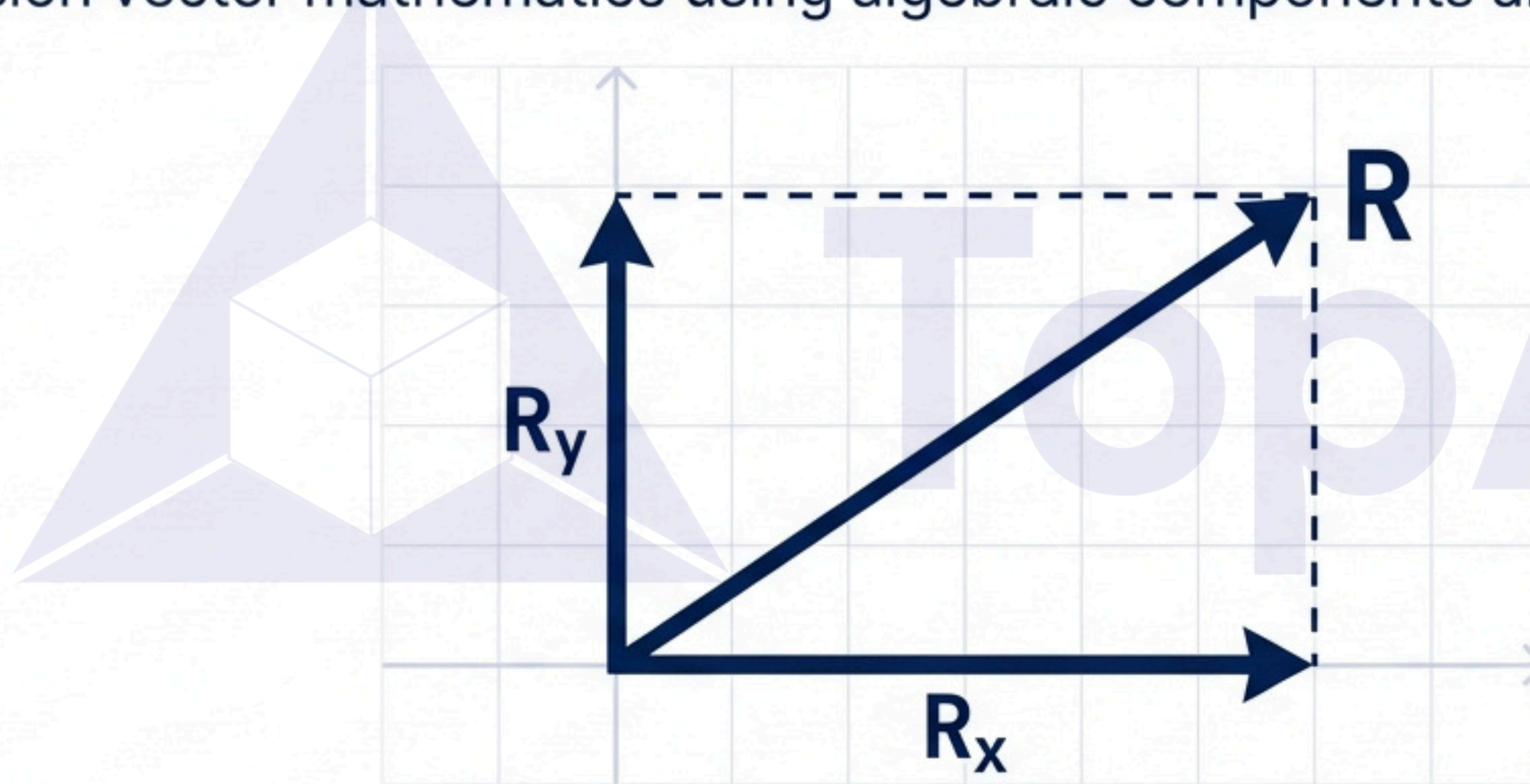


Vector Addition — Analytical Method

High-precision vector mathematics using algebraic components and trigonometric laws.



