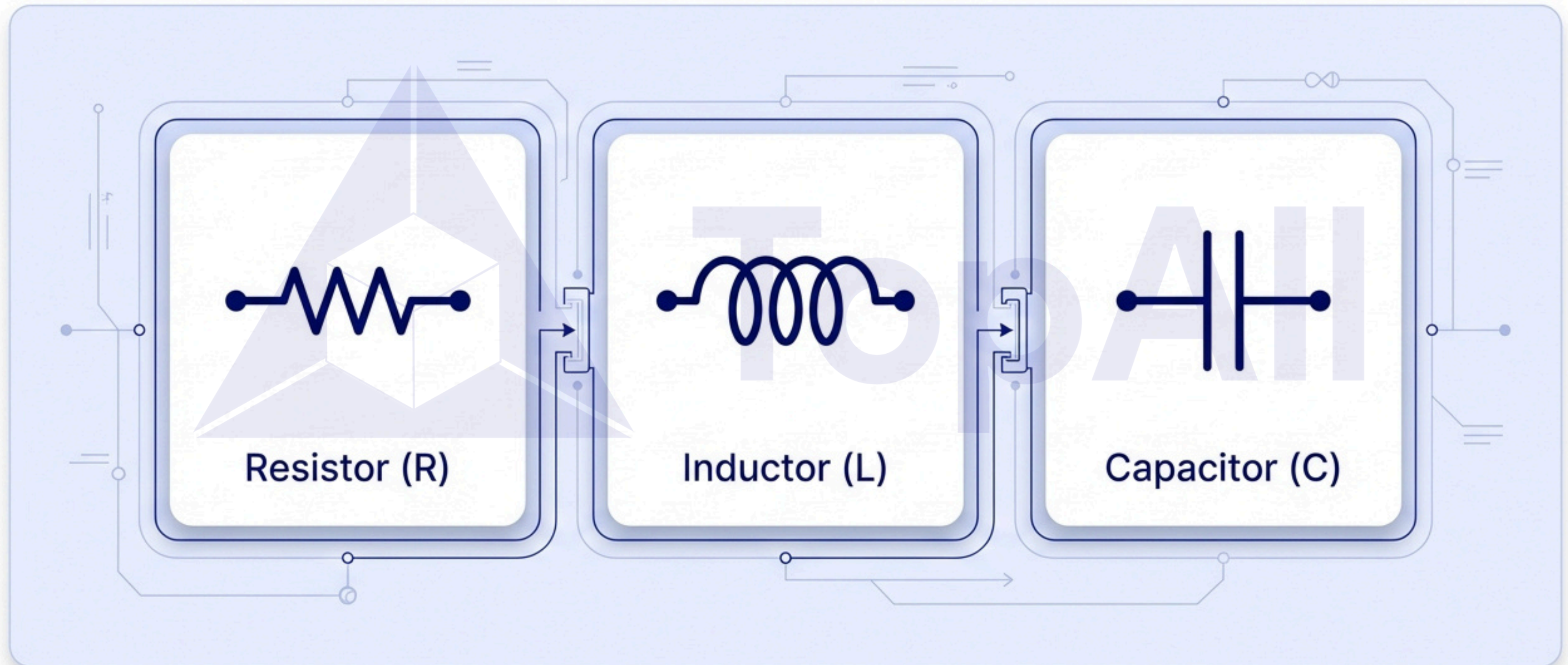
