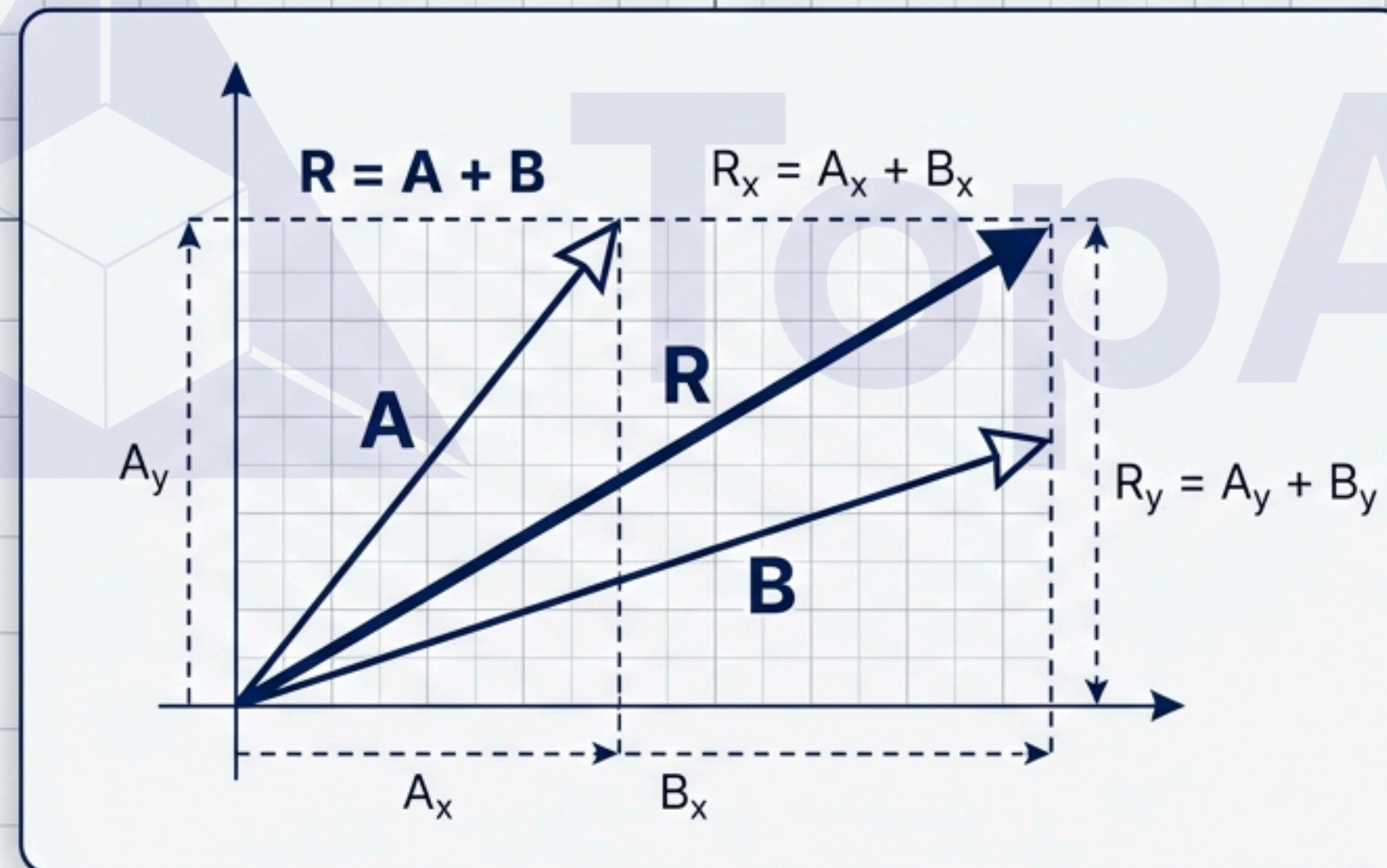


Motion in a Plane · Concept 5

Vector Addition — Analytical Method