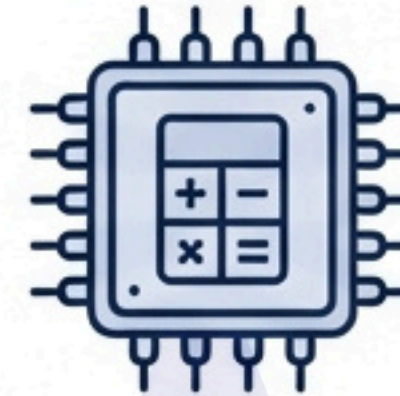
$$\mathbf{R} = R_x \hat{\mathbf{i}} + R_y \hat{\mathbf{j}}$$

Escaping the Limits of the Graphical Method



Graphical Method

- **Execution:** Tedious head-to-tail drawing.
- **Precision:** Limited by human measuring accuracy and instrument quality.
- **Scalability:** Highly complex when moving to 3D space.

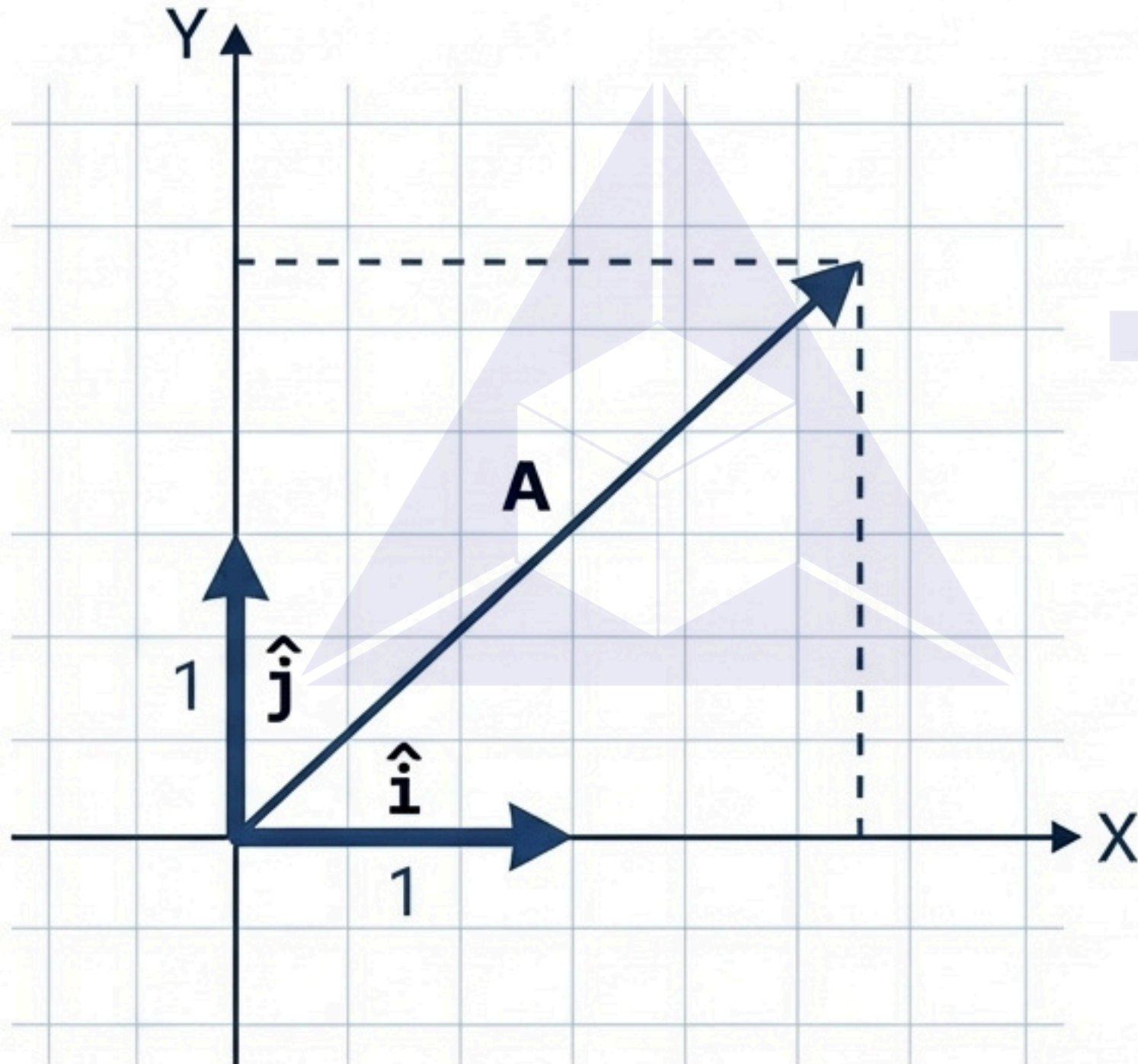


Analytical Method

- **Execution:** Pure algebraic combination of components.
- **Precision:** Absolute mathematical precision.
- **Scalability:** Easily scales to infinite vectors in 2D or 3D coordinate systems.