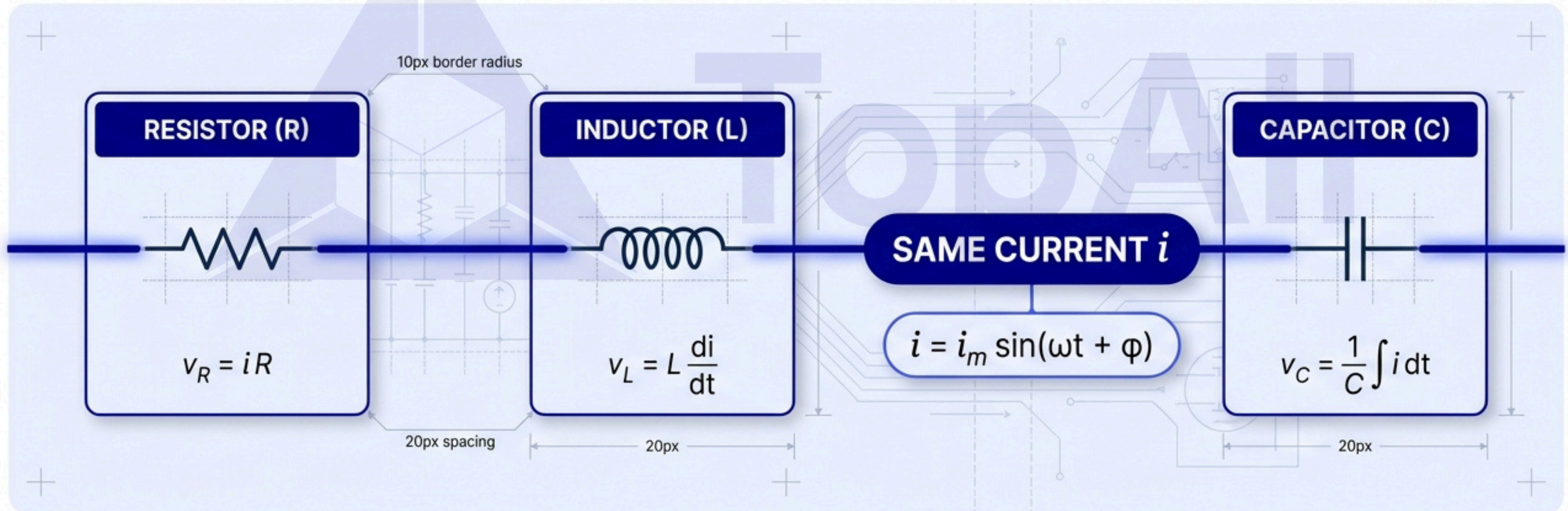


