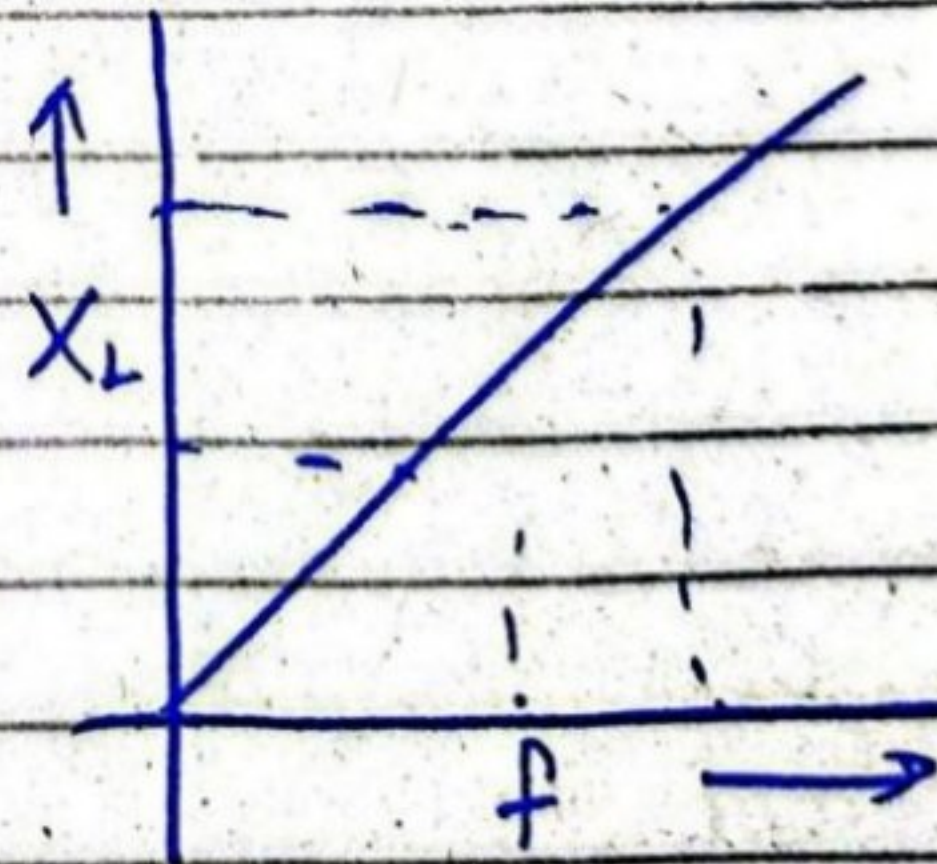
Ans) The relation between X_L & f :

Shows $X_L = 2\pi f L$ that

X_L is directly prop to f .

The gradient would be

$$\tan \phi = \frac{P}{B} = \frac{X_L}{f} = \frac{2\pi f L}{f} = \boxed{2\pi L}$$



Thus the gradient gives us self inductance (L).

Q) How does the doubling frequency affect

a) an inductor

$$X_L = 2\pi fL$$
$$f' = 2f$$
$$X_L' = 2\pi(2f)L$$
$$\boxed{X_L' = 2X_L}$$

b) a capacitor

$$X_C = \frac{1}{2\pi f(2f)C}$$

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

Q) If peak value is 1000V, what is effective value?

Ans) $V_p = 1000V$

$V_{rms} = ?$

$$V_{rms} = \frac{1000}{\sqrt{2}} \Rightarrow \boxed{707V}$$

Q) Show reactance is measured in ohms (Ω)

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

$$X_C = \frac{V_0}{V_0 \omega C}$$

$$X_C = \frac{V_0}{I_0} = \frac{\text{Volt}}{\text{ampere}} = \boxed{\text{Ohms } (\Omega)}$$

For Inductors:-

$$X_L = \omega L$$

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

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

$$X_L = \frac{\text{Volt}}{\text{ampere}} = \text{ohm } (\Omega)$$

Punjab book (PTB) Conceptuals

Q) A sinocidal current, has rms value 10A what is peak value?

$$V = 10 \times \sqrt{2} = \boxed{14.14V}$$

Q) Name the device that

a) Permit DC: ^{block AC} Inductor allows DC to flow but when AC flows, magnetic flux changes and induces emf and oppose AC current.

b) Permit AC block DC: Capacitor allow AC to flow when DC flows, after sometime charge accumulates on plates and no further flow is allowed.

