Date
Page

Assignment - 2 (AC Circuit)

1 Define the following

(i) Voltage : Voltage describes the "pressure" that pushes electrons. The amount of voltage is indicated by a unit know is the volt (V).

(ii) Current : Current is the rate at which electrons flow past a point in a complete electrical circuit.

(iii) Frequency : Electrical (ac) frequency is the number of cycles per second in an ac sine wave.

(iv) Cycle : A cycle is one complete repetition of the sine wave pattern.

(v) Time period : The time interval between a definite value of two successive cycles is the periode.

(vi) Peak Value : Peak value is defined as the maximum value that the alternating quantity reaches in one cycle.

(vii) Average Value : The average value of an alternating current is the ~~avg~~ average of all the instantaneouse value during one alternation.

(viii) R.M.S Value : That value of steady current, which would generate the same amount of heat in a given resistance is given time, as is done by A.C current. when maintained across the same resistance for the same time.

(ix) Instantaneous Value : It is the value of an alternating current at a particular distance in the cycle.

(x) Amplitude factor : The amplitude factor is a measurement of constructive or destructive wave interference. When one or more particles are located in two groups at a single distance.

(xi) Form factor : The ratio of the RMS (root mean square) value to the average value.

(xii) Phase & Phase Difference : When they have the same frequency, but they attain their zero value at different instants.

(xiii) Power factor : The ratio of working power, measured in kilowatts, to apparent power, measured in kilovolts amperes.

3

2 Explain how to produce an Alternating EMF.

- Electromotive force is define as the electric potential produce by the conversion of other forms of energy such as chemical or magnetic into electrical energy.
- Alternating EMF is produced when AC generator is made to generate current.
- The EMF will oscillate between its highter value and lowed value and the direction of the current also change with respect to it.
- An AC generator produce EMF by rotating a coil made of conductors in the presence of an electrical field.

Date ______
Page ______

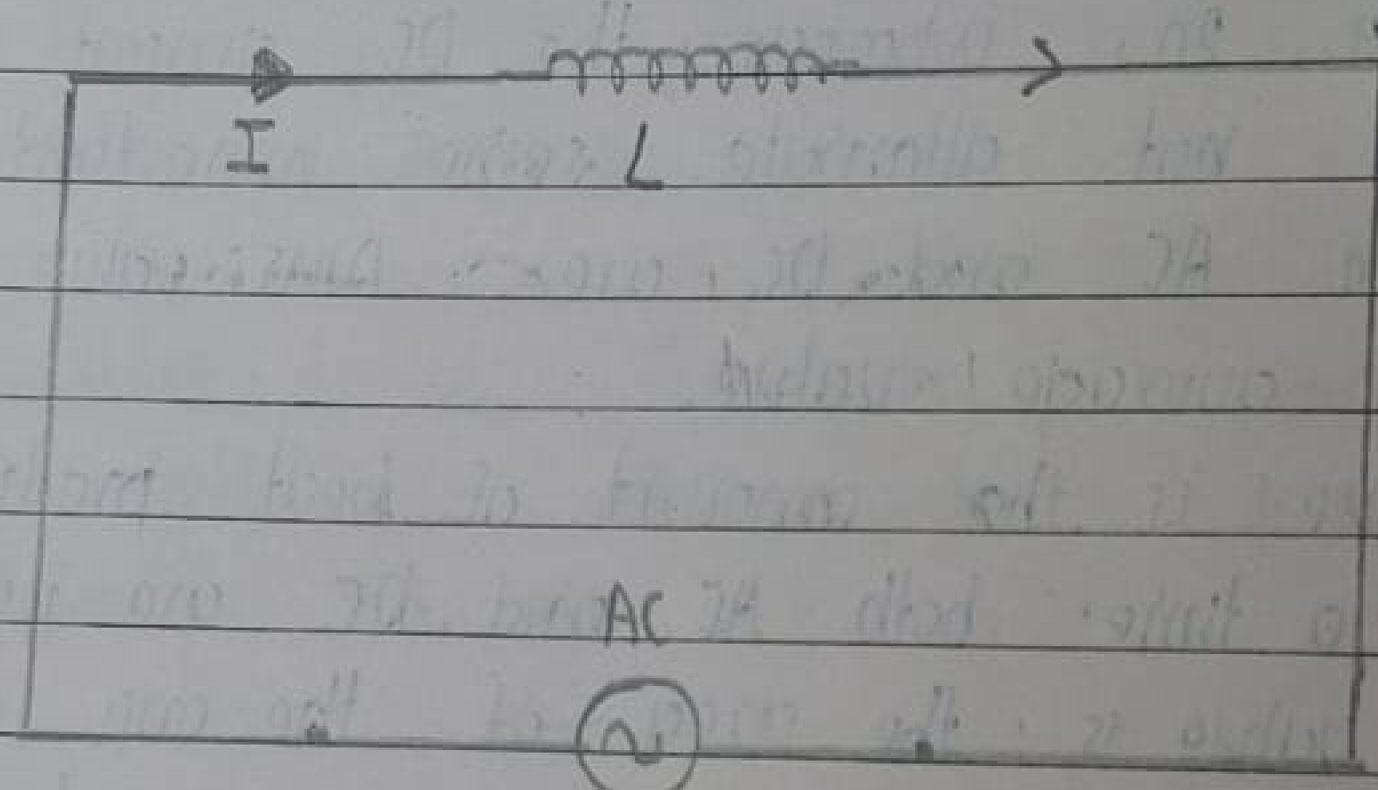
- The amplitude of the EMF thus generated will depend upon the material the coil of the generator is made of.
- Highter the conductivity of the material, the highter the amplitud of EMF produced.

3 Derive the expression of Average value and R.M.S value in terms of Maximum value for sinusoidal quantities.

- Average value and RMS value are important expression for sinusoidal wave. As we know that there are two type of source AC and DC. The AC is the one that repeats itself after 2π, whereas the DC current source is the one that does not alternate. some important terms associated with both AC and DC are: RMS value instantaneous value and the average value.
- RMS value is the amount of heat produced by a resistor when at a time both AC and DC are passed throught it. Average value is the area of the one cycle of sinusoidal wave to the time period. However, instantaneous value is the value at a particular instance let us further understand these concepts below.
- We have already seen the expression for the RMS value but we will now derive the RMS value using the - analytical method. Let's first derives the RMS value of current and then we can generalise it for voltage too. since the sine wave is symmetrical, we can calculate the RMS value by considering the half cycle only
- We know that the equation of a sinusoidal alternating current is given as $i = I_m \sin\theta$
- Since the current change form positive to negative in an AC signal we will use the squared current wave - because it is always positive for our calculations.

4 Prove that current in purely inductive circuit current is always lags by 90° than voltage and average power consumed is zero. Draw phasor diagram and the wave forms of voltage, current and instantaneous power.

- Such a circuit theoretically has zero resistance and hence zero loss. A back EMF due to the self inductance of the coil is produced whenever alternating voltage is applie to a purely inductive circuit. Due to the absence of ohmic resistance the only force that the applied voltage has to overcome is the circuit's self-inductance.



Purely Inductive Circuit Diagram.

