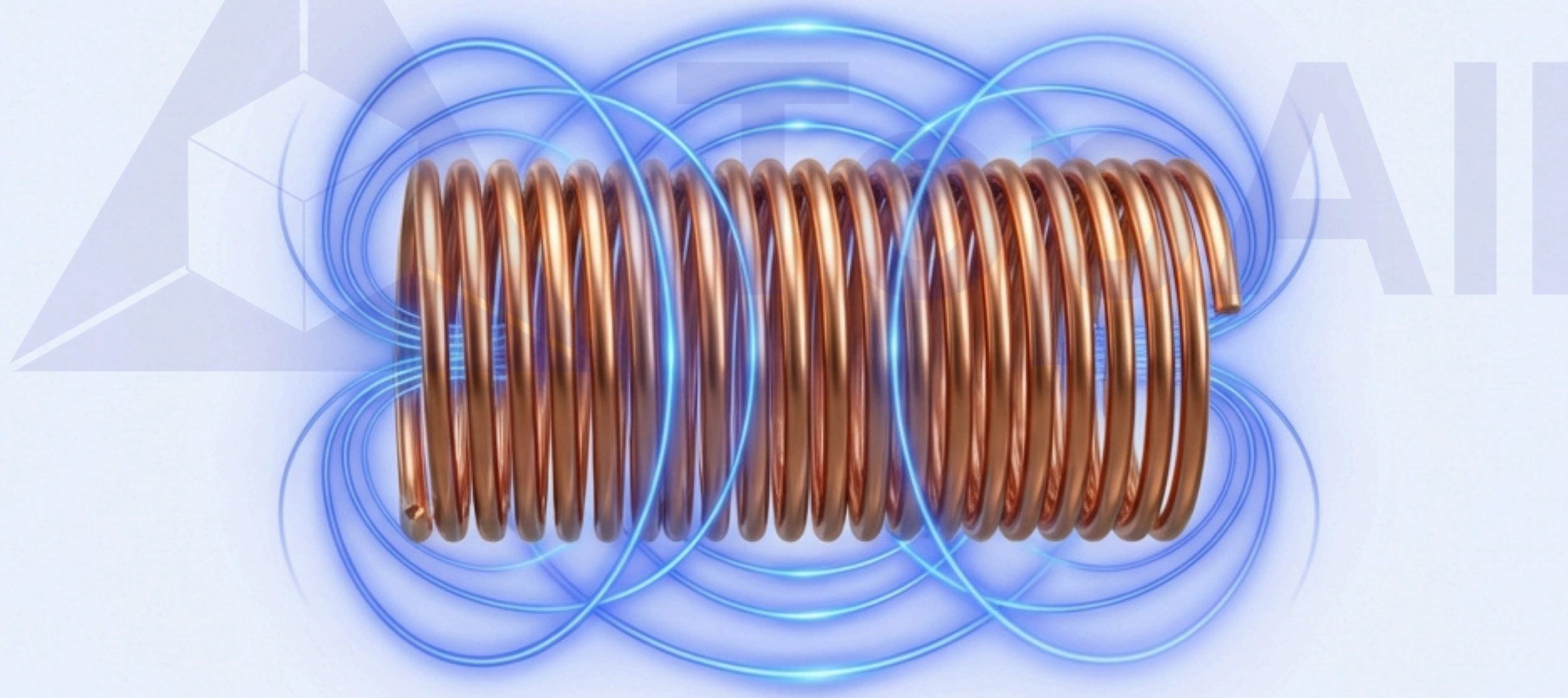
