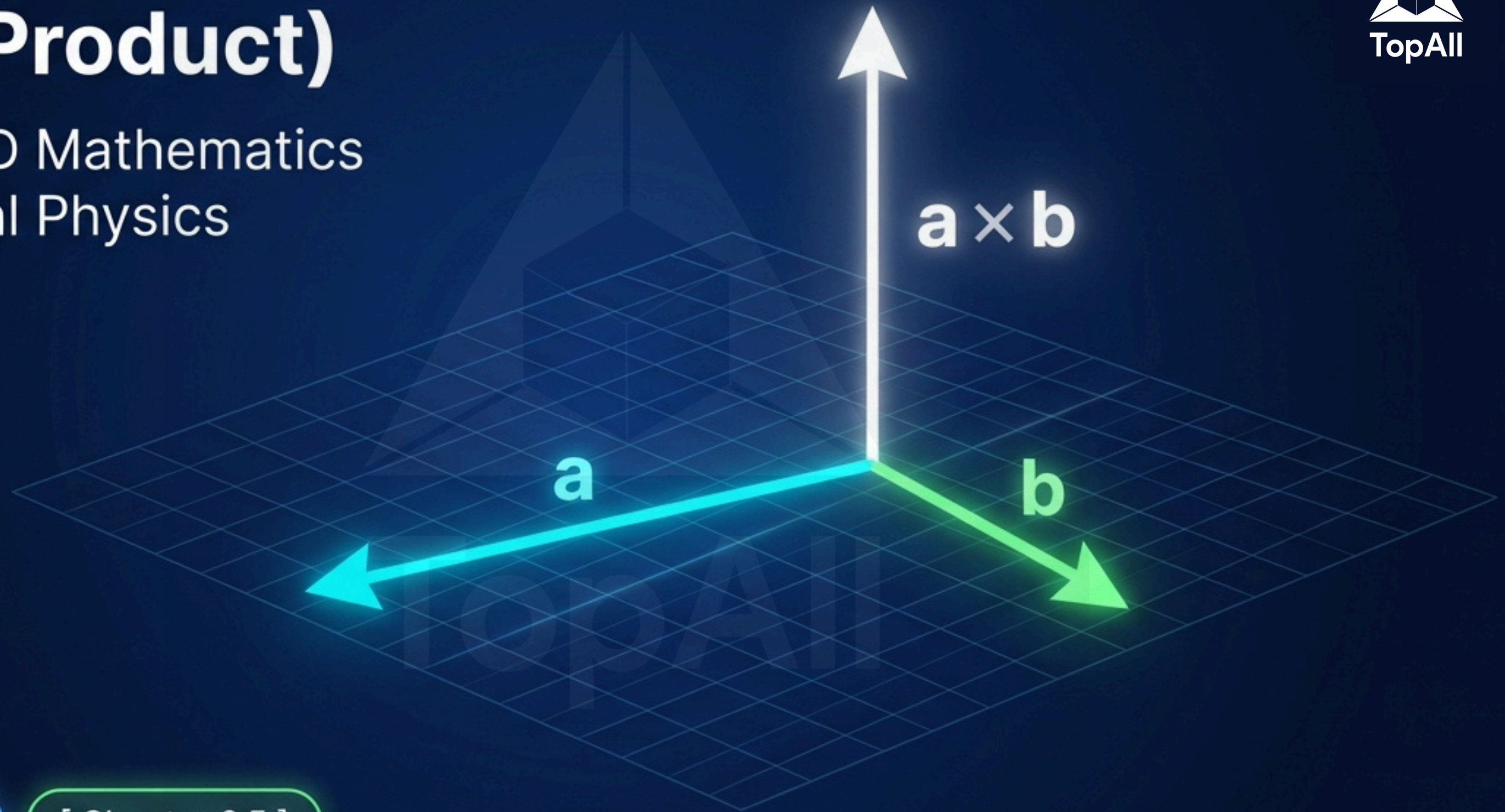


The Vector Product (Cross Product)

