

CHAPTER 3 • MOTION IN A PLANE

Graphical Addition and Subtraction of Vectors

Mastering the Head-to-Tail Method, Vector Properties, and Parallelogram Law.



[NEET Physics Focus]

[Core Concept]



The Head-to-Tail Method

Given:



Action:



Explanation Card

- **Free Vectors:** Vectors can be shifted parallel to themselves anywhere in space without changing their magnitude (length) or direction (angle).
- **The Assembly:** To graphically find the sum $\vec{A} + \vec{B}$, simply place the tail of the second vector exactly at the head of the first.

The lengths of the drawn segments must strictly remain proportional to the true magnitude of the given physical vectors.

VECTOR ADDITION • THE RESULTANT

The Triangle Law



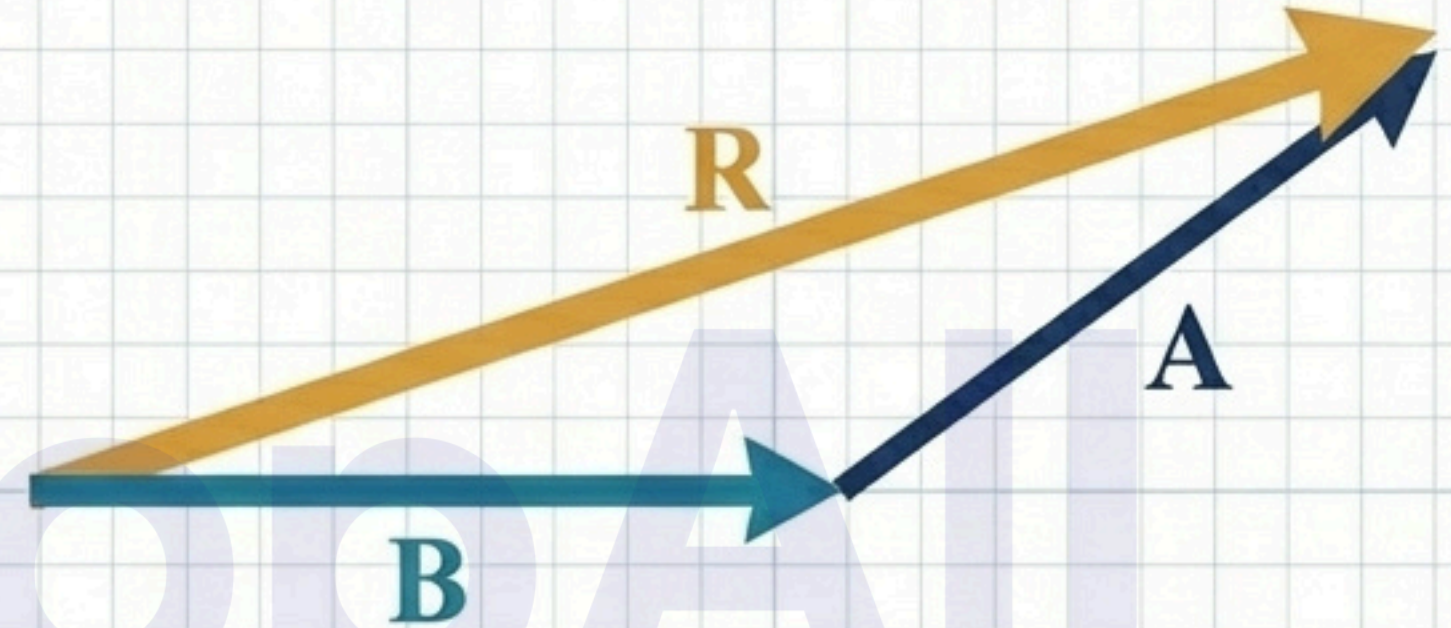
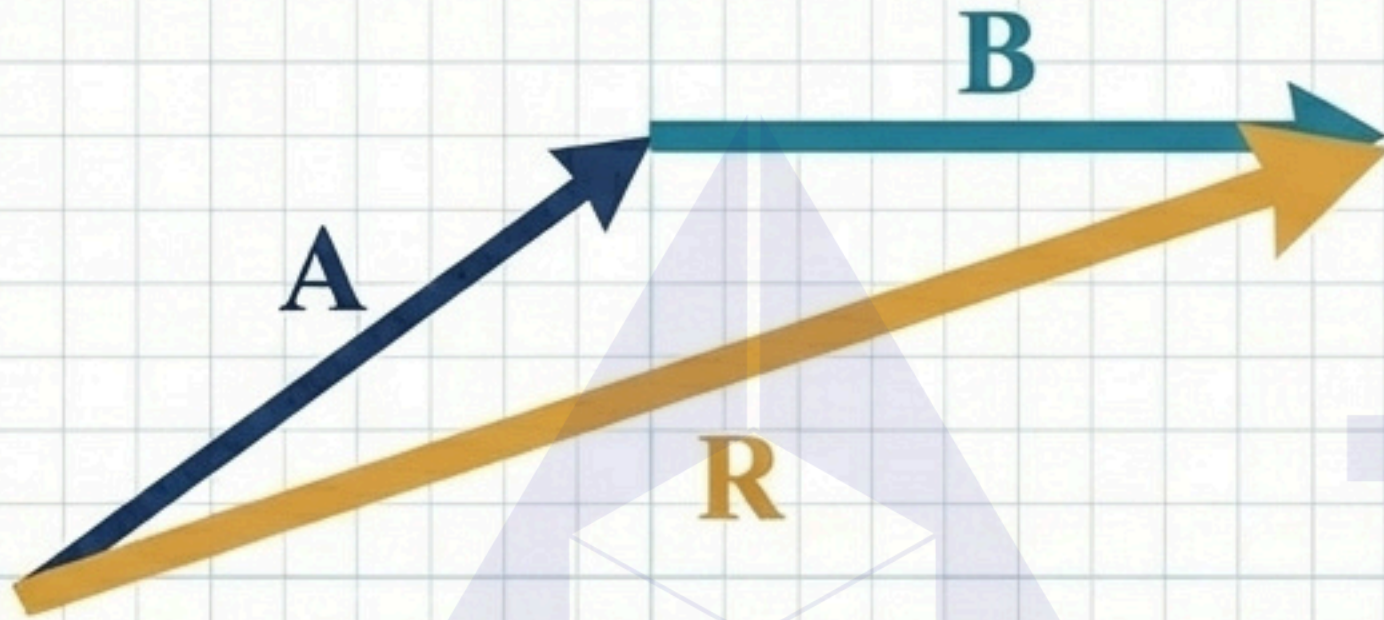
Explanation Card