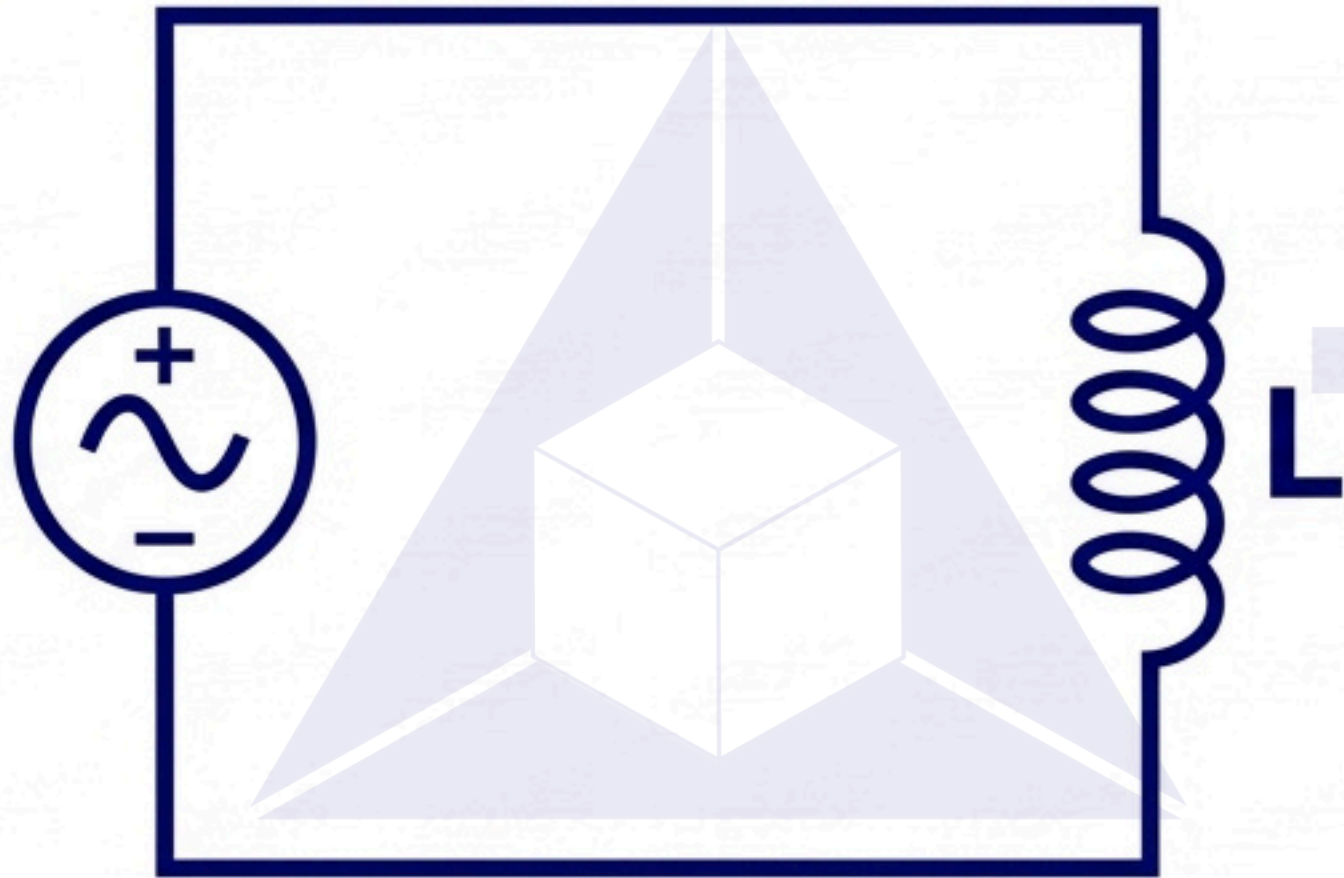