- When the voltage and current values are at their positive peak, the value of power is also positive and similarly when the voltage and current values are at their negative peak, power is alone negative. The current value change during a voltage drop and at the instant when the current value is at its peak the voltage will reach zero.

- The voltage and current are out of phase with each other by 90° $V = ~~t~~ V_m \sin \omega t$
- The instantaneous power in a purely inductive circuit can be derived as follows

$P = VI$

$P = (V_m \sin \omega t)\ I_m \sin(\omega t + \pi/2)$

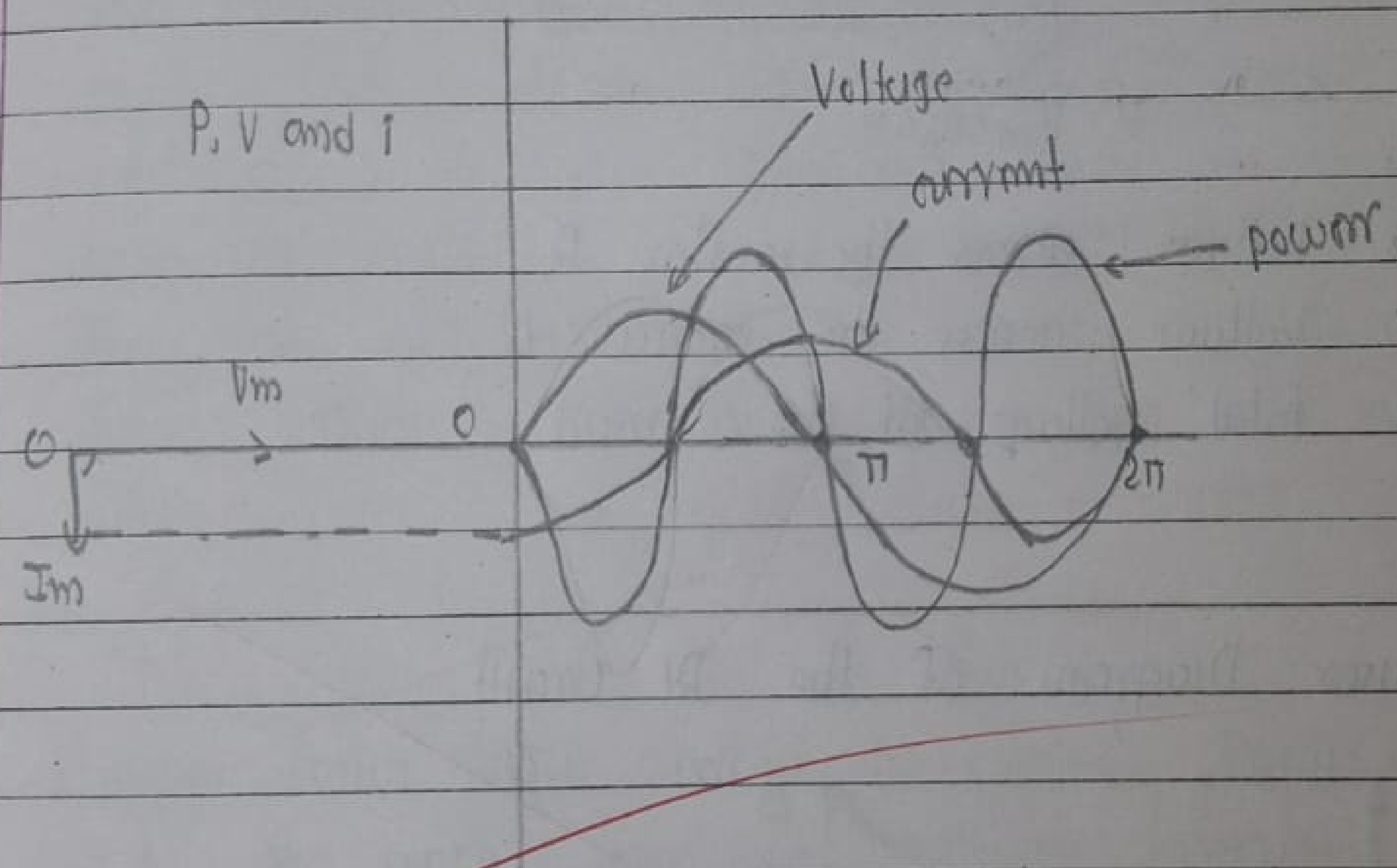
$P = V_m I_m \sin \omega t \cos \omega t$

$P = \frac{V_m I_m}{2}\ 2 \sin \omega t \cos \omega t$

$P = \frac{V_m}{\sqrt{2}} \frac{I_m}{\sqrt{2}} \sin \omega t$

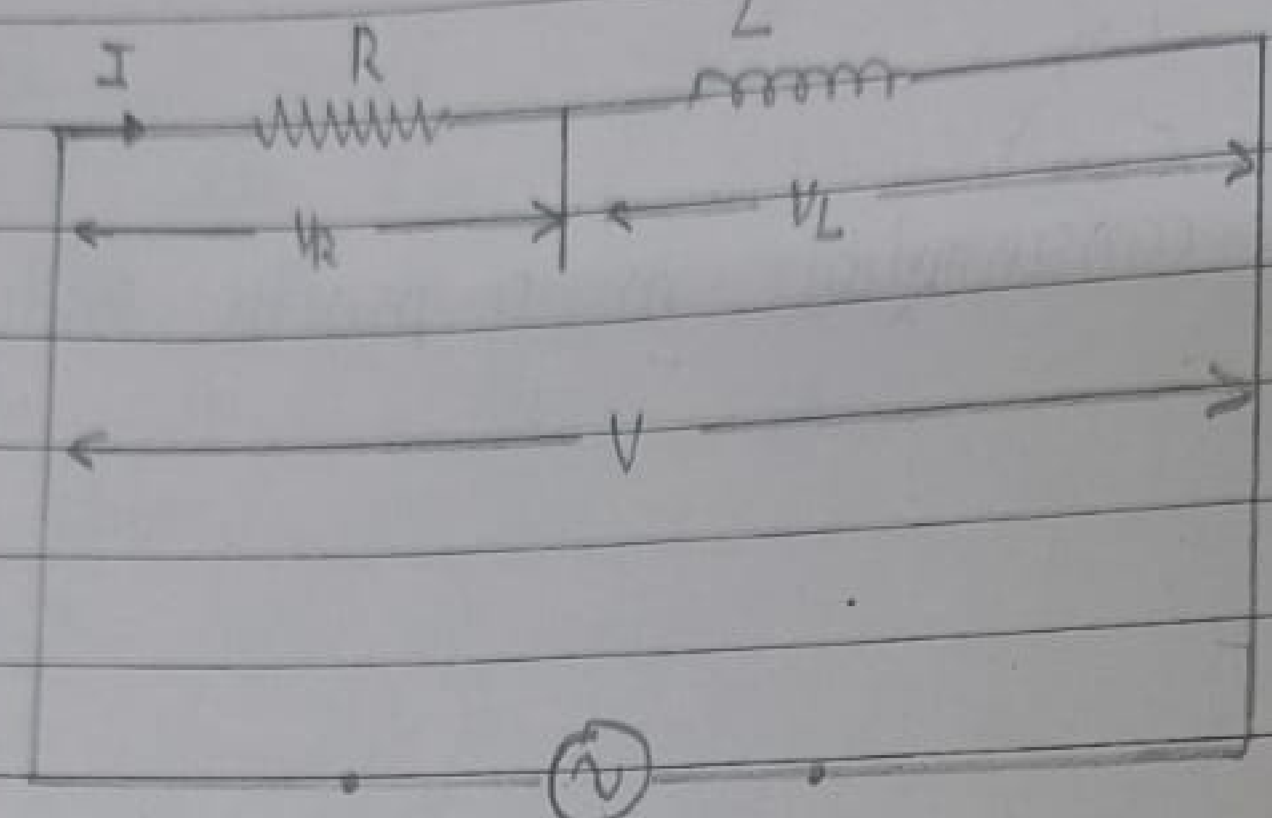
- average power consumption in a purely inductive circuit is zero

Phaser Diagram :



5 Explain series R-L circuit in brief. Draw phasor diagram and the wave forms of voltage, current and instantaneous power.