- If **two vectors** are represented in magnitude and direction by two sides of a triangle taken in order (head-to-tail)...
- ...their **resultant** is represented by the third closing side of the triangle, taken in the opposite order (tail-to-tail, head-to-head).

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

R always points from the exact starting point to the final destination

Commutative Law of Vector Addition



Explanation Card

- The order in which vectors are added does not matter. Whether traversing path **A** then **B**, or path **B** then **A**, the final displacement vector **R** remains mathematically identical in magnitude and direction.

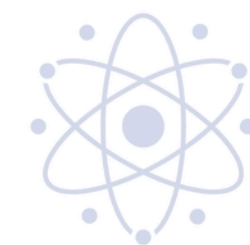
$$\mathbf{A} + \mathbf{B} = \mathbf{B} + \mathbf{A}$$

Vector addition is strictly order-independent



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$$E=mc^2$$



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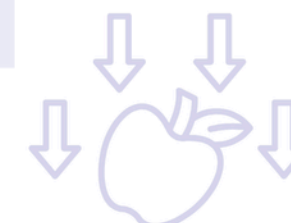
Practice Now



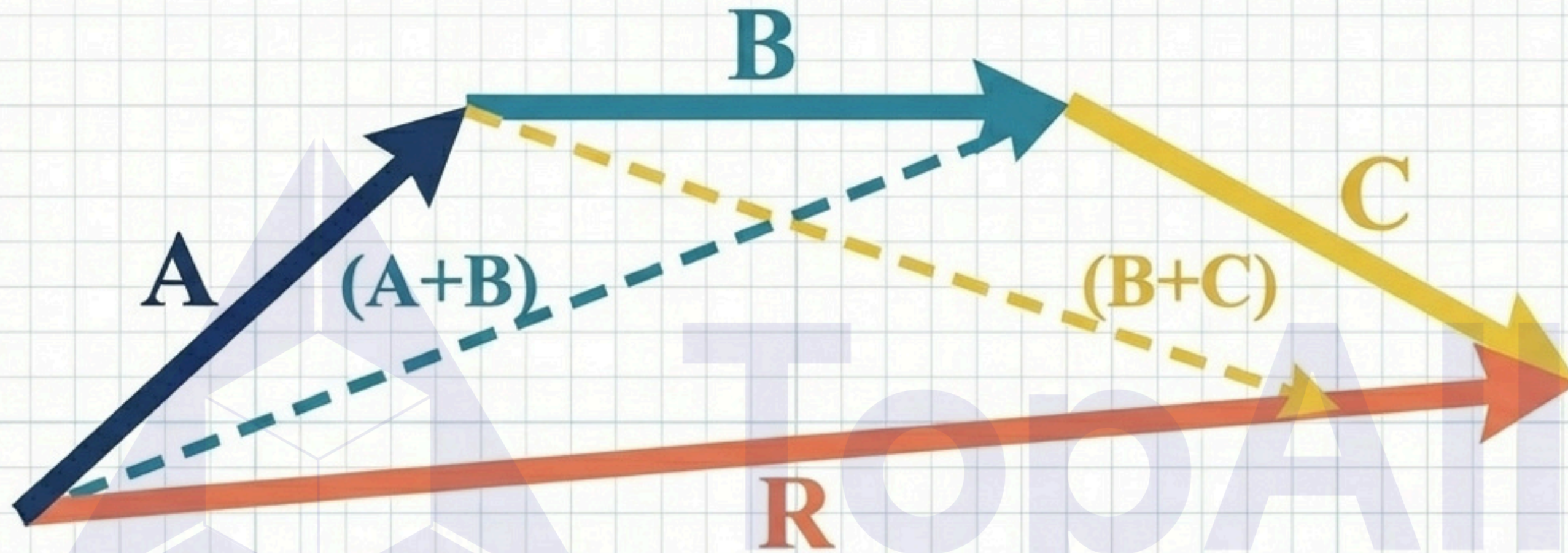
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Associative Law of Vector Addition