Q) How many times per second will reach max brilliance if $f = 50\text{Hz}$.

A) if freq is 50Hz it reach max brilliance almost 100 times per second.

Q) A circuit contains iron coated inductor, switch and DC source in series. The switch is closed and opened, why there occurs a spark?

A) when switch is closed and then reopened current changes maximum which produces induced current (Back emf) which is why spark jumps across the ends of this switch.

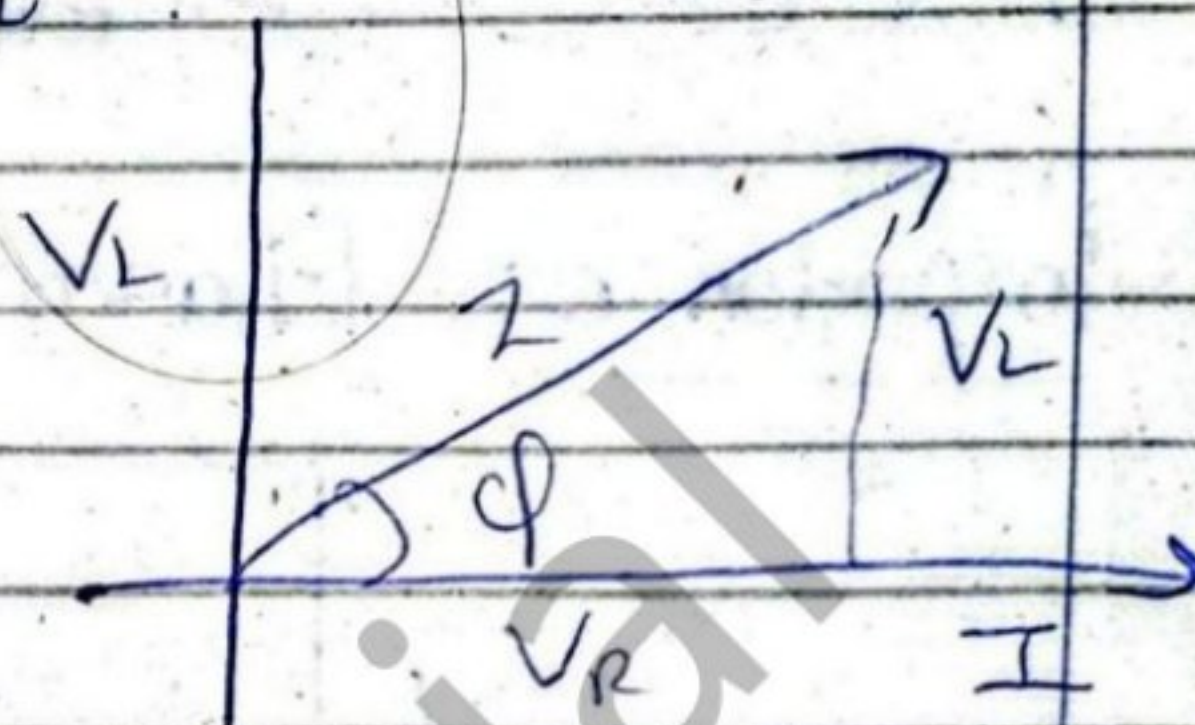
Q) Does voltage lead or lag in RL circuit?

Voltage leads in **RL** circuit.

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

$$\phi = \tan^{-1}\left[\frac{I_{rms} X_L}{I_{rms} R}\right]$$

$$\phi = \tan^{-1}\left[\frac{V_L}{V_R}\right]$$



Q) A choke is connected to AC source & lamp why it is dim? By addition of capacitor it become bright why?