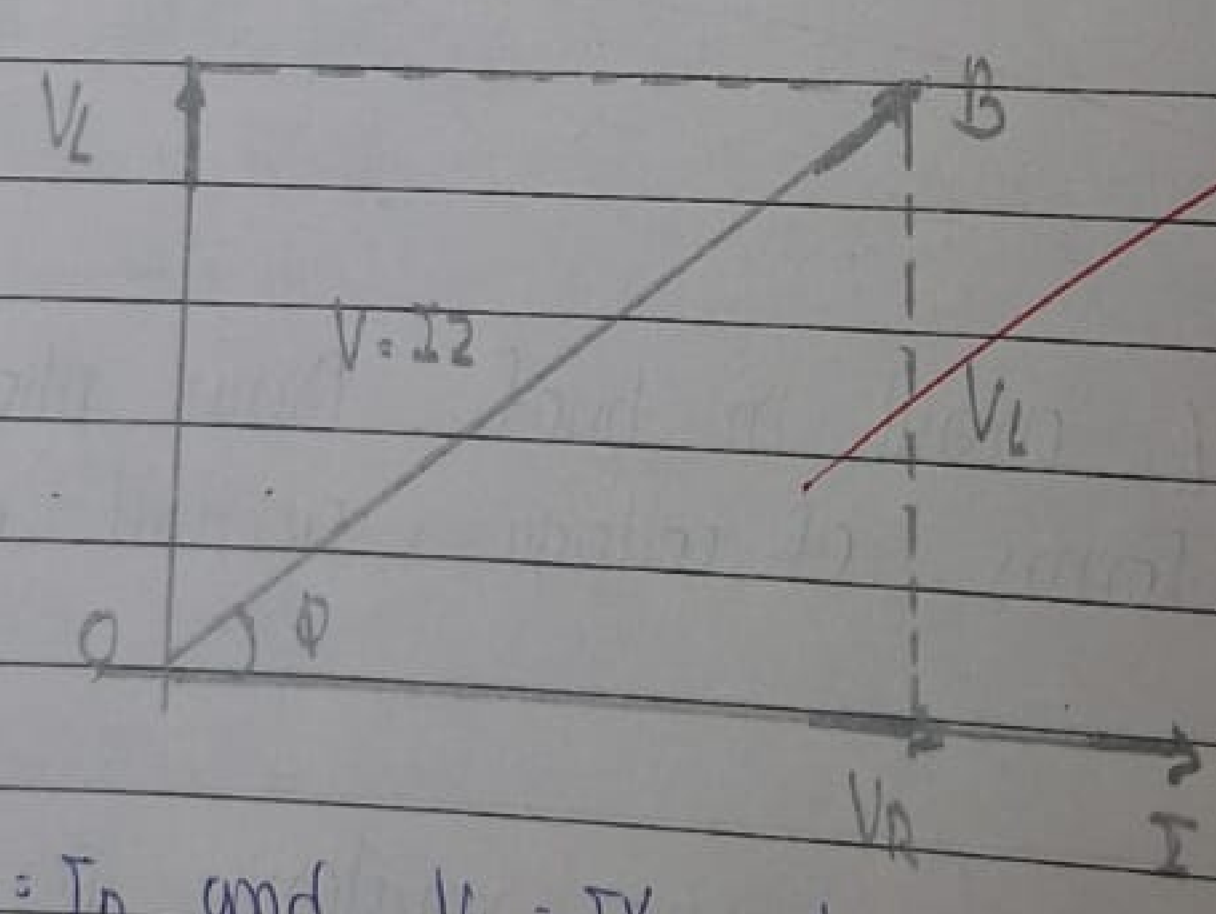
- A circuit that contains a pure resistance R ohm connected in series with a coil having a pure inductance of L (Henry) is known as RL circuit. There is two types of RL circuit first is series RL circuit and parallel RL circuit. When an AC supply voltage V is applied the current I flows in the circuit. So, I_R and I_L will be the current flowing in the resistor and inductor respectively, but the amount of current flowing through both the elements will be same as they are connected is series with each other. The circuit diagram of RL series circuit is shown below.



$V = V_m \sin \omega t$.

$V_R \rightarrow$ Voltage across the resistor R
$V_L \rightarrow$ Voltage across the inductor L
$V \rightarrow$ total voltage of the circuit

- Phasor Diagram of the RL circuit.