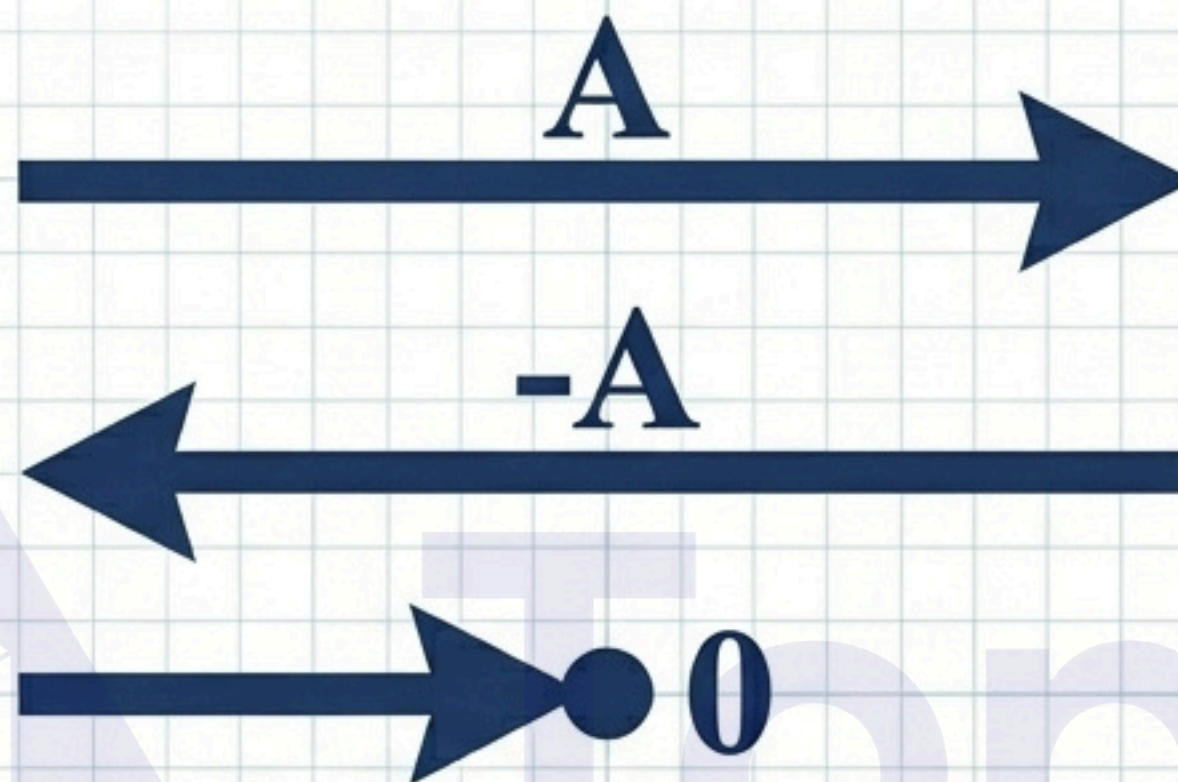
Explanation Card

- When adding three or more vectors sequentially, how you group them into intermediate sums does not affect the final resultant vector.

$$(A + B) + C = A + (B + C)$$

Intermediate grouping order does not alter the final outcome

The Null (Zero) Vector

**Explanation Card**

- Multiplying a vector by -1 creates an exact negative counterpart (same magnitude, perfectly reversed 180° direction).
- Adding a vector to its negative counterpart yields the Null Vector. It has exactly zero magnitude, meaning its specific direction cannot be defined.
- Physical Meaning: An object moving from point P and returning to point P undergoes a null displacement.