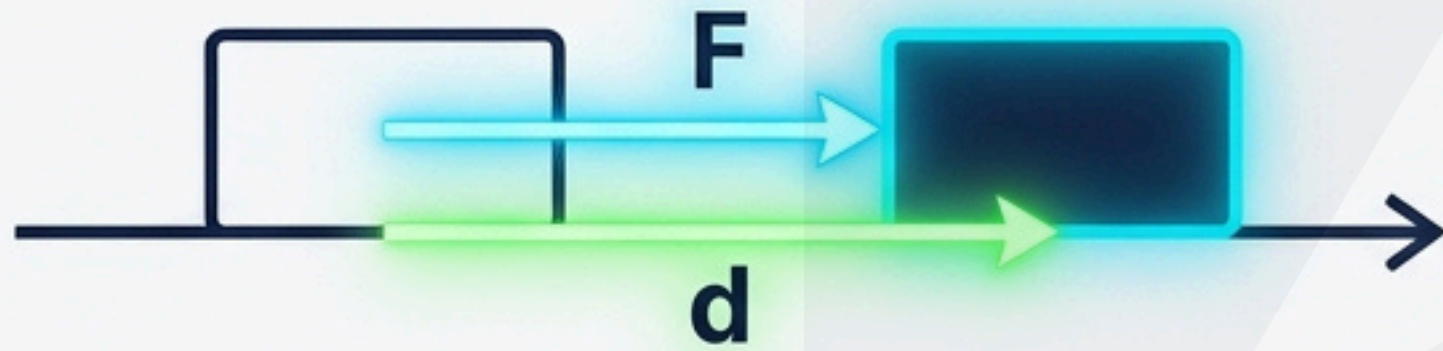
Unlocking 3D Mathematics
for Rotational Physics



[NEET Physics]

[Chapter 6.5]

Linear Physics (Dot Product)

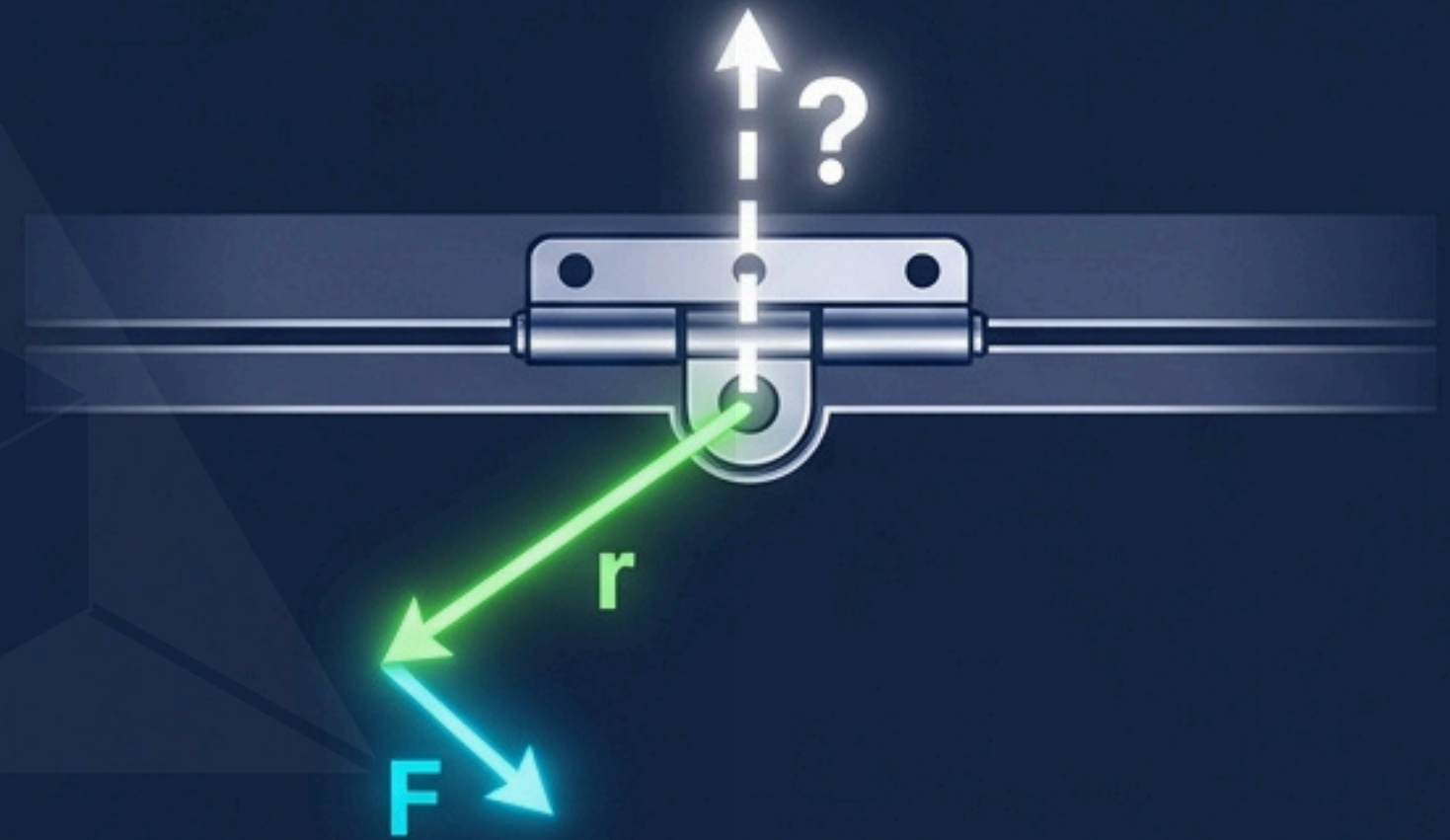


Yields a pure scalar number
(e.g., Work $W = \mathbf{F} \cdot \mathbf{d}$).