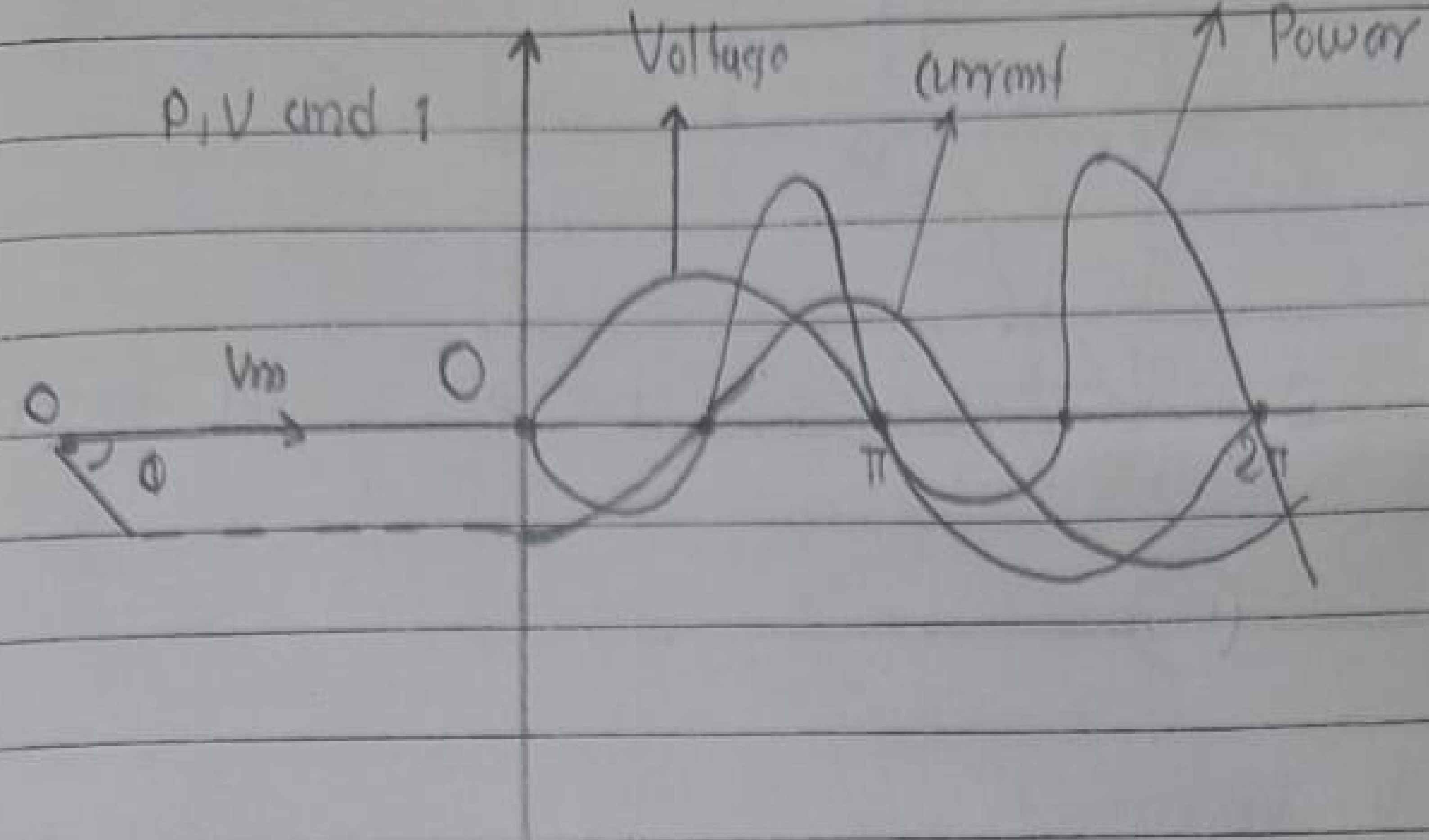
$V_R = I_R$ and $V_L = IX_L$ where $X_L = 2\pi fL$

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

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

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

- The waveform and power curve of the RL series circuit is shown below.

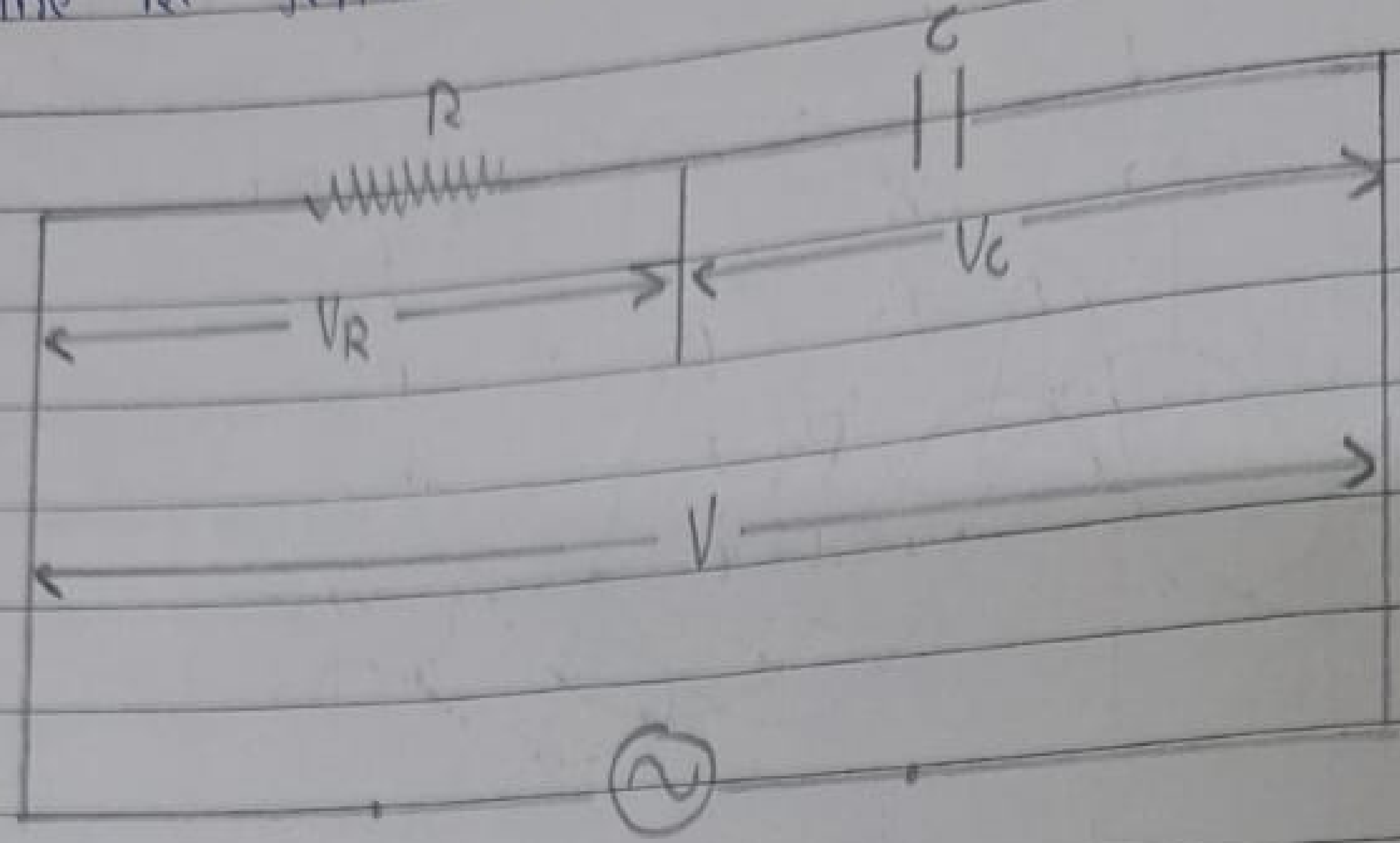


- The various points on the power curve are obtained by the product of voltage and current. If you analysed the curve carefully it is seen that the power is negative between 0 and Φ and between 180 degrees and (180 + Φ) and during the rest of the cycle the power is positive. The current lags the voltage and thus they are not in phase with each other.

6 Explain series R-C circuit in brief. Draw phasor diagram and the wave form of voltage, current and instantaneous power.

- A circuit that contains pure resistance R ohm connected in series with a pure capacitor of capacitance C farads is known as RC series circuit. A sinusoidal voltage is applied and current I flows through the resistance (R) and the capacitance (C) of the circuit. Take the current I as a reference vector. Voltage drop in resistance $V_R = IR$ is takes in phase with the current vector. The vector sum of the two voltage drops is equal to the applied voltage (V)

- The RC series circuit is shown in the figure below.