KEY TAKEAWAY: The analytical method translates geometry into algebra, replacing drawing tools with exact computational formulas.

The Language of Vectors: Unit Vectors



Unit Vectors ($\hat{i}$ and $\hat{j}$)

Magnitude of exactly 1. Used solely to specify direction along the Cartesian axes.

Resolution

Any vector can be resolved into a sum of vectors lying on these axes.

$$\mathbf{A} = A_x \hat{i} + A_y \hat{j}$$

$$\mathbf{B} = B_x \hat{i} + B_y \hat{j}$$

Where A_x and A_y are real numbers representing the scalar magnitude of each component.



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$$E=mc^2$$



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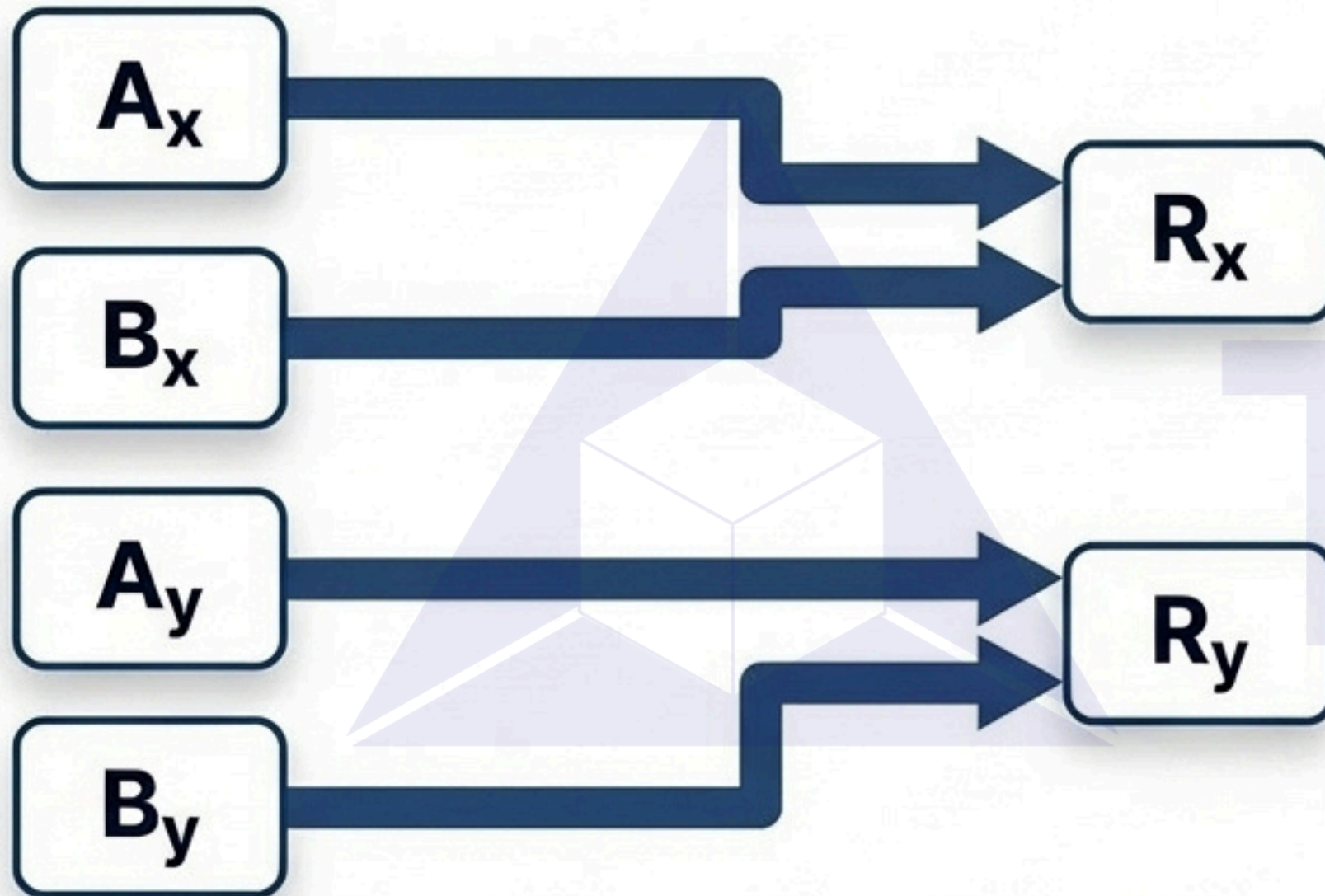
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- » Climb the Leaderboard Among Fellow Aspirants
- » Practice Unlimited MCQs for NEET & JEE
- » Get Clear Explanations, Not Just Marks
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Algebraic Summation of Vectors