AC Voltage Applied to a Pure Inductor

Understanding phase shift, inductive reactance, and phasor diagrams for NEET & JEE.





Connecting an AC Source to an Inductor

Consider a purely inductive circuit where the inductor has negligible resistance. By Kirchhoff's loop rule ($\sum \varepsilon(t) = 0$), the source voltage must equal the self-induced Faraday emf.

AC Voltage Source: $v = v_m \sin(\omega t)$

$$v - L \frac{di}{dt} = 0$$

$L (di/dt)$ represents the self-induced emf opposing the voltage.

Deriving the Current $i(t)$

Rearrange:

$$\frac{di}{dt} = \frac{v_m}{L} \sin(\omega t)$$



Integrate:

$$\int di = \int \frac{v_m}{L} \sin(\omega t) dt \rightarrow i = -\frac{v_m}{\omega L} \cos(\omega t)$$



Apply Trig Identity:

Using $-\cos(\omega t) = \sin(\omega t - \pi/2)$

$$i = i_m \sin(\omega t - \pi/2)$$



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$$E=mc^2$$



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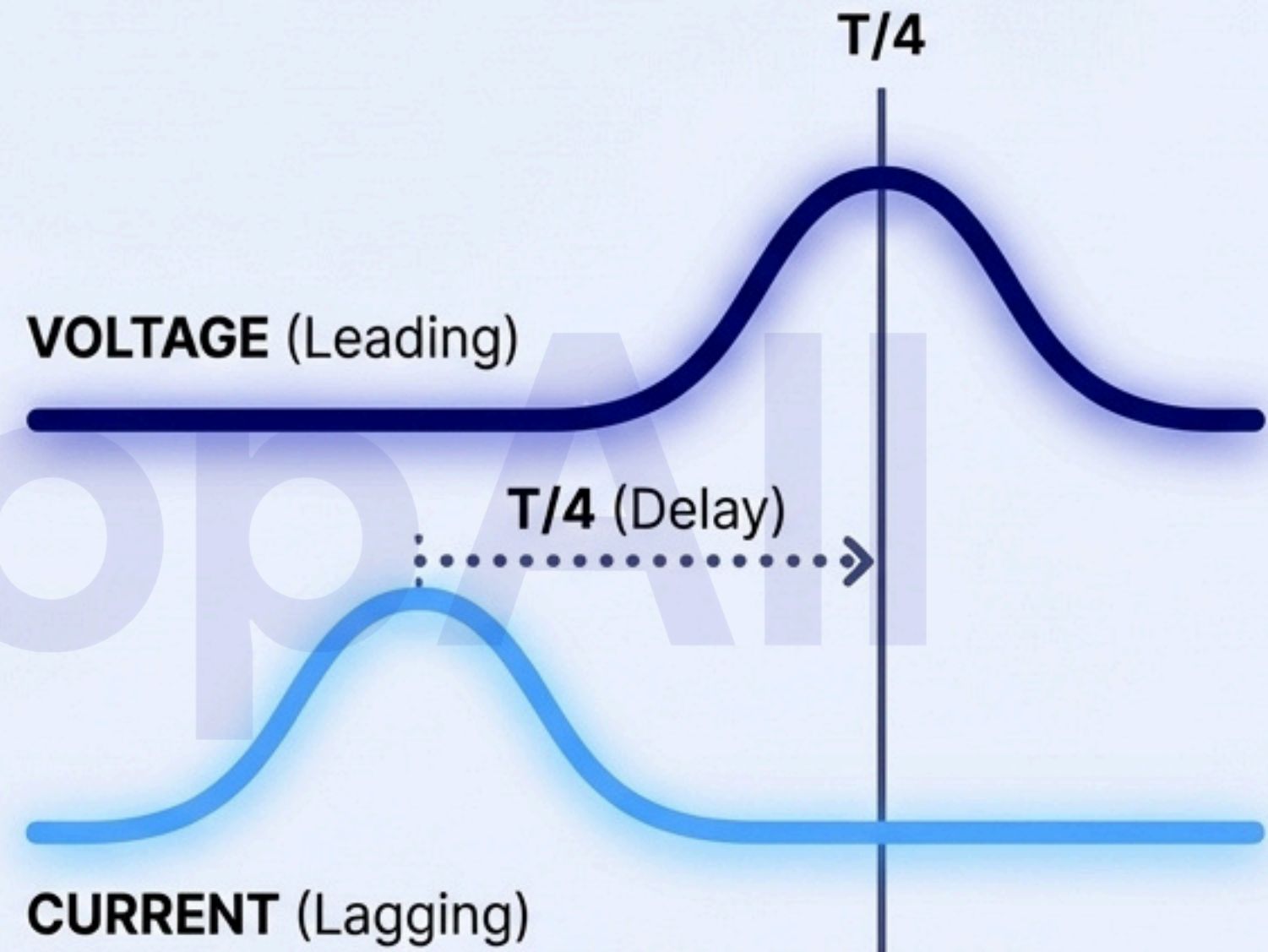
The Electrical Inertia Effect