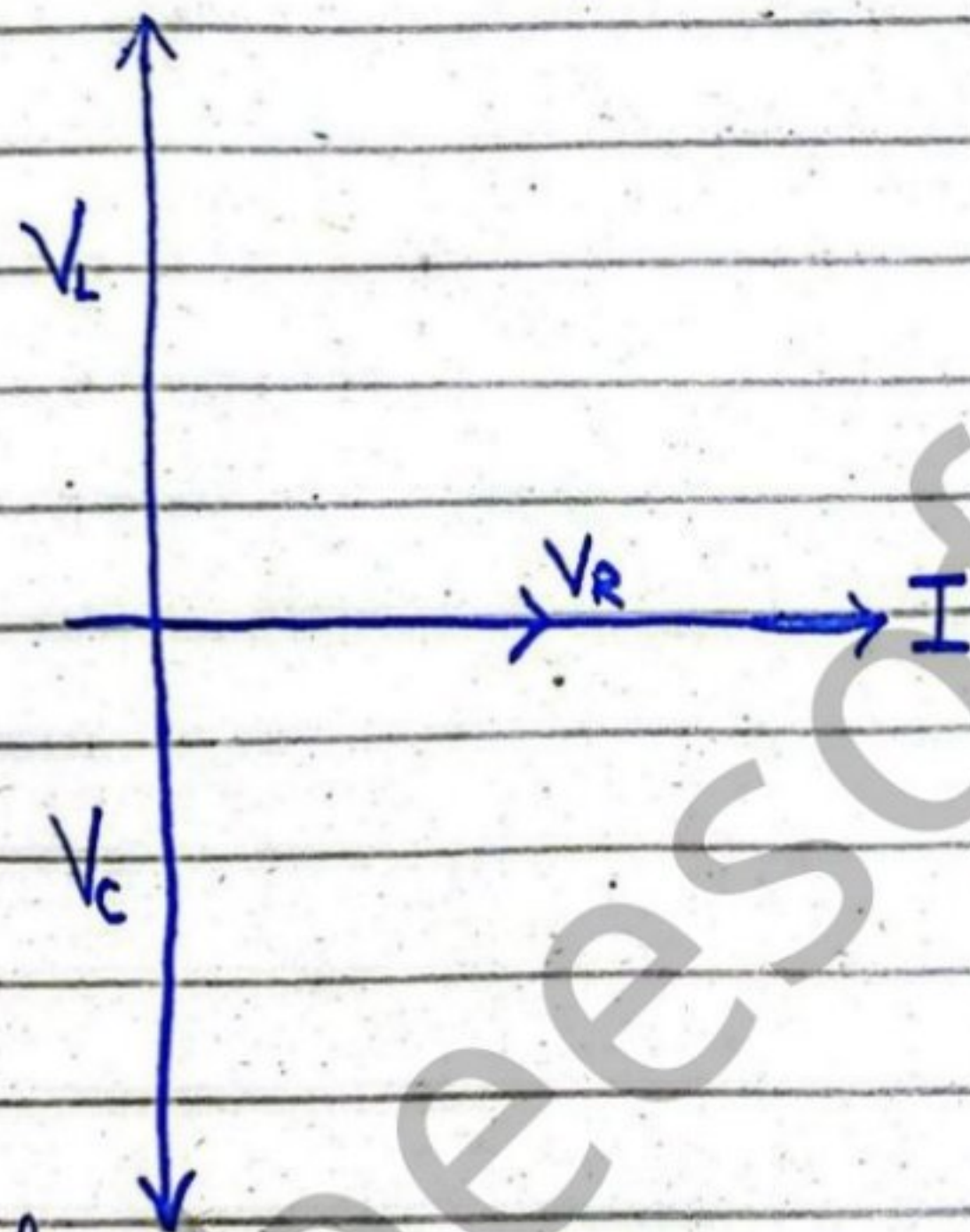
Q) In first case an RL circuit forms thus impedance causes lamp to be dim. If capacitor is also connected it cancels each other as they are opposite. We make $X_L = X_C$, bulb glows.