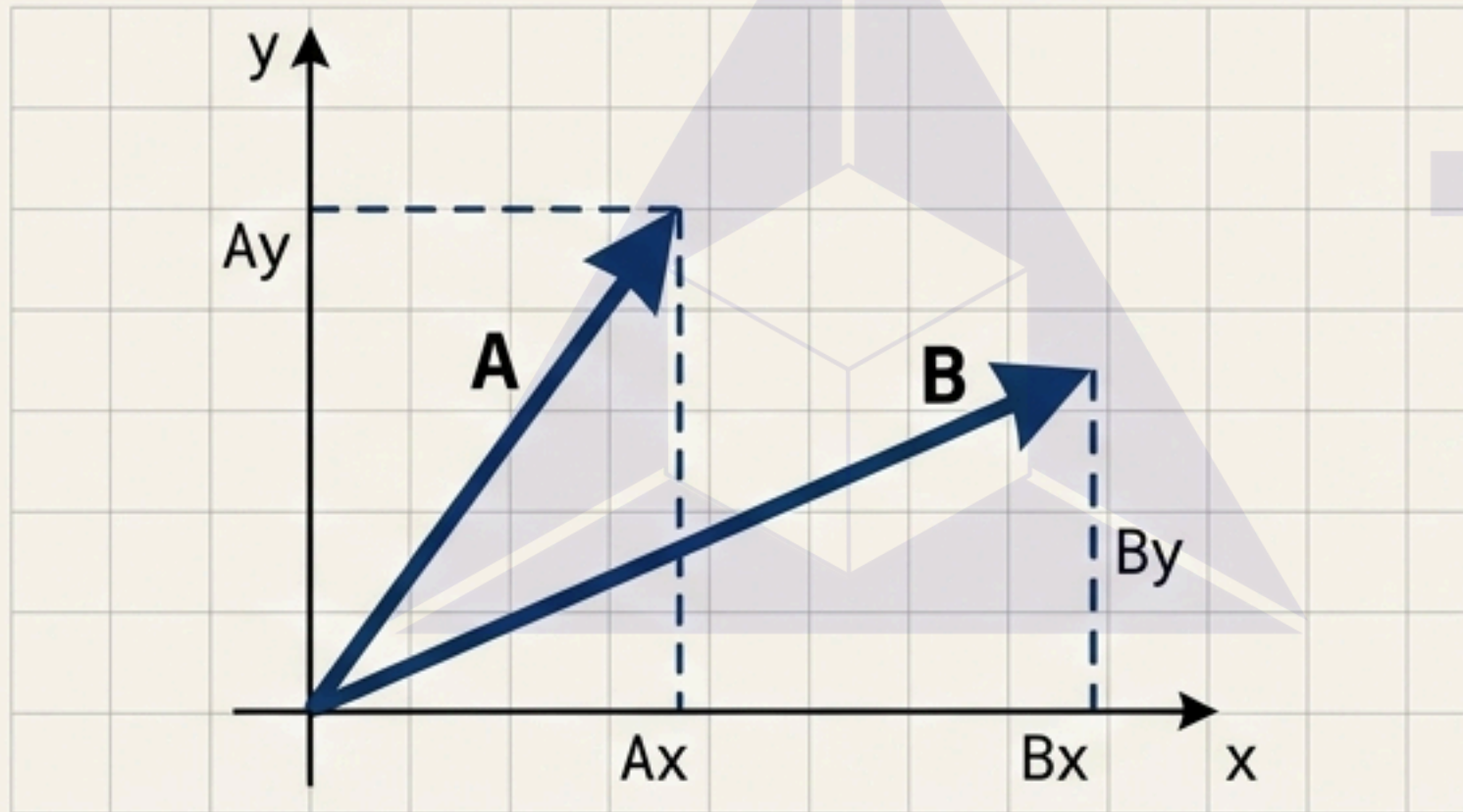
Moving from graphical estimation to exact mathematical precision.