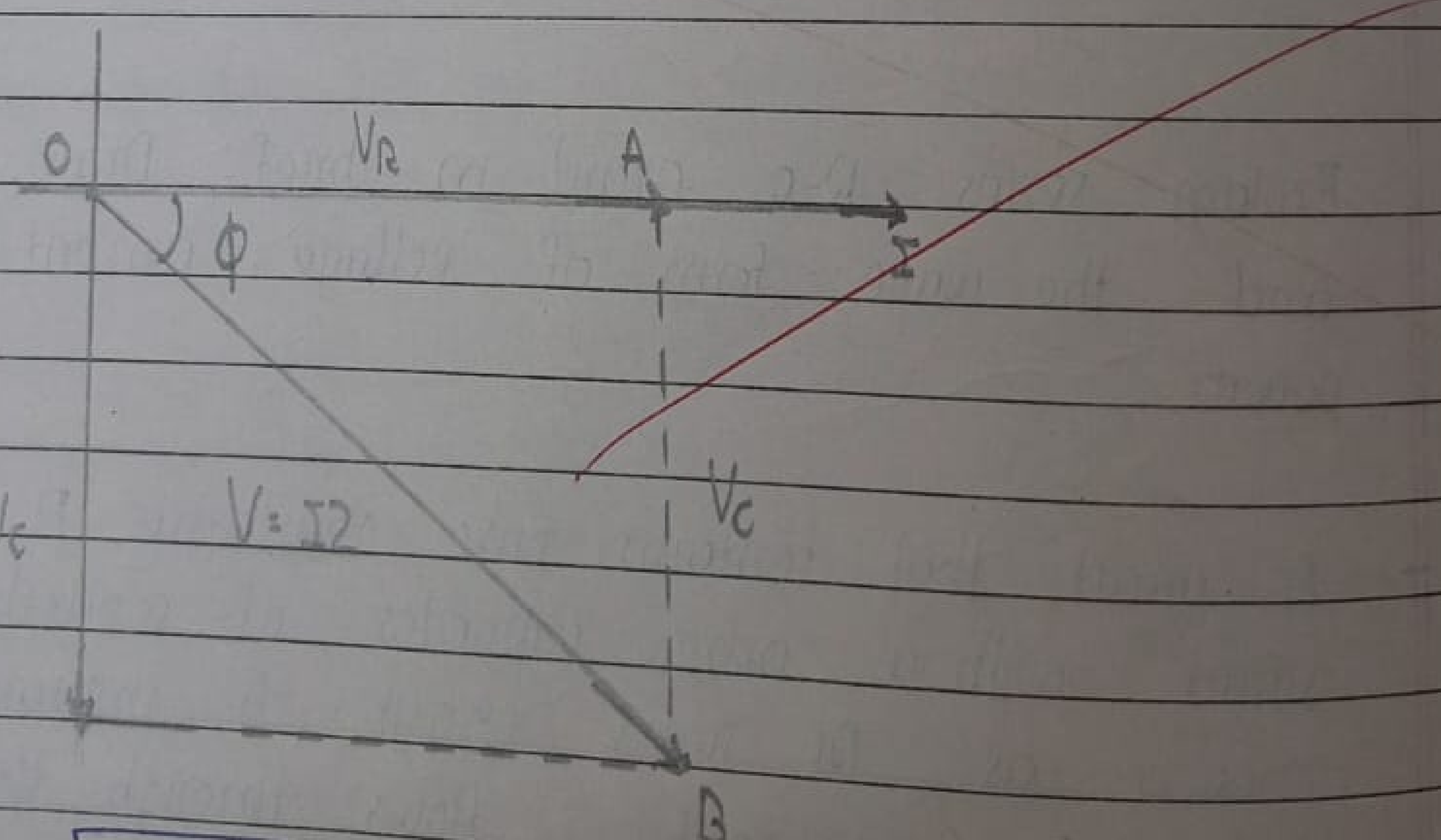


RC series circuit

$V = V_m \sin \omega t$

$V_R \rightarrow$ Voltage across the resistance R
$V_C \rightarrow$ Voltage across capacitor C
$V \rightarrow$ Voltage across the RC series circuit

- Phasor Diagram of RC series circuit.

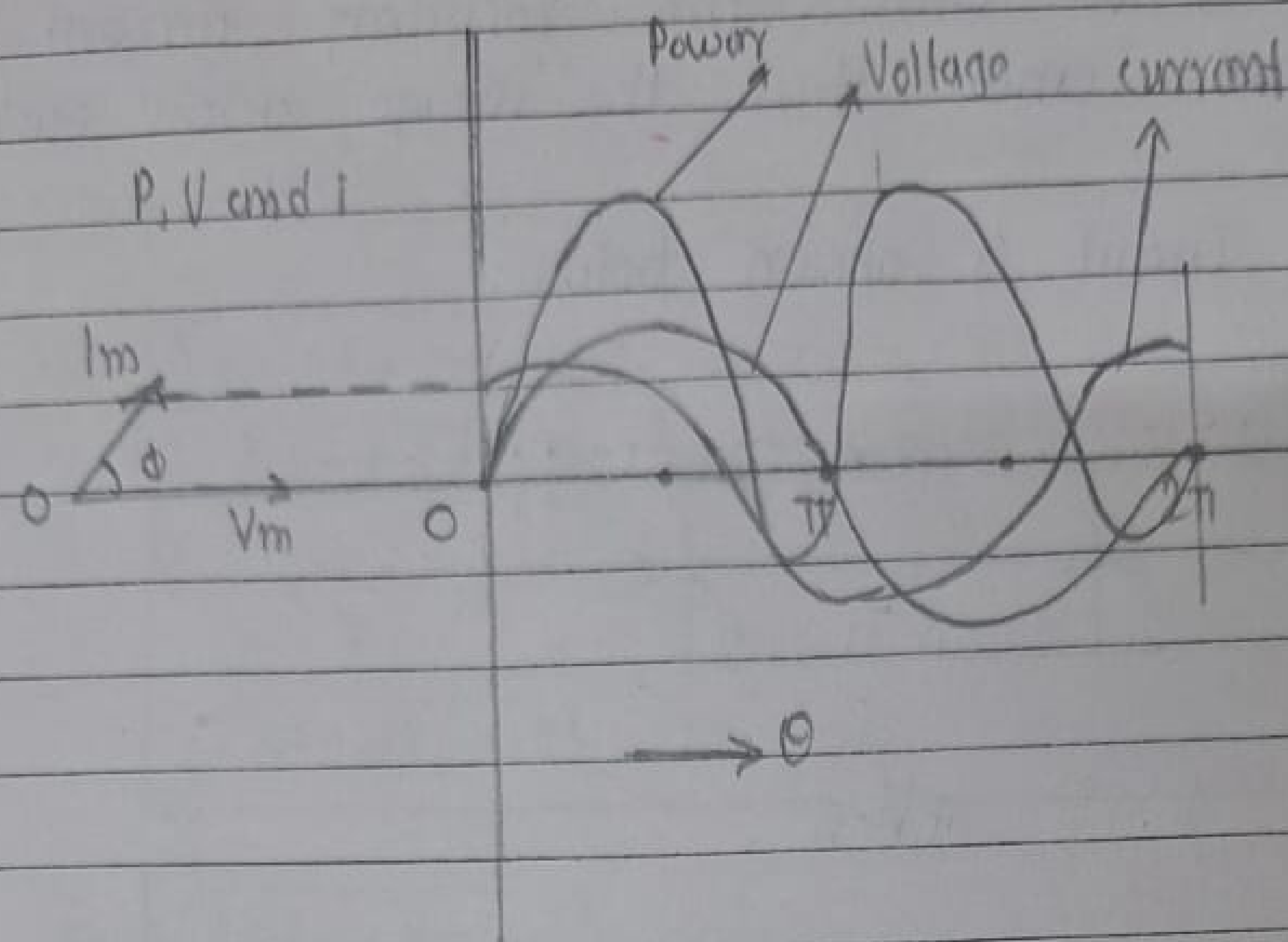


$V = \sqrt{(V_R)^2 + (V_C)^2}$

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

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

- Waveform and Power curve of the RC series circuit.