CH#20

CLG

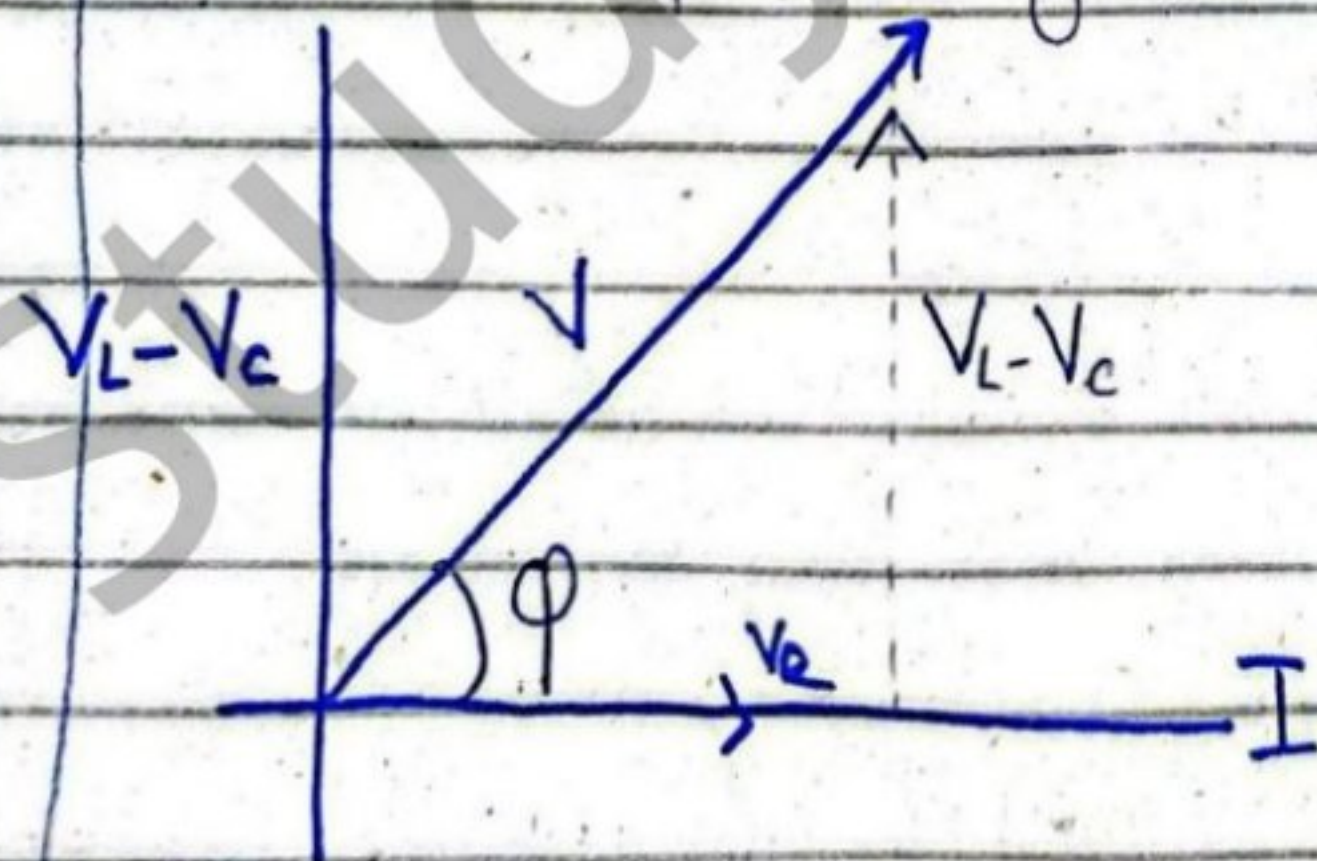
RLC Series AC circuit / RLC AC resonance circuit.