Step 1:

$$\mathbf{R} = \mathbf{A} + \mathbf{B}$$

Step 2:

$$\mathbf{R} = (A_x \hat{\mathbf{i}} + A_y \hat{\mathbf{j}}) + (B_x \hat{\mathbf{i}} + B_y \hat{\mathbf{j}})$$

Step 3:

$$\mathbf{R} = (A_x + B_x) \hat{\mathbf{i}} + (A_y + B_y) \hat{\mathbf{j}}$$

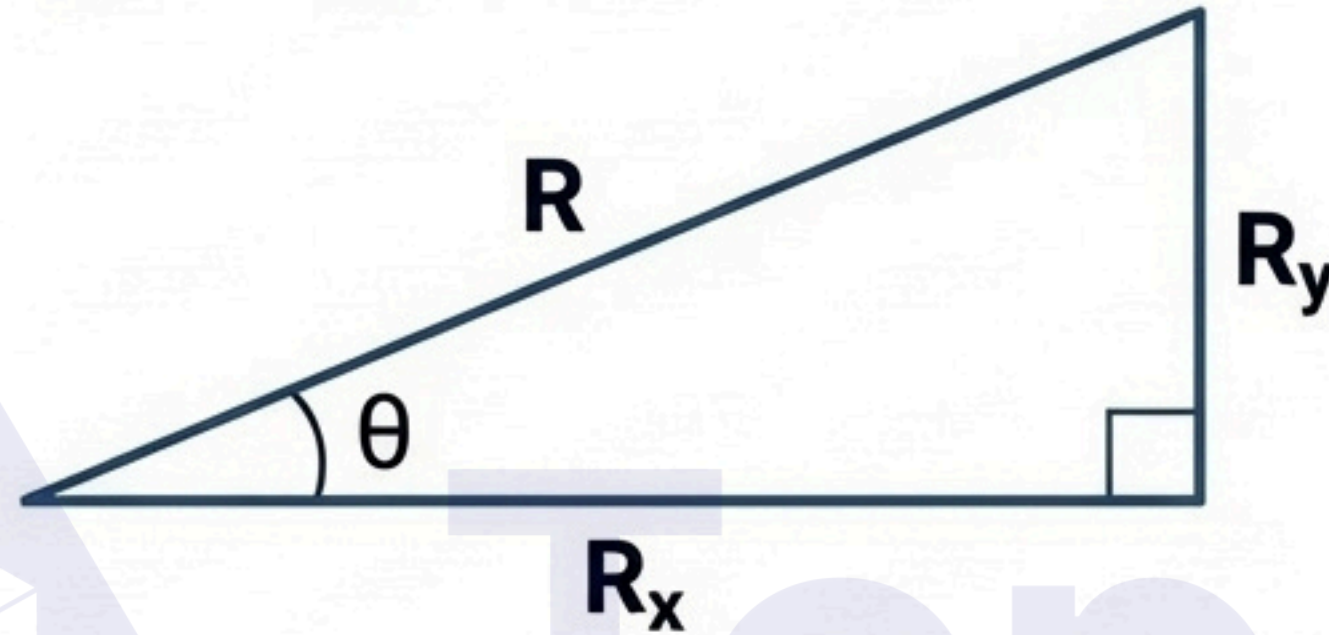
KEY TAKEAWAY PANEL

$$\mathbf{R} = R_x \hat{\mathbf{i}} + R_y \hat{\mathbf{j}}$$

$$R_x = A_x + B_x$$

$$R_y = A_y + B_y$$

Synthesizing the Final Vector



Magnitude

Applying the Pythagorean theorem to the orthogonal components yields the absolute length.