$$\mathbf{A} + (-\mathbf{A}) = \mathbf{0}$$

$$|\mathbf{0}| = 0$$

$$\mathbf{A} + \mathbf{0} = \mathbf{A}$$

$$\lambda \mathbf{0} = \mathbf{0}$$

$$\mathbf{0} \mathbf{A} = \mathbf{0}$$

Graphical Vector Subtraction

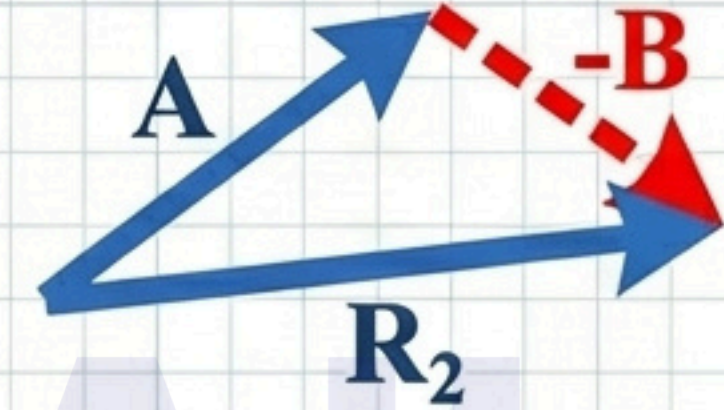
1. Given



2. Invert



3. Add



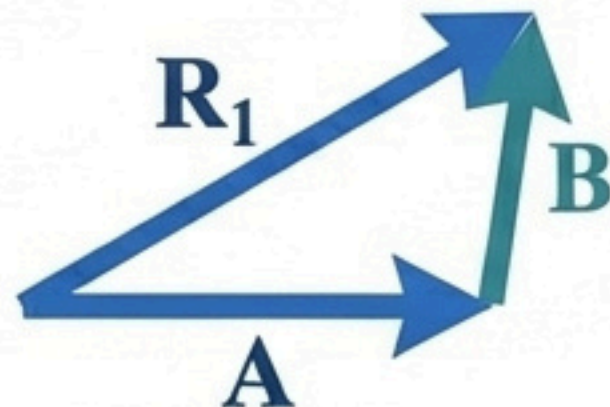
Explanation Card

- Graphical subtraction is simply an illusion defined in terms of addition. To subtract vector **B** from vector **A**, simply flip **B**'s direction by 180° and proceed with standard vector addition.

$$\mathbf{A} - \mathbf{B} = \mathbf{A} + (-\mathbf{B})$$

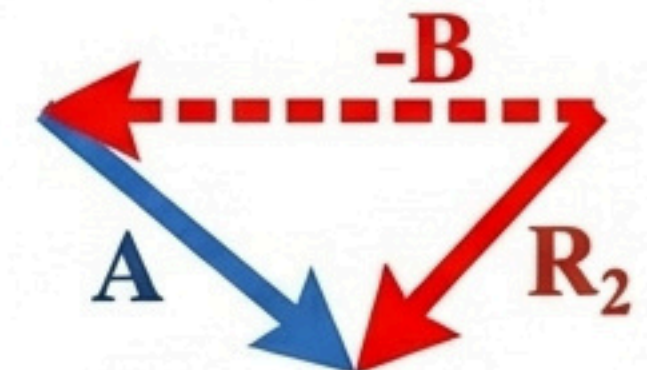
Mini Comparison Matrix

Addition: $\mathbf{R}_1 = \mathbf{A} + \mathbf{B}$
(Standard upward closing triangle)



Mini Comparison Matrix

Subtraction: $\mathbf{R}_2 = \mathbf{A} - \mathbf{B}$
(Inverted downward closing triangle)