Remaining
Impedance:- Phasor Diagram:-



At Higher frequency:- $V_L > V_C$

The modified phasor diagram-



V leads I by $0^\circ < \phi < 90^\circ$

Using pythagoras theorem

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

$$V = \sqrt{I^2 R^2 + (IX_L - IX_C)^2}$$

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

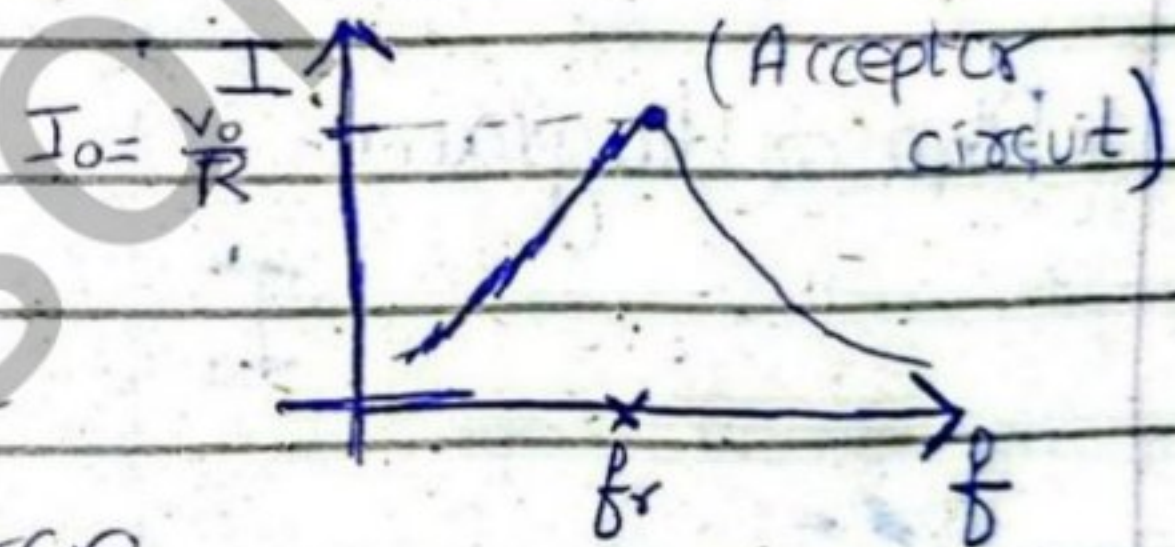
$$V = I \sqrt{R^2 + (X_L - X_C)^2}$$

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

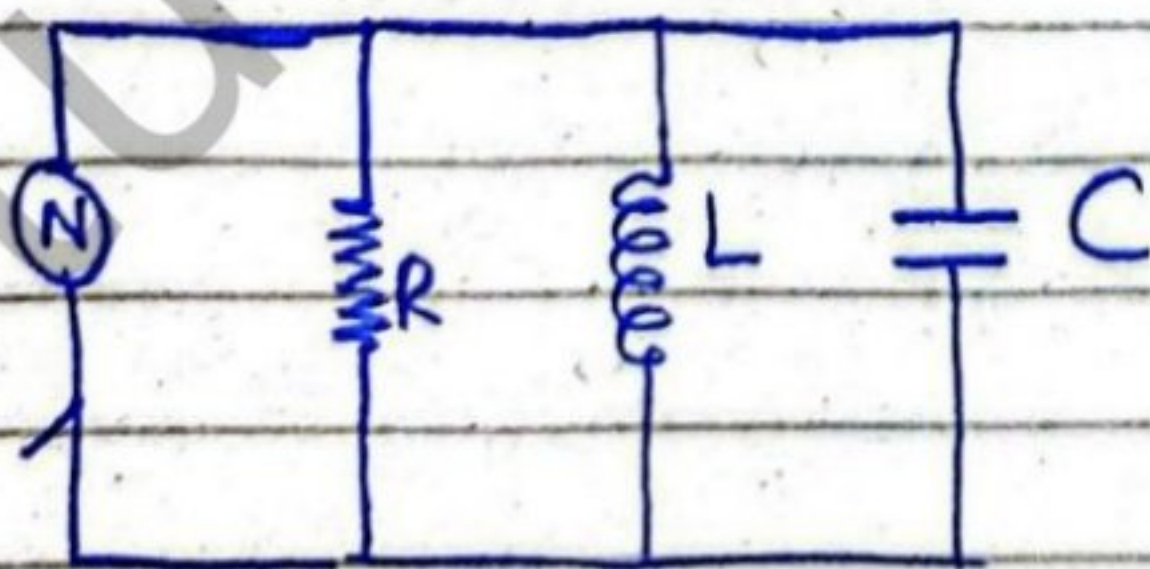
Properties of RLC Series Resonance circuit:-

- At resonance circuit behave as pure circuit
- At resonance Impedance of circuit is equal to R
- At resonance power factor is 1
- At resonance impedance of circuit is minimum so current is maximum

- At resonance voltage drop across capacitor or inductor may be larger than source voltage -



RLC Parallel Circuit / RLC parallel resonance circuit.



Consider a resistor of resistance R , inductor of inductance L and

capacitor of capacitance C are connected in parallel via switch -

At low frequency, $X_C > X_L$
circuit behave as RC circuit.