$$|R| = \sqrt{R_x^2 + R_y^2}$$

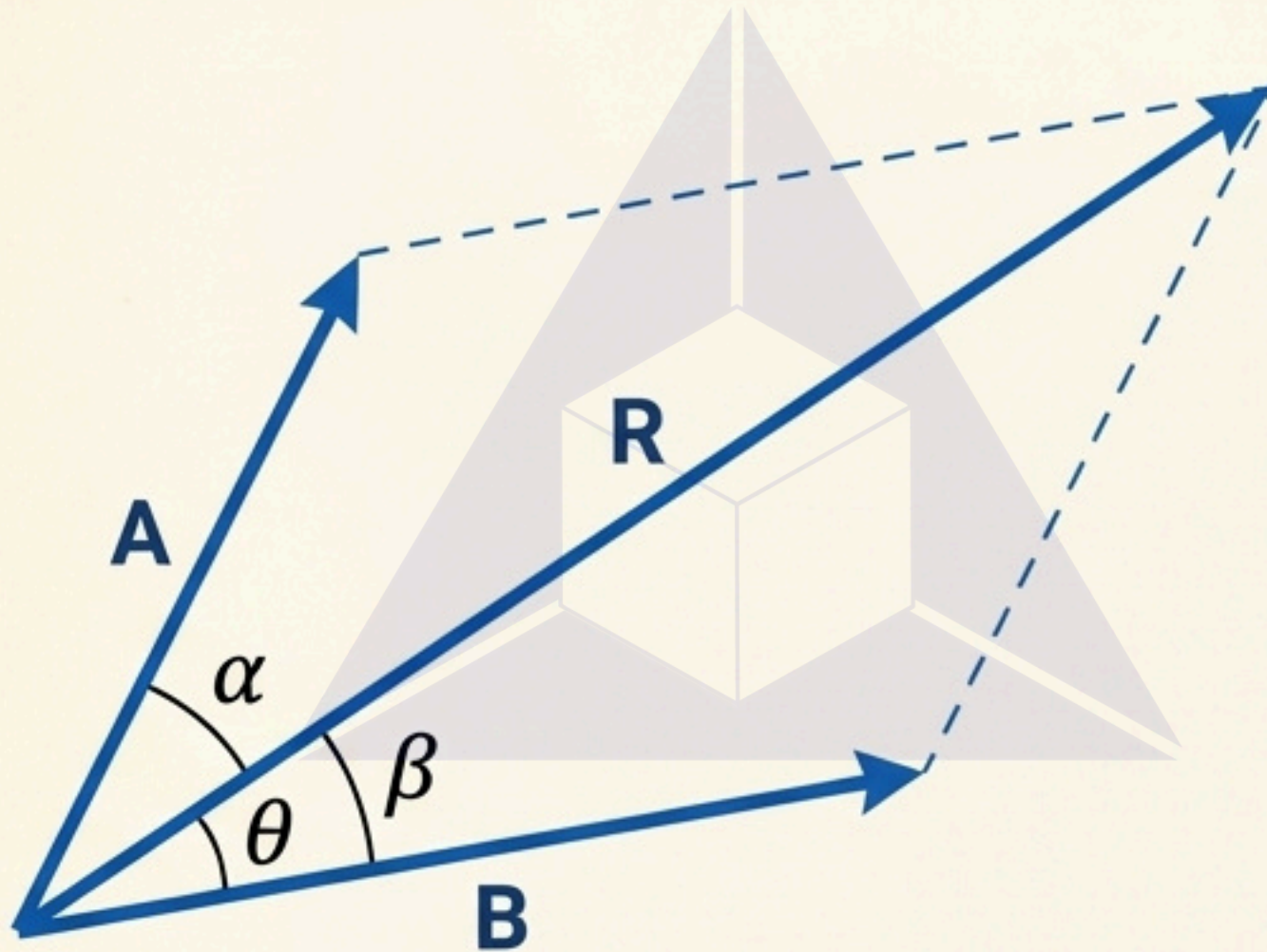
Direction

Applying inverse trigonometry yields the specific angle relative to the X-axis.

$$\theta = \tan^{-1}(R_y / R_x)$$

RECAP: This converts the Cartesian output (R_x , R_y) back into Polar form (Magnitude, Direction).

Law of Cosines and Law of Sines



Magnitude via Law of Cosines

For determining the length of the resultant when the angle θ between two vectors is known.

$$R = \sqrt{A^2 + B^2 + 2AB \cos \theta}$$

Direction via Law of Sines

For determining the internal angles of the vector triangle.