The Component Method (Universal & Safest)

Component addition requires no complex trigonometry once the initial components are resolved—**just simple scalar addition.**

2D Foundation

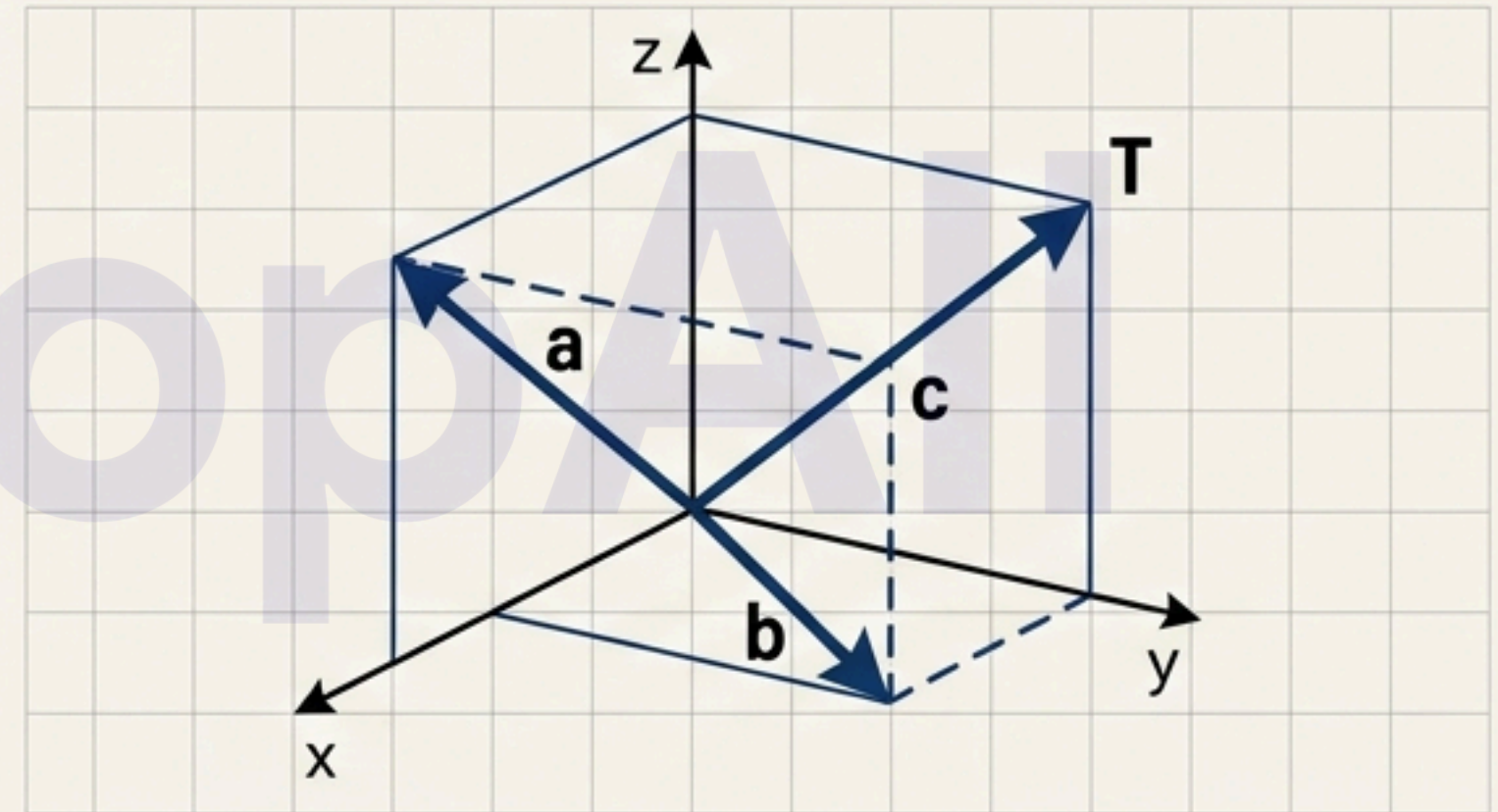