Voltage: $v = v_m \sin(\omega t)$

Current: $i = i_m \sin(\omega t - \pi/2)$

- Current reaches its maximum value exactly one-quarter period ($T/4$) later than voltage.
- The inductor opposes the change in current, acting like electrical inertia and delaying the flow.

EXAM FACT: Phase difference $\phi = -\pi/2$ (or -90°)

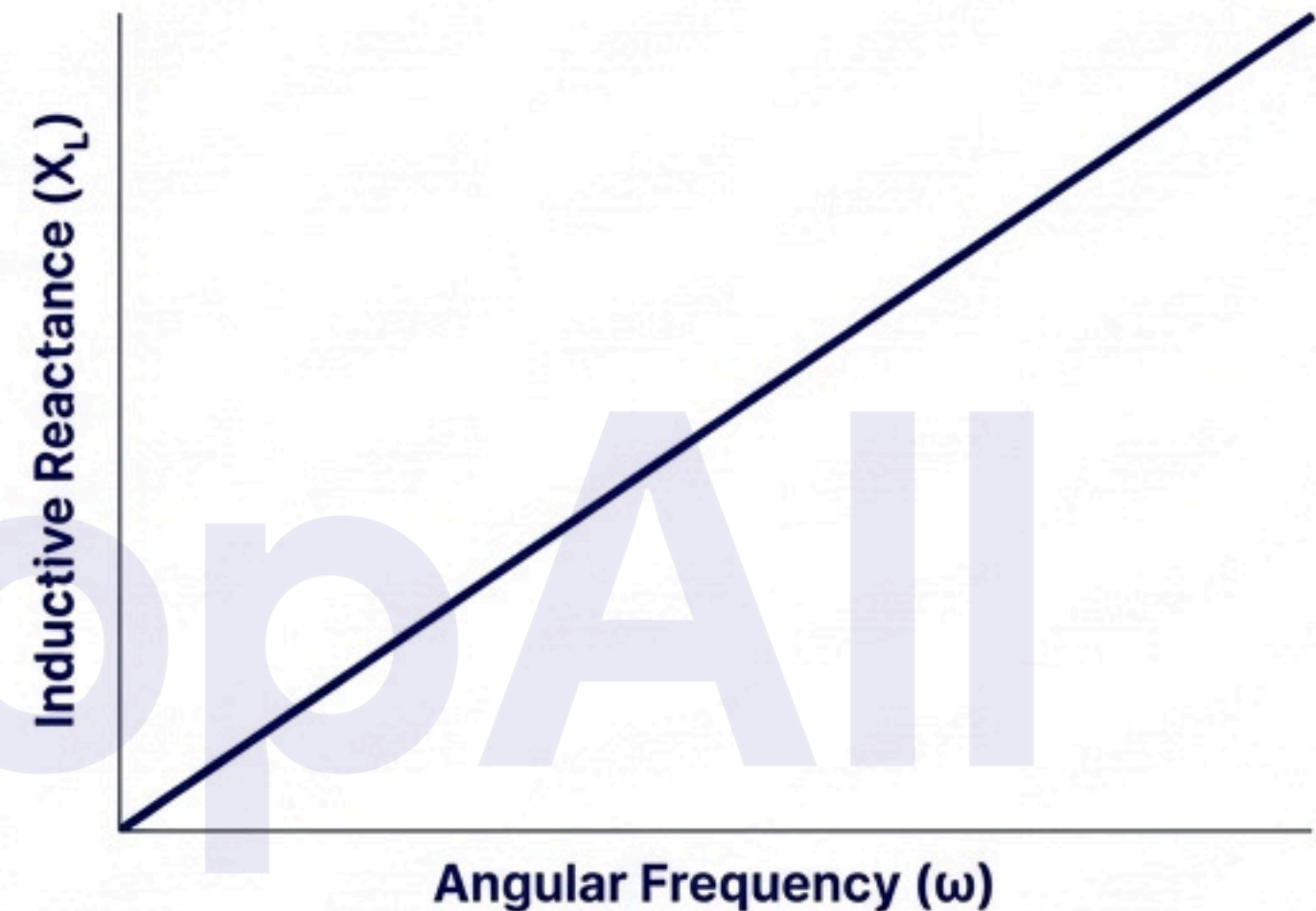


How an Inductor Limits Current

Just as resistance limits current in a DC circuit, inductive reactance limits current amplitude in an AC circuit.