7.6 AC Voltage Applied to a Series LCR Circuit



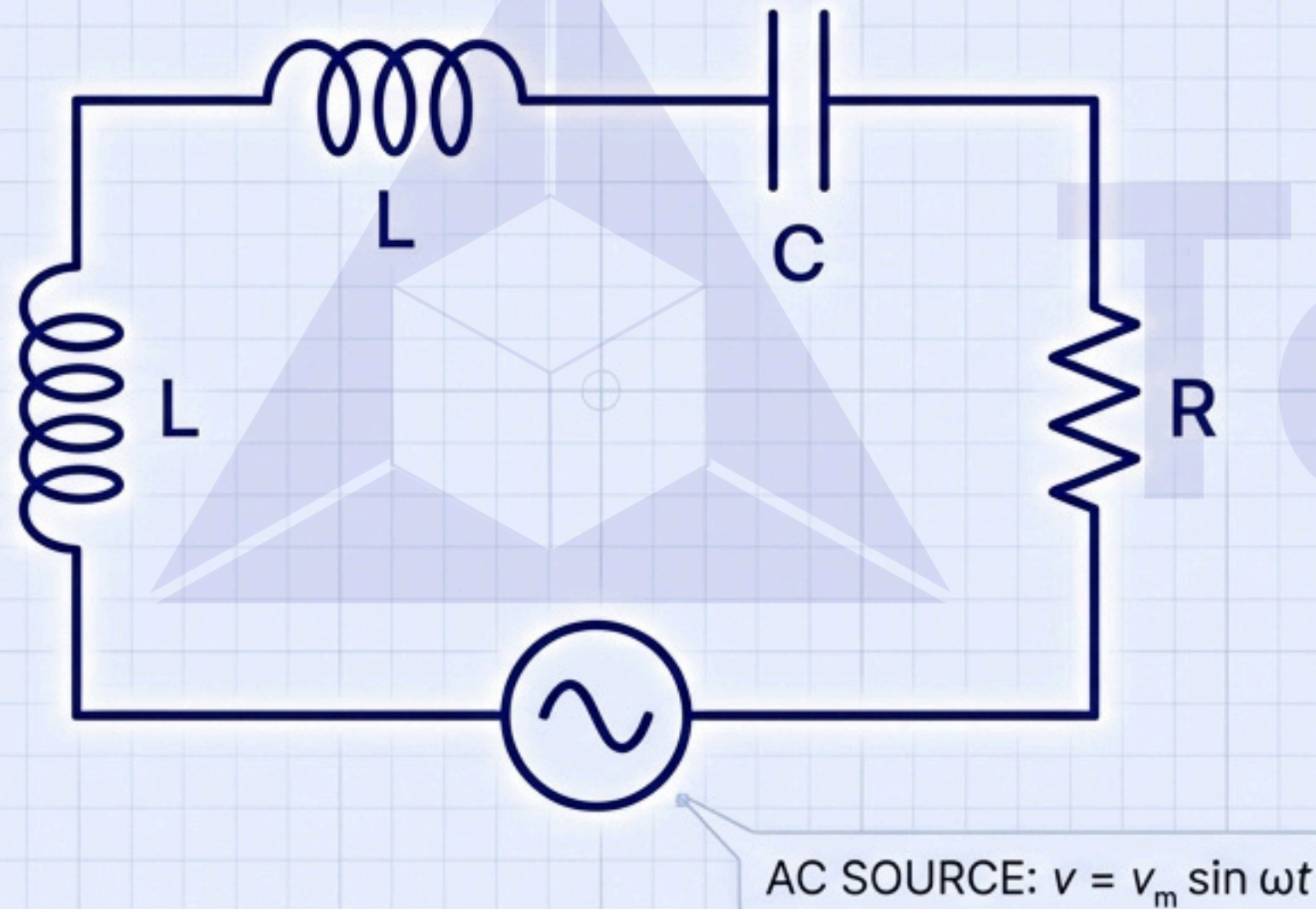
The Universal Rule of the Series Circuit

- Because the components are connected in series, the exact same alternating current flows through each element at any given instant.
- They share the same amplitude (i_m) and the same phase.



H1: The System Schematic

FIGURE 7.10 CIRCUIT OVERVIEW



- A sinusoidal voltage source v is applied to the entire loop.
- v_m = amplitude of oscillating potential difference
- ω = angular frequency



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$$E=mc^2$$



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The Governing Law: Kirchhoff's Loop Equation

EXAM TIP:
Memorize this as
the starting point
for all series
LCR analytical
derivations.

$$L \frac{di}{dt} + iR + \frac{q}{C} = v$$

- By Kirchhoff's loop rule, the sum of the potential differences across all components equals the applied source voltage v .
- This equation holds true at every single instant in time t .

Deconstructing the Equation

$$L\left(\frac{di}{dt}\right) + iR + \frac{q}{C} = v$$



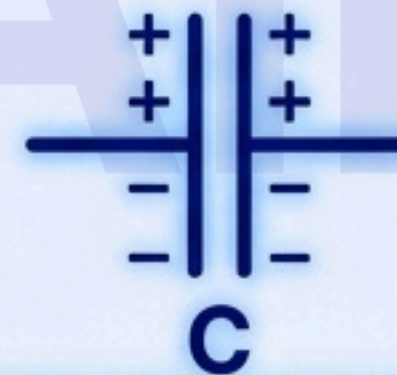
v_L (Induced EMF)

Opposes the change
in current.



v_R (Voltage Drop)

In phase with the
current.