$$\mathbf{R} = \mathbf{A} + \mathbf{B}$$

$$R_x = A_x + B_x$$

$$R_y = A_y + B_y$$

Extended to 3D



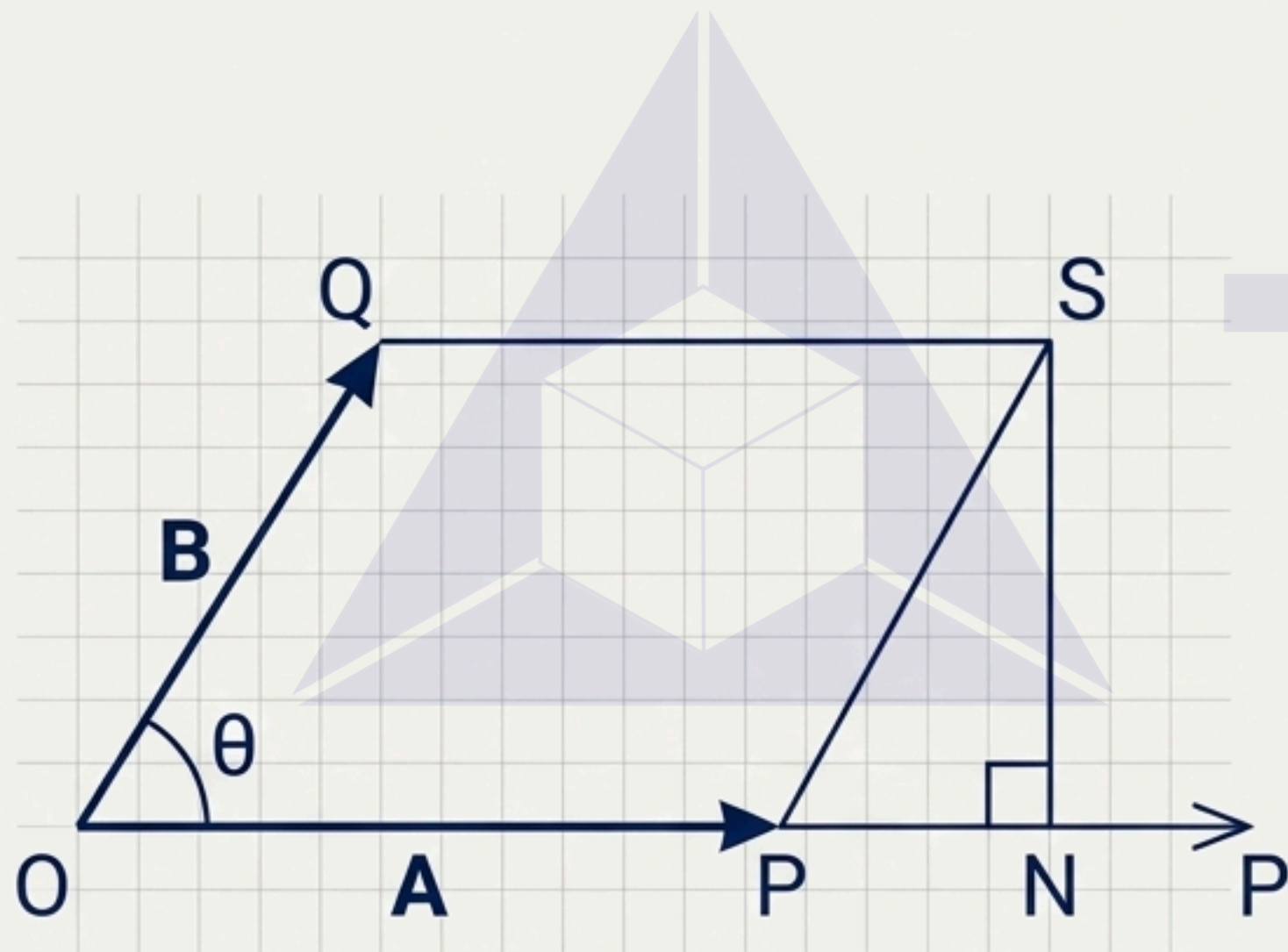
$$\mathbf{T} = \mathbf{a} + \mathbf{b} - \mathbf{c}$$