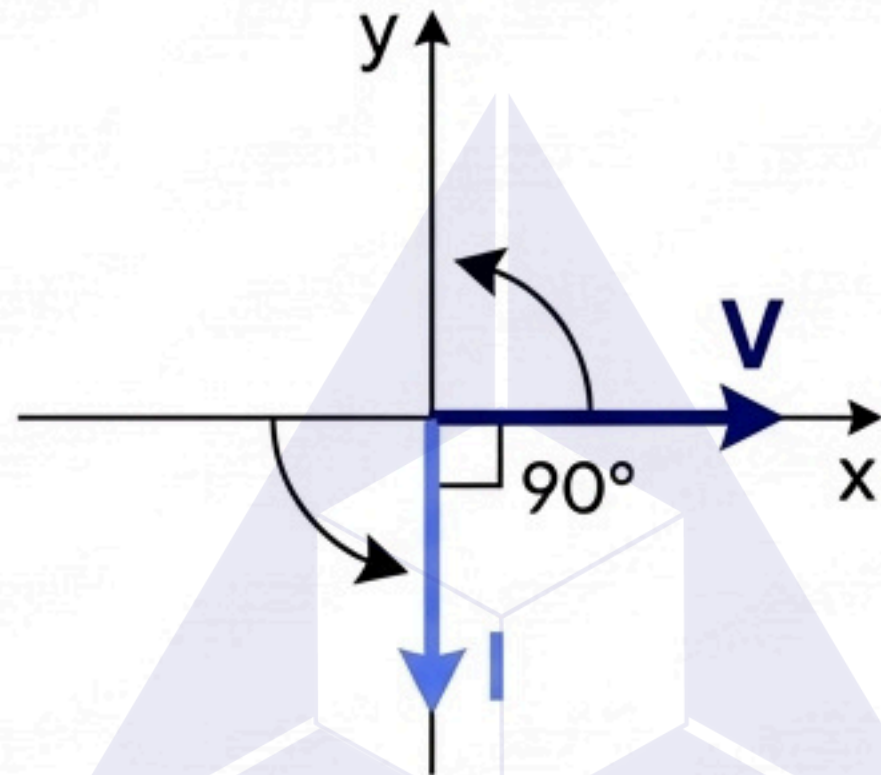
$$X_L = \omega L$$

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

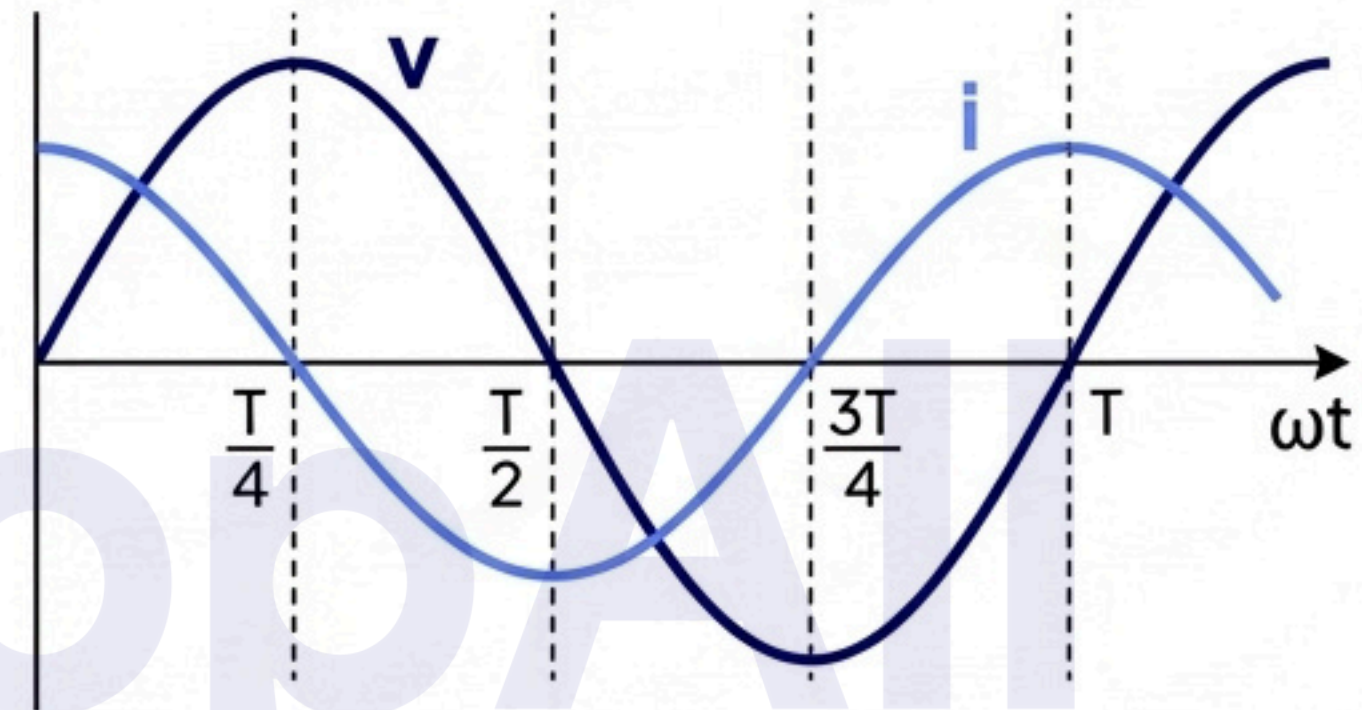


- SI Unit: Ohm (Ω)
- Reactance is directly proportional to inductance (L) and frequency (ω).

Phasor & Waveform Representations



Phasor Diagram: Current I is 90° behind voltage V .



Waveform Graph: The i curve crosses zero $1/4$ cycle after the v curve.

POWER PHENOMENON: Because of this exact $\pi/2$ phase shift, the average power supplied over a complete cycle is ZERO ($P_{avg} = 0$).

Chapter 7.4 Summary & Key Takeaways

Current Lags Voltage:

By exactly $\pi/2$ (90°).

$$i = i_m \sin(\omega t - \pi/2).$$

Inductive Reactance (X_L):

Limits current. Measured in Ohms (Ω).

$$X_L = \omega L.$$

Ohm's Law Analogy:

Peak current is defined by the reactance.

$$i_m = v_m / X_L.$$

Wattless Component:

Average power over a complete cycle is exactly zero.

$$P_{\text{avg}} = 0.$$



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