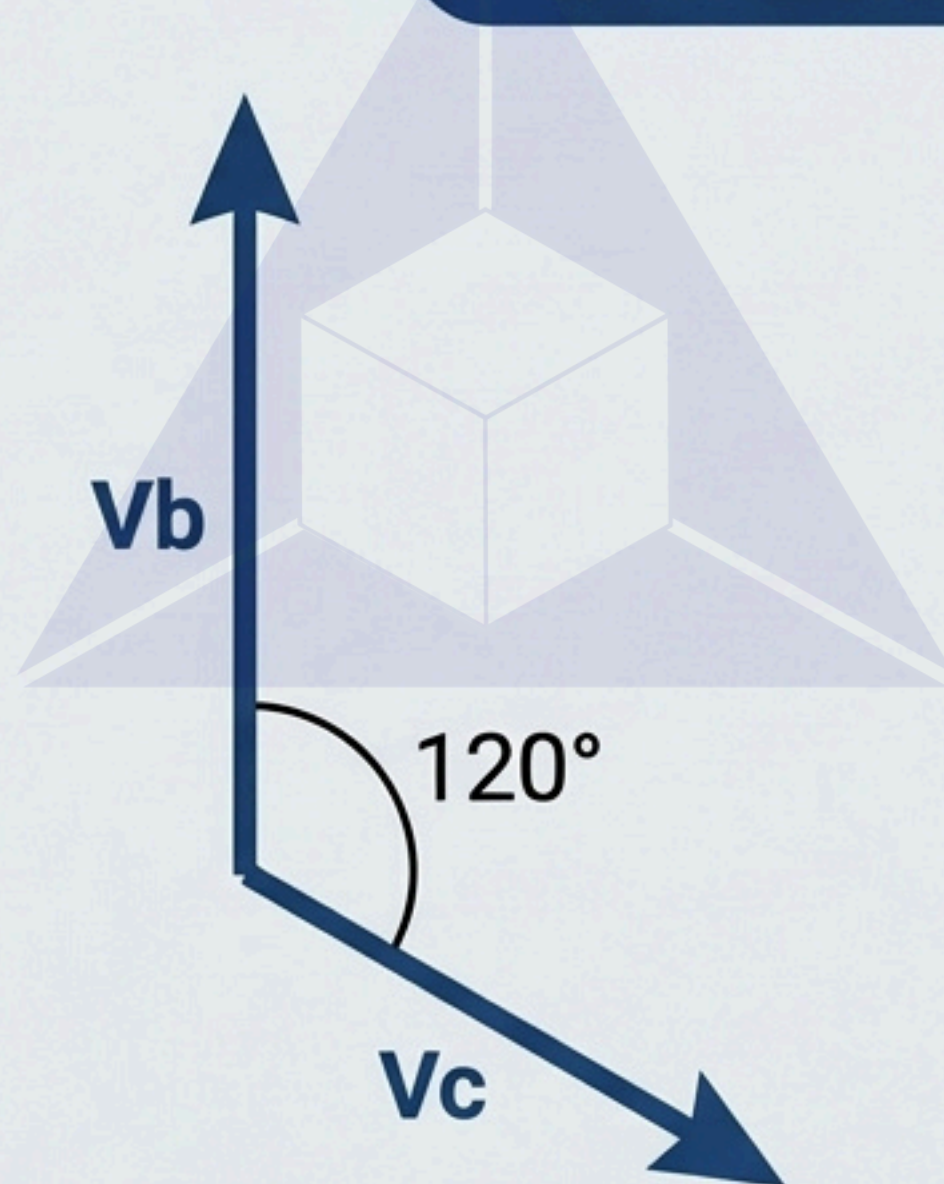
$$\frac{R}{\sin \theta} = \frac{A}{\sin \beta} = \frac{B}{\sin \alpha}$$

EXAM TIP: Use these laws for rapid 2-vector problems where orthogonal components aren't provided.

Real-World Synthesis: The Motorboat Problem

Boat (V_b) = 25 km/h North

Current (V_c) = 10 km/h
60° East of South



STEP 1: MAGNITUDE Apply Law of Cosines

$$R = \sqrt{(25^2 + 10^2 + 2(25)(10)\cos(120^\circ))}$$

Result: $R \approx 22$ km/h

STEP 2: DIRECTION Apply Law of Sines

$$\frac{10}{\sin(\phi)} = \frac{21.8}{\sin(120^\circ)}$$

Result: $\phi \approx 23.4^\circ$ East of North

FINAL VECTOR: 22 km/h at 23.4° East of North.



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