$$T_x = a_x + b_x - c_x$$

$$T_y = a_y + b_y - c_y$$

$$T_z = a_z + b_z - c_z$$

Law of Cosines: The Geometric Shortcut



Step 1: Apply Pythagoras to right triangle OSN

$$OS^2 = ON^2 + SN^2$$

Step 2: Substitute geometric components

$$ON = A + B \cos(\theta)$$

$$SN = B \sin(\theta)$$

Step 3: Expand and Simplify

$$R^2 = (A + B \cos(\theta))^2 + (B \sin(\theta))^2$$

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



**You've Learned the Theory.
Let's Test Them Now.**

$$E=mc^2$$



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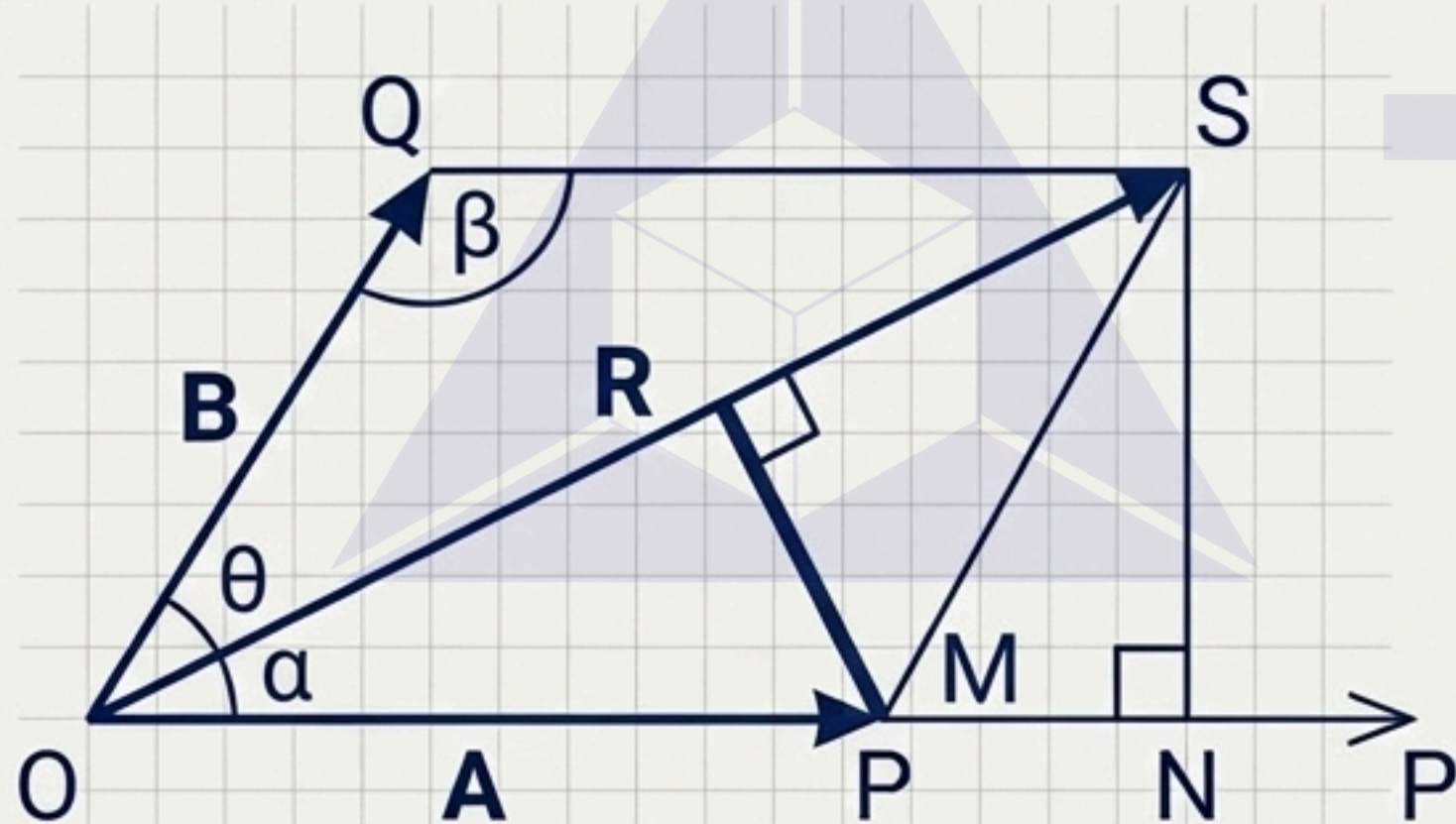
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- » Track Your Performance Smarter