- At High frequency: circuit behave as RL circuit

$$X_L > X_C$$

• At resonance frequency

$$X_L = X_C$$

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

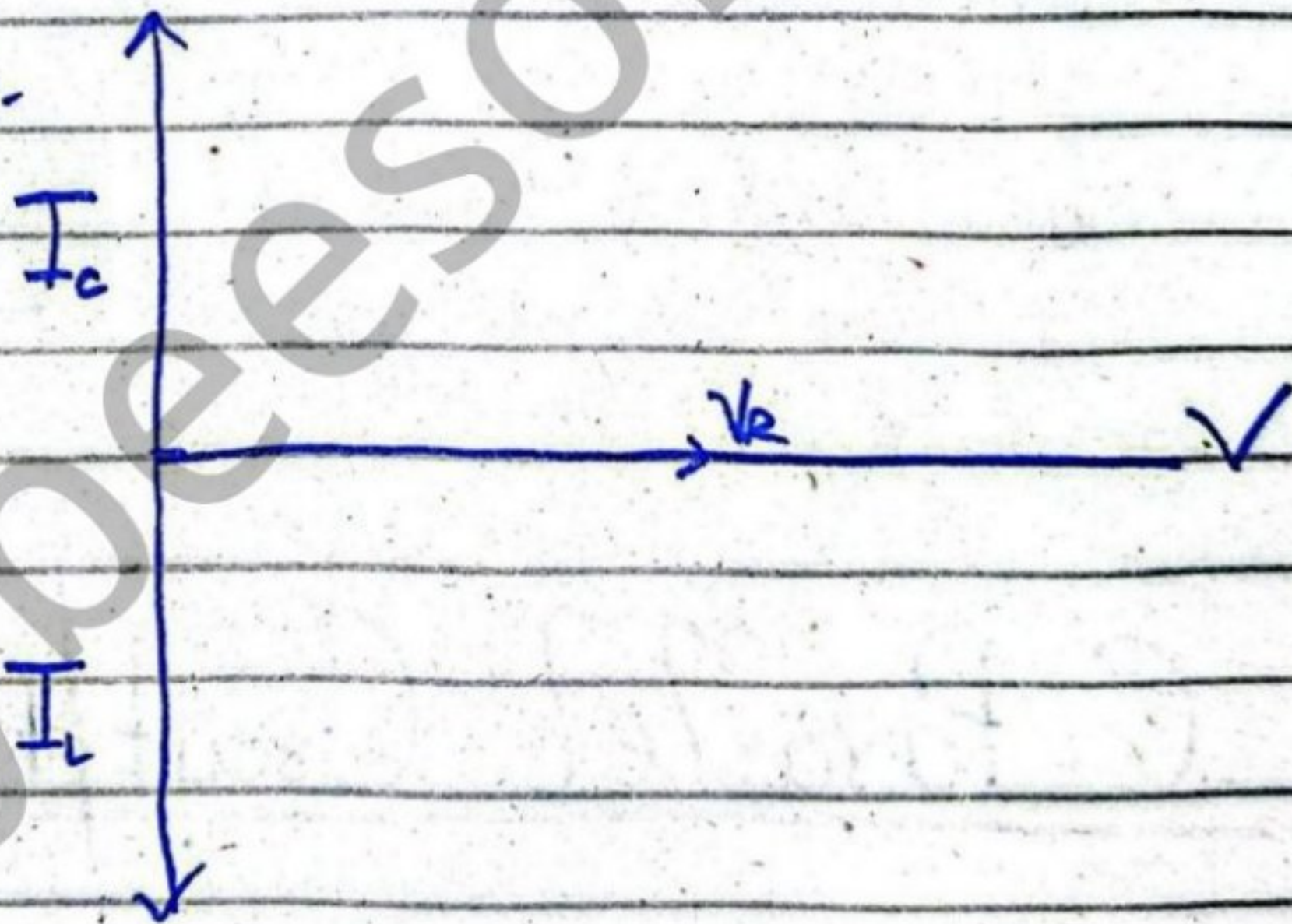
$$\sqrt{\omega^2} = \frac{1}{LC}$$

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

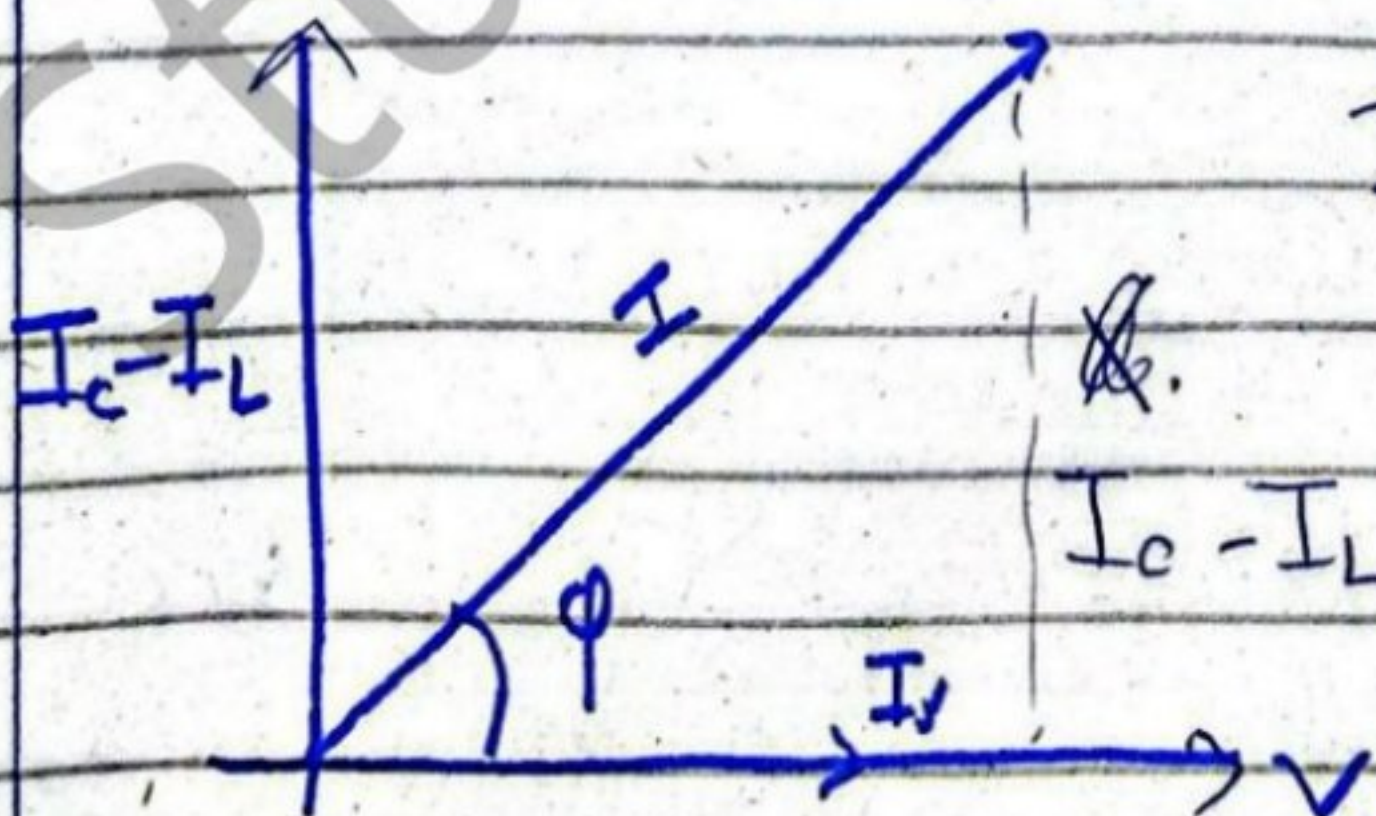
$$2\pi f_r = \frac{1}{\sqrt{LC}}$$

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

Phasor diagram:-



At high freq



I lead V by ϕ

$$0^\circ < \phi < 90^\circ$$

Using Pythagoras Theorem:- $\sqrt{I^2} = \sqrt{(I_R)^2 + (I_C - I_L)^2}$

$$I = \sqrt{\frac{V^2}{R^2} + \left(\frac{V}{X_C} - \frac{V}{X_L}\right)^2}$$

$$I = \sqrt{\frac{V^2}{R^2} + V^2 \left(\frac{1}{X_C^2} - \frac{1}{X_L^2}\right)^2}$$

$$I = V \sqrt{\frac{1}{R^2} + \left(\frac{1}{X_C} - \frac{1}{X_L}\right)^2}$$

$$Y = \sqrt{\frac{1}{R^2} + \left(\frac{1}{X_C} - \frac{1}{X_L}\right)^2}$$

$$Y = \frac{1}{\sqrt{\frac{1}{R^2} + \left(\frac{1}{X_C} - \frac{1}{X_L}\right)^2}}$$

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

$$Z = \sqrt{\frac{1}{R^2} + \left(\frac{1}{X_C} - \frac{1}{X_L}\right)^2}$$

- Properties:-
- At resonance impedance of circuit is maximum and is equal to R.
 - At resonance the current in the circuit is minimum.
 - At resonance power factor is 1.
 - At resonance current ~~is~~ across inductor of capacitor may be larger than source current.