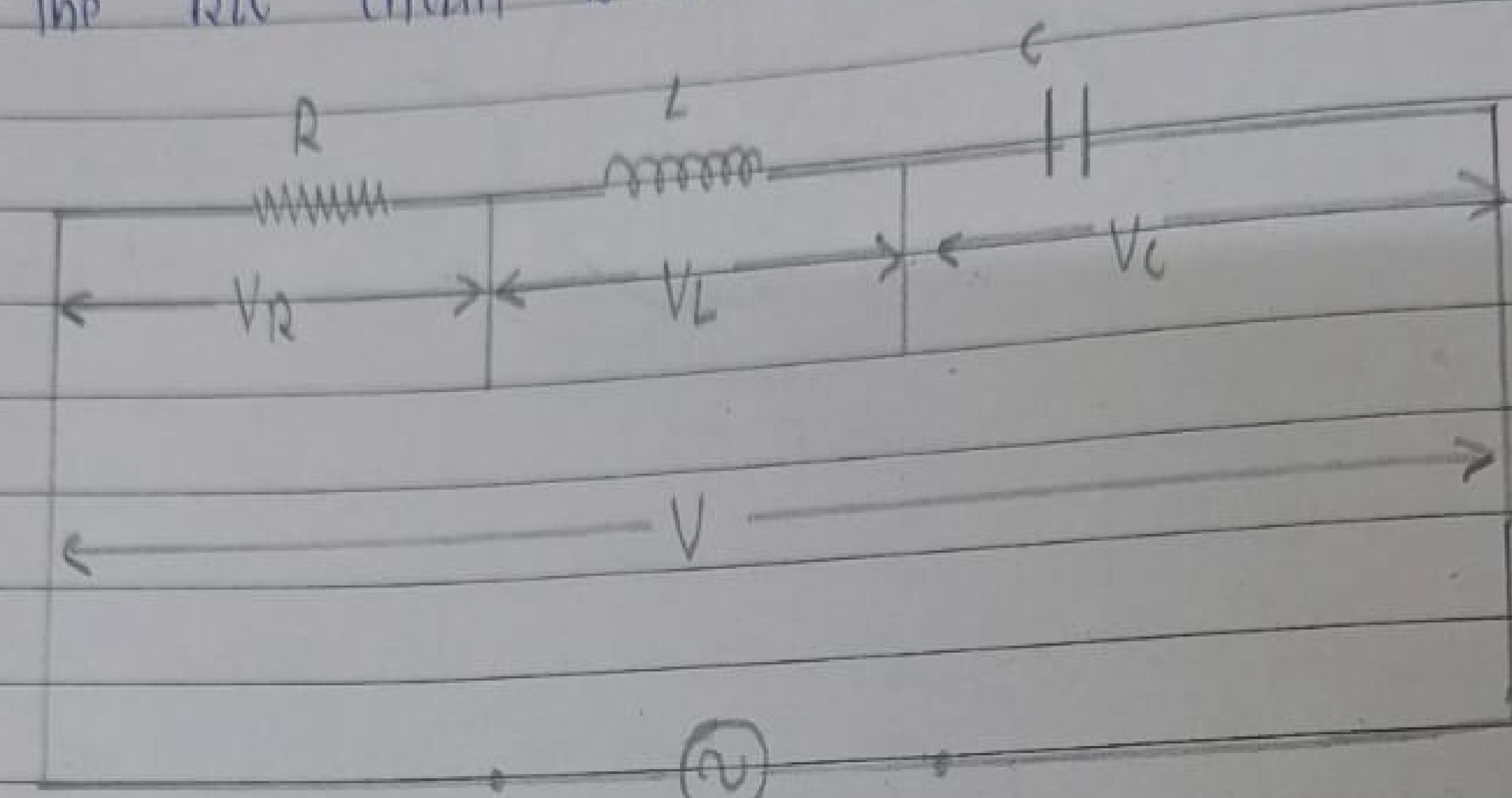
- The power is negative between the angle $(180° - \phi)$ and 180° and between $(360° - \phi)$ and 360° and in the rest of the cycle, the power is positive. since the area under the positive loops is greater than the that under the negative loops, therefore the net power over a complete cycle is positive. The various points on the power curve are obtained from the product of the instaneous value of voltage and current.

7 Discuss Resonance in R-L-C series circuit Explain how power factor, XL and R vary with frequency. Draw relevant vector diagram.

- When a pure resistance of R ohms, a pure inductance of L Henry and a pure capacitance of C farads are connected together in series combination with each other then RLC series circuit is formed. As all the three elements are connected in series so, the current flowing through each element of the circuit will be the same as the total current

Flowing in the circuit. When the AC voltage is applied through the circuit, the resulting current I flows through the RLC series circuit, and thus the voltage across each element will be

- The RLC circuit is shown below:



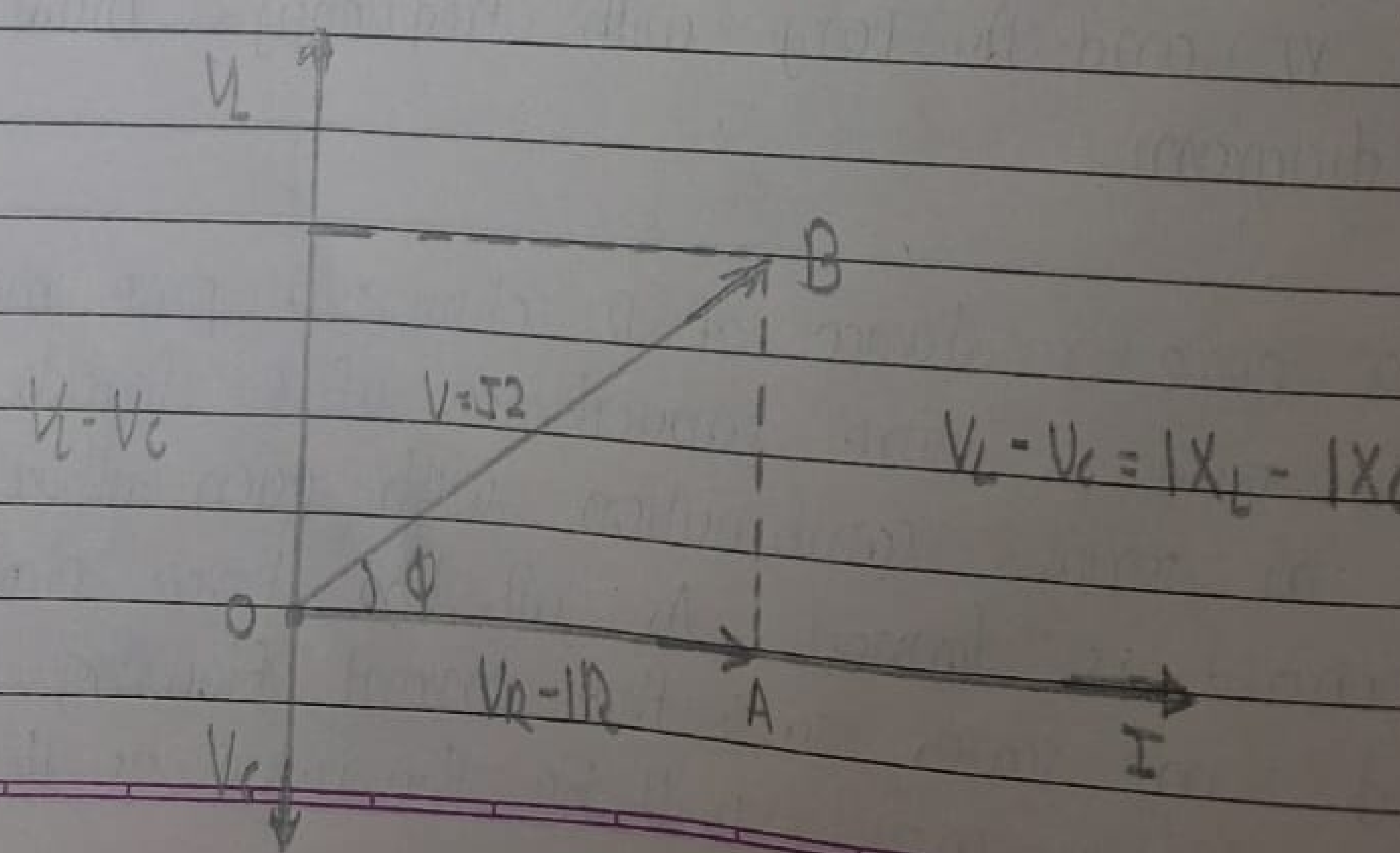
$V = V_m \sin \omega t$

$V_R = IR$ that is the voltage across the resistance R and is in phase with the current I.

$V_L = IX_L$ that is the voltage across the inductance L and it leads the current I by an angle of 90 degrees.

$V_C = IX_C$ that is the voltage across capacitor C and it lags the current I by an angle of 90 degrees.

Phasor Diagram of RLC series circuit.



- The phasor diagram of the RLC series circuit when the circuit is acting as an inductive circuit that mean ($V_L > V_C$) is shown below and if ($V_L < V_C$) the circuit will behave as a capacitive circuit

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

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

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

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

- The product of voltage and current is defined as power.

$$P = VI\cos\phi = I^2 R$$

- Where $\cos\phi$ is the power factor of the circuit and is expressed as

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

- The tree cases of RLC series circuit. when $X_L > X_C$ the phase angle ϕ is positive. The circuit behaves as RL series circuit in which the current lags behind the applied voltage and the power factor is lagging
- When $X_L < X_C$ the ~~pt~~ phase angle ϕ is negative and the circuit acts as a series RC circuit in which the current lead the voltage by 90 degree.
- When $X_L = X_C$ the phase angle ϕ is zero as a result the circuit behaves like a purely resistive circuit. In this type of circuit. the current and voltage are in phase with each other
The value of the power ~~fat~~ factor is unity

8 What is Q - factor of series resonant circuit ? Also explain futures of series resonance.

- Sharpness of an LCR circuit can be measured using the quality factor. The sharpness of an LCR circuit is measured by the quality factor in an LCR circuit. It is a dimensionless quantity. The larger the sharpness of resonance sharper is the Q factor. Resonance occurs in a circuit that is connected in series when the supply frequency causes the voltage across the inductor and capacitor to be equal.

- The Q - factor is the energy stored per unit cycle to the dissipated per cycle. Higher the Q factor means more energy is stored

- Q - factor can be defined as to how quickly the energy of the oscillating system decays. When the system sharpness increases then damping increases and when damping decreasing the sharpness decreases.

$$Q = \frac{V_L}{V_R} = \frac{\omega \times L}{R}$$

- Q is the quality factor. R is the resistance, L is the inductance. V_L is the voltage across the inductor.

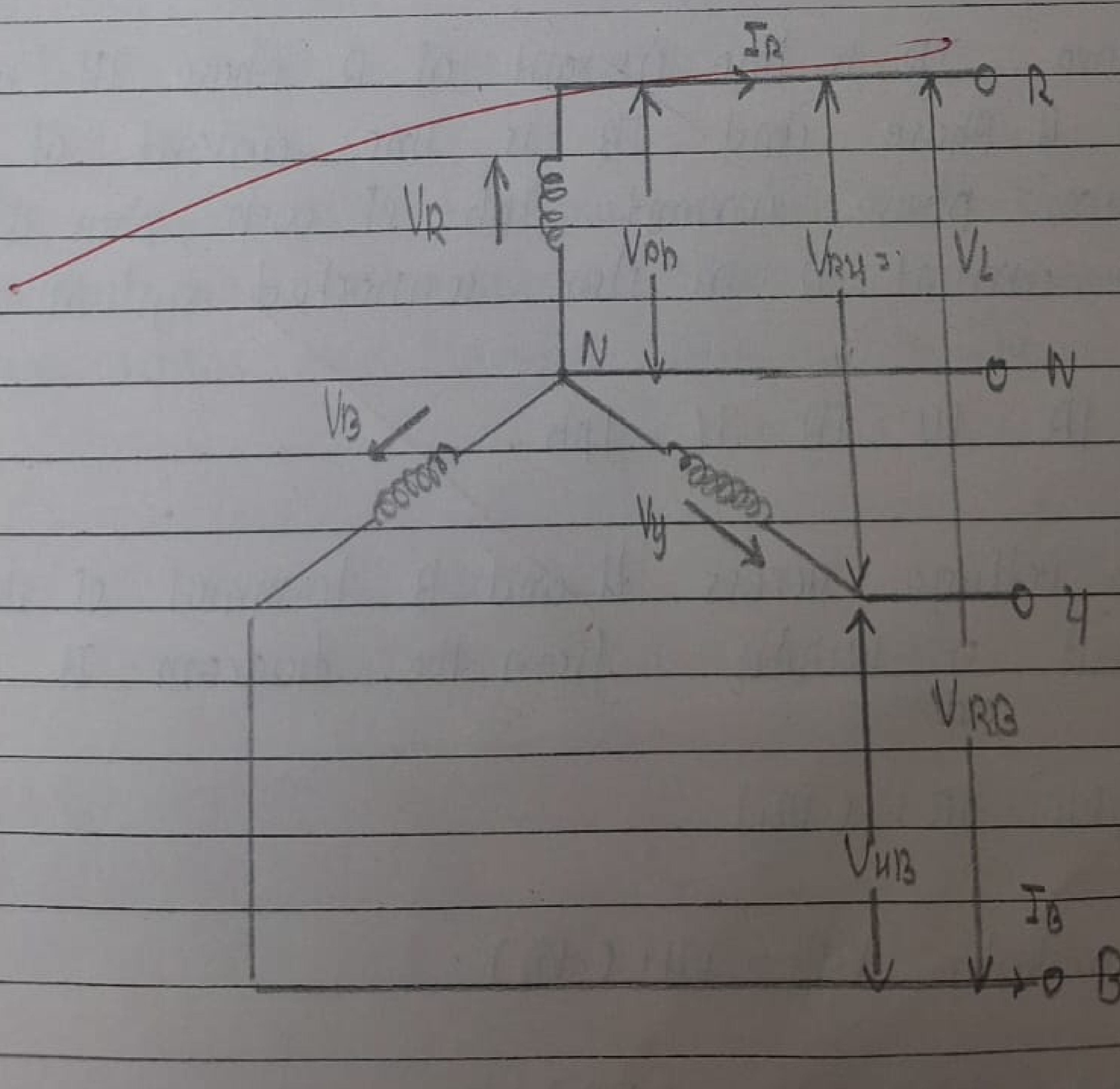
- In a series resonance circuit the inductive impedance of the system and the capacitive reactance of a capacitor bank are in series to a source of harmonic current. Series resonance usually occurs when capacitors are located towards the end of a feeder branch.