Law of Sines: Finding the Direction



Equating Perpendicular Heights:

$$SN = R \sin(\alpha) = B \sin(\theta)$$

Direction Formula (tan):

$$\tan(\alpha) = \frac{SN}{ON} = \frac{B \sin(\theta)}{A + B \cos(\theta)}$$

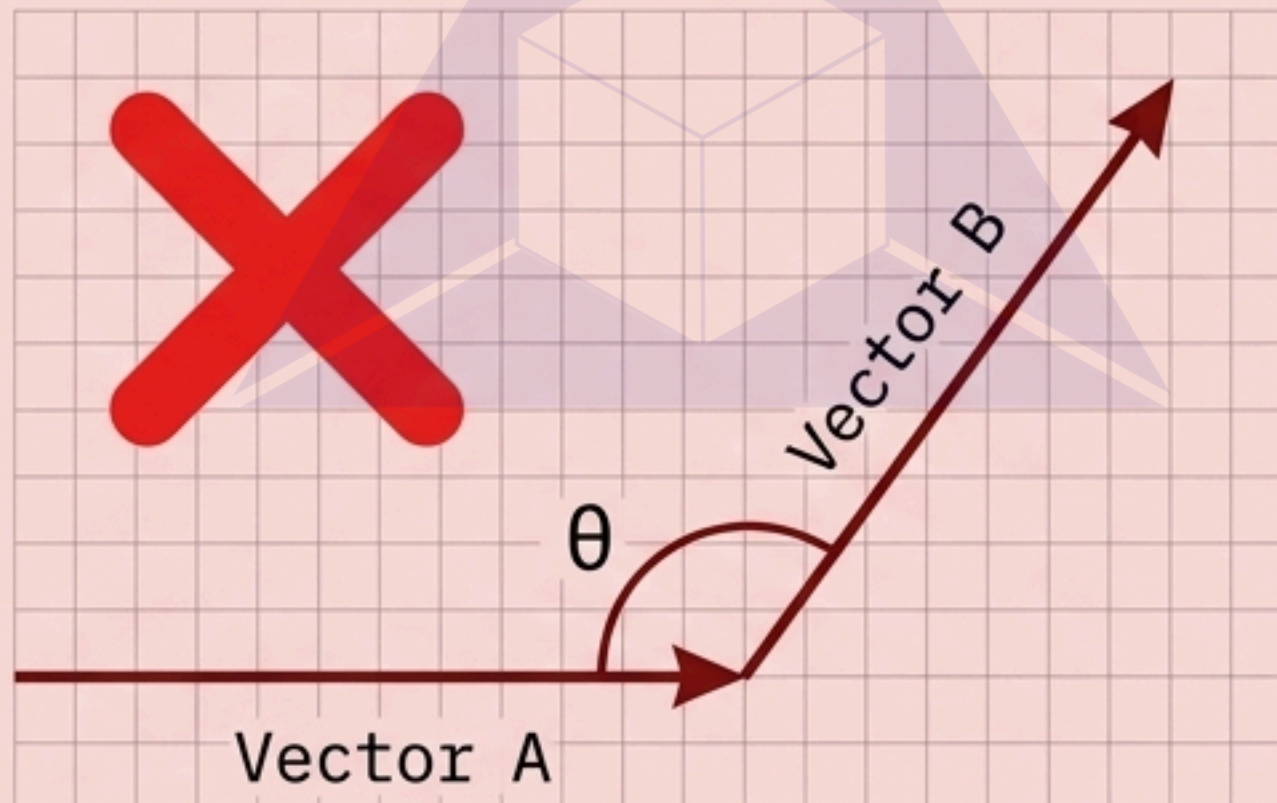
The Symmetry Equation (Law of Sines):