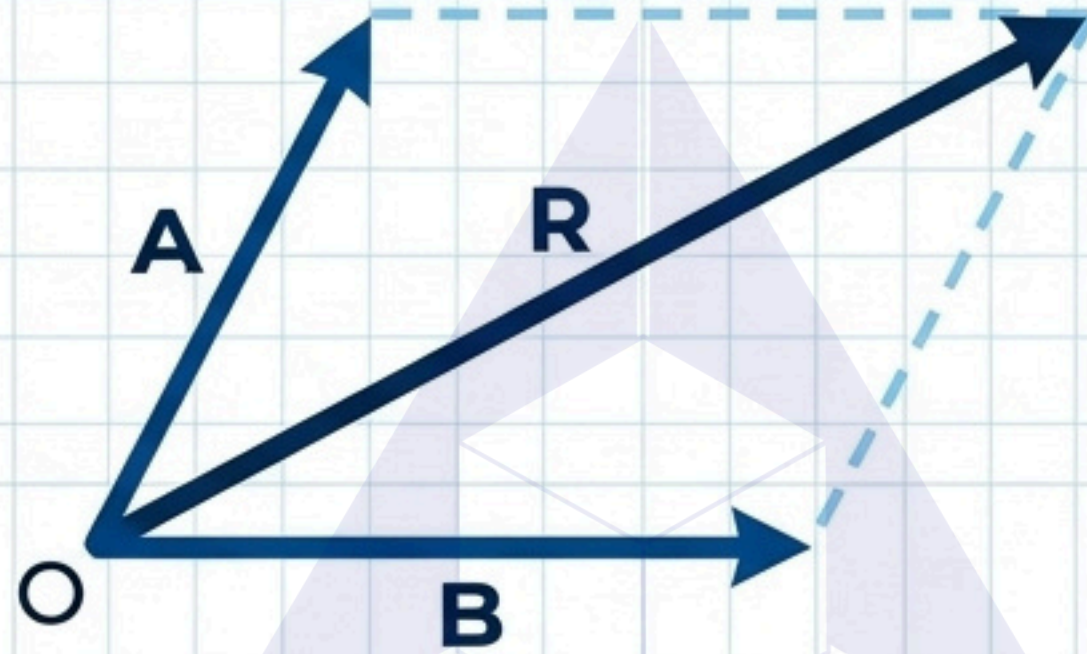


APPLIED VECTOR ADDITION

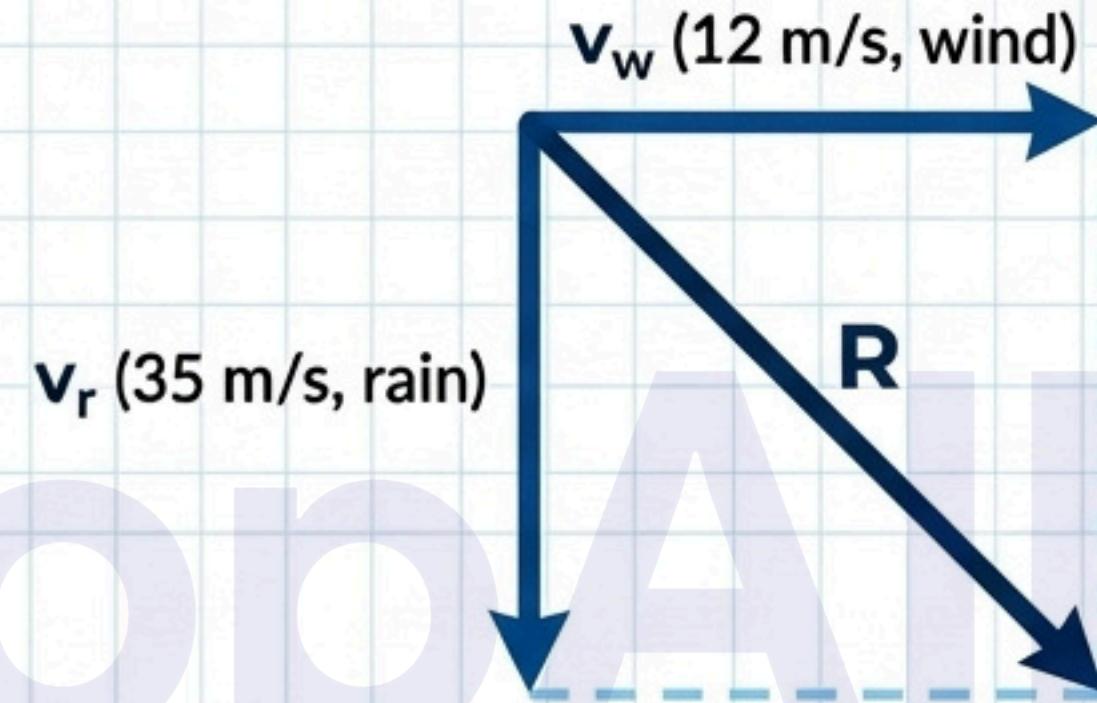
The Parallelogram Law & Real Applications



The Theory



The Application - Rain Problem



The Law: When two vectors originate from the same point, they form adjacent sides of a **parallelogram**. The diagonal passing through that origin is their resultant.

The Problem: A boy experiences vertical rain and horizontal wind simultaneously. The resultant vector **R** tells him exactly the angle to tilt his umbrella to block the true trajectory of the drops.

$$\tan \theta = \frac{v_w}{v_r} \rightarrow \theta = \tan^{-1} \left(\frac{12}{35} \right) \approx 19^\circ \text{ East of Vertical}$$

The Parallelogram method is optimal for simultaneous vectors acting on a single point



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