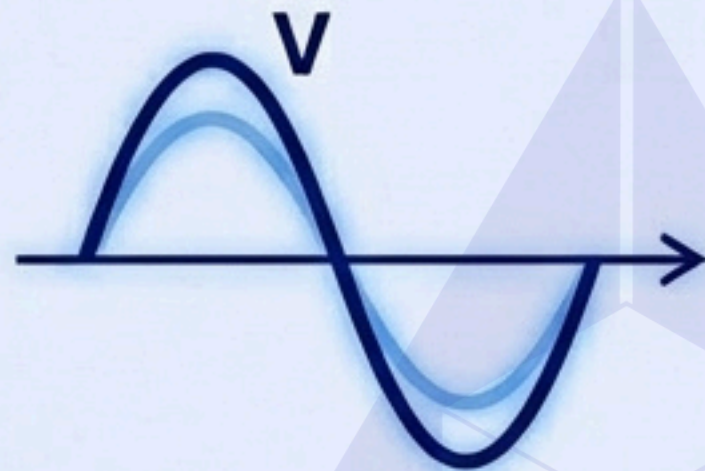


v_C (Capacitor Voltage)

Depends on
accumulated charge q .

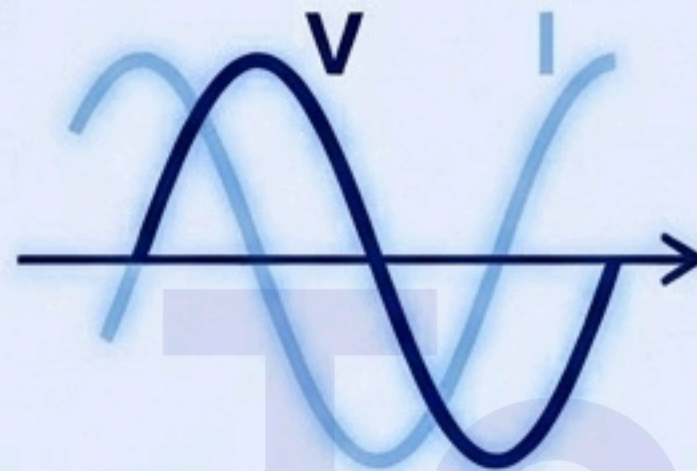
The Phase Dilemma: Why Simple Addition Fails

Resistor



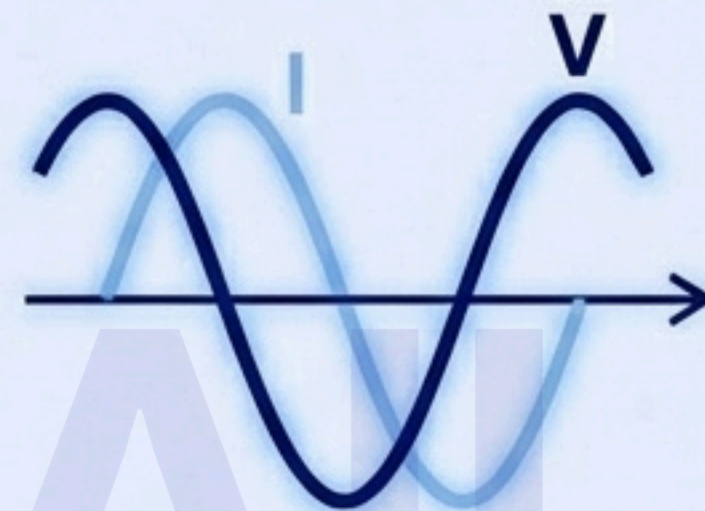
Voltage & Current
are IN PHASE.

Inductor



Voltage LEADS
Current by $\pi/2$.

Capacitor



Voltage LAGS
Current by $\pi/2$.

ALGEBRAIC ADDITION FAILS

Because these maximum voltages occur at different times, we cannot simply add their peak values together ($v_m \neq v_{Rm} + v_{Lm} + v_{Cm}$). We need a new mathematical tool.

Mission Objective & The Path Forward

KEY TAKEAWAYS

- **Series constraint:** Current (i) is identical everywhere.
- **Governing law:** Kirchhoff's loop rule ($L(di/dt) + iR + q/C = v$).
- **The challenge:** Voltages are out of phase and cannot be added algebraically.

THE OBJECTIVE

Goal: Determine the instantaneous current i and its phase relationship (ϕ) to the applied voltage v .

Method 1: Phasor
Diagram Solution
(Geometric)

Method 2:
Analytical Solution
(Algebraic)

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