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

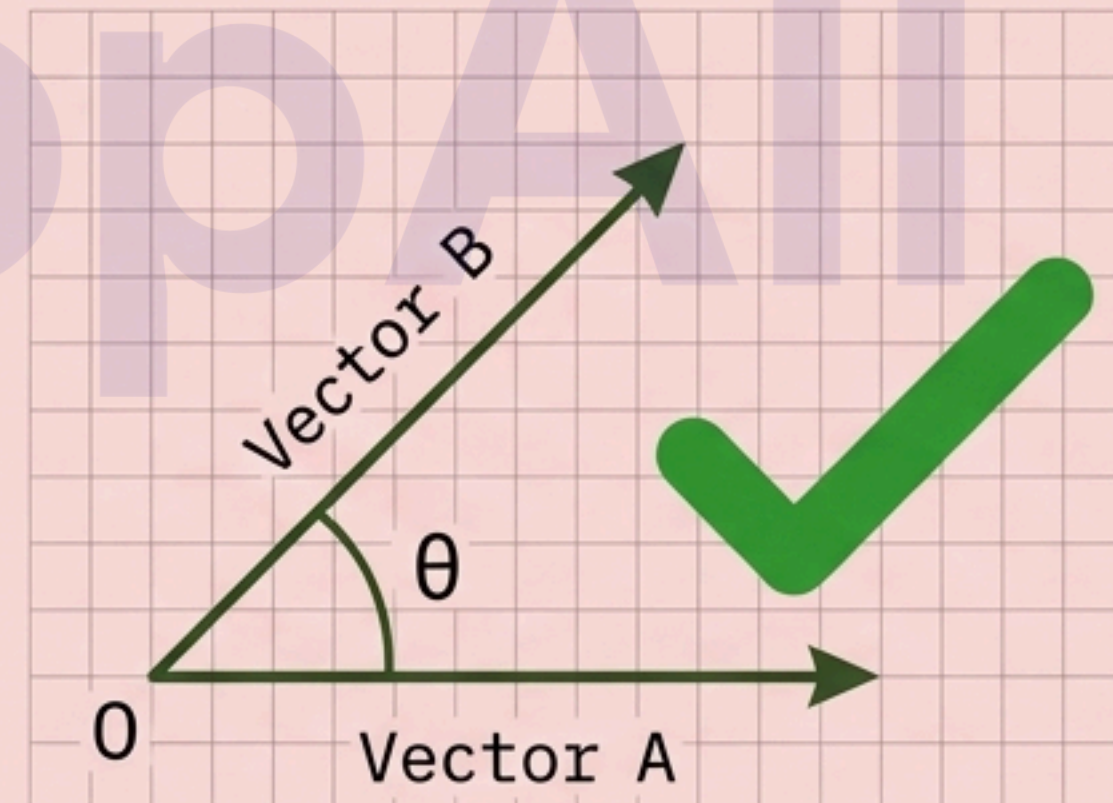
TRAP ALERT: Always find the TRUE angle (θ)

A stated directional bearing (e.g., "60° East of South") is not automatically the included angle θ . Before applying the Law of Cosines, vectors must be positioned tail-to-tail.