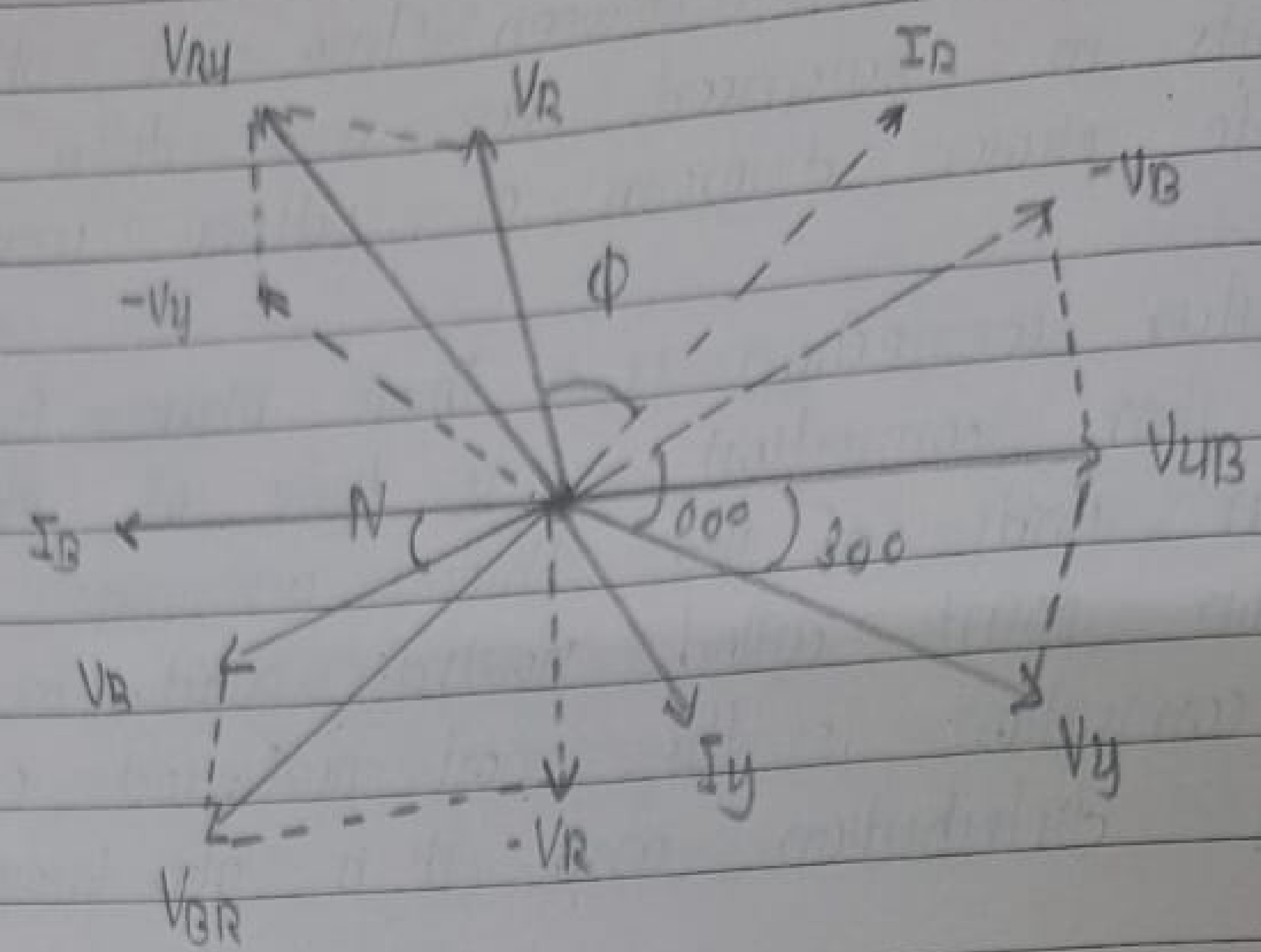
9 Establish relationship between line and phase voltage and currents in balanced star and delta connection. Draw complete phasor diagram of voltage and current.

- The star connection is a Three phase four wire system. The star connection is a type of electrical circuit where similar ends of the three windings are connected to a common point called neutral point or the star point. The star connection is the most preferred circuit system for AC power distribution and it is also know as the Y-system.

- Line voltage: The potential difference or the voltage between two line of the circuit Here the line voltage are there.

- Phase voltage: The potential difference or the voltage btw a line and the neutral point, from the circuit diagram the phase voltage are there.





- We know in the star connection, line current is same as phase current. The magnitude of this current is same in all three phase and say it is IL.

$\therefore$ IR = IY = IB = IL,

- Where, IR is line current of R phase, IY is line current of Y phase and IB is line current of B phase. Again phase current, Iph of each phase is same as line current IL in star connected system.

$\therefore$ IR = IY = IB = IL = Iph.

- The voltage across Y and B terminal of star connection circuit is VYBBR from the diagram It is found that

VRY = VR + (-VY)

Similarly VYB = VY + (-VB)

and VBR = VB + (-VR)

- Now an angle between V_R and V_Y is $120°$ (electrical) the angle between V_R and $-V_Y$ is $180° - 120° = 60°$ (electrical)

$$V_L = |V_{RY}| = \sqrt{V_R^2 + V_Y^2 + 2V_R V_Y \cos 60°}$$

$$= \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph} V_{ph} \times 1/2}$$

$$= \sqrt{3}\, V_{ph}$$

$$\therefore V_L = \sqrt{3}\, V_{ph}$$

- Thus for the star-connected system line voltage = $\sqrt{3}$ x phase-voltage and line current = phase current

- line voltage = $\sqrt{3}$ x phase voltag.

- line current = phase current.

- This is the relation between line and phase voltage along with an explanation. Understand the meaning of these two terms and relate them as mentioned in this article