INCORRECT

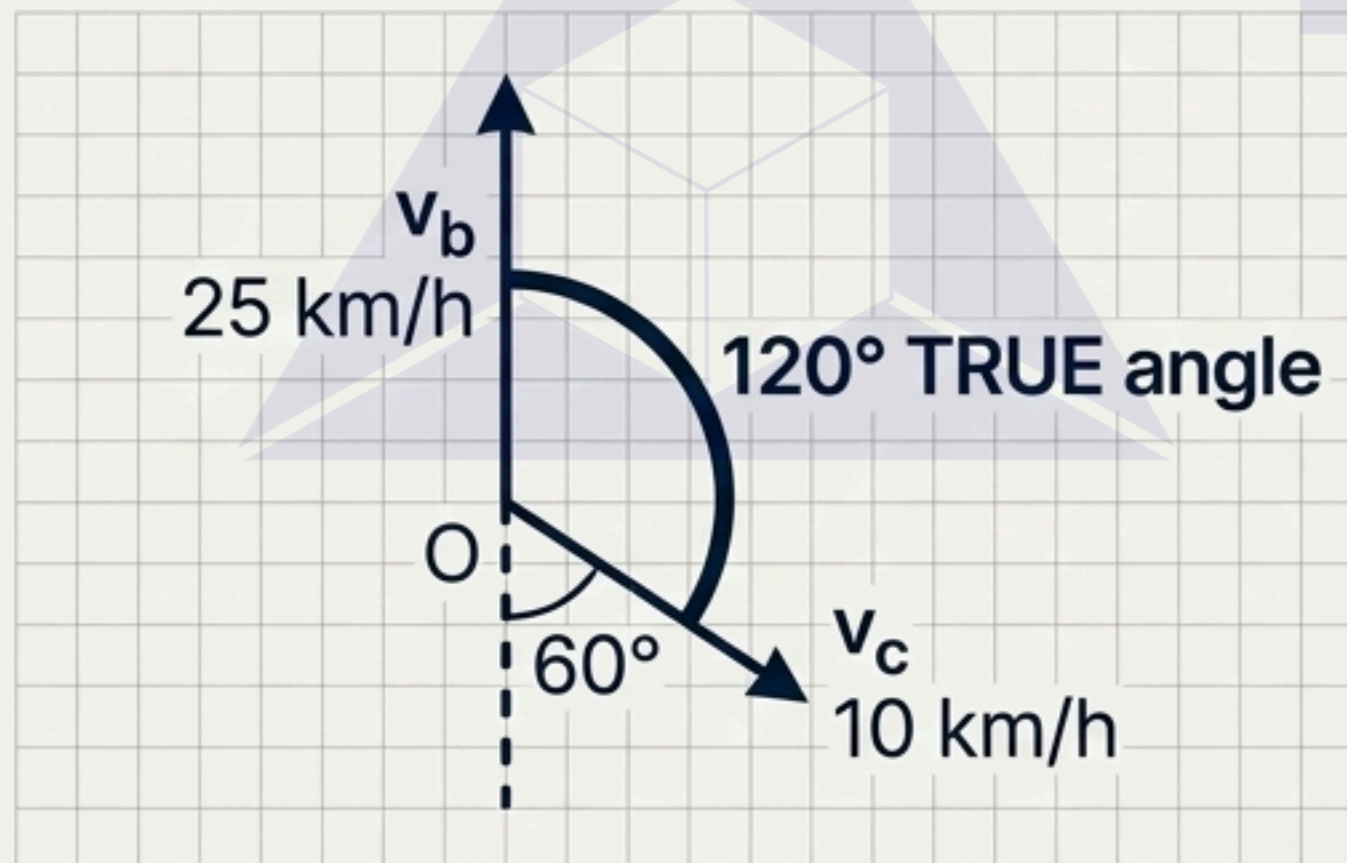


CORRECT



Worked Example 3.3

A motorboat is racing towards north at 25 km/h and the water current is 10 km/h in the direction of 60° East of South. Find the resultant velocity and direction.



Magnitude:

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

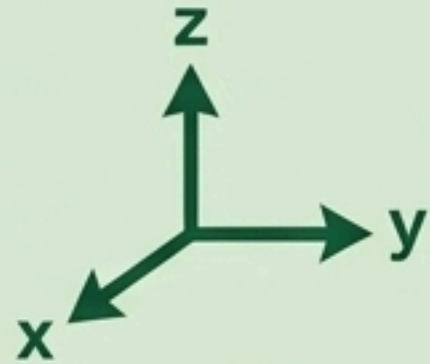
$$R \approx 22 \text{ km/h}$$

Direction:

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

$$\phi \approx 23.4^\circ$$

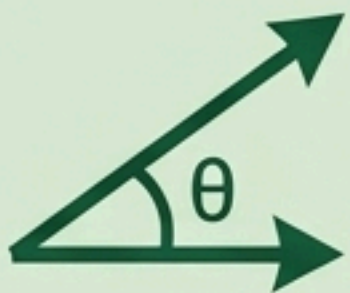
Key Takeaways



Component-wise addition is the safest and most scalable method, especially for 3D or 3+ vectors. If in doubt, break it down to the grid.



The Law of Cosines/Sines provides a rapid analytical shortcut for exactly 2 vectors.



If using the shortcut, always verify vectors are placed tail-to-tail to confirm the actual included angle (θ) first.



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