[Scalar Result]

Rotational Physics (The Gap)



How do we mathematically describe an axis of rotation? We need an operation that takes two vectors and outputs a new, perpendicular vector.

[Vector Result Needed]

[Magnitude]

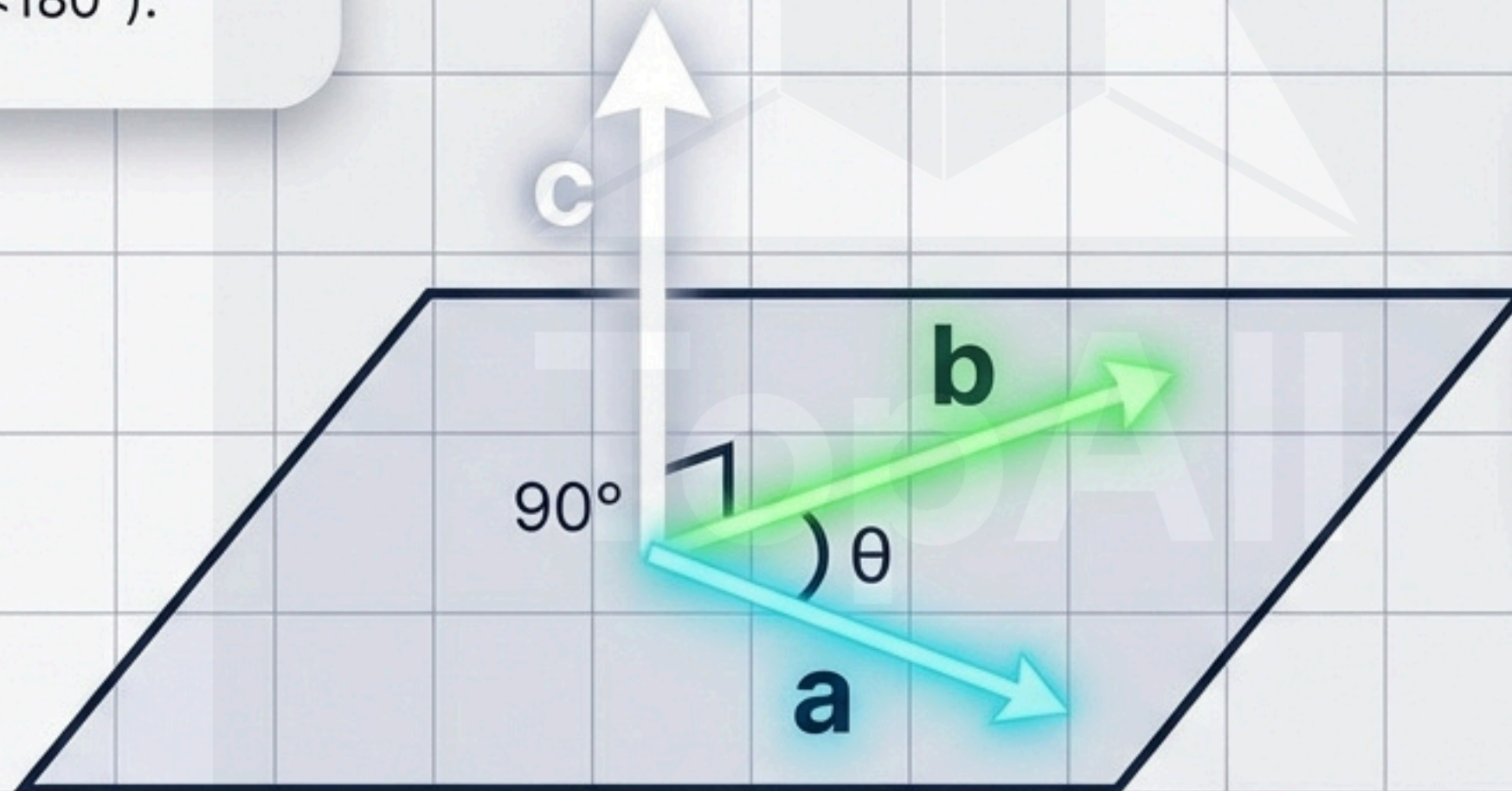
$$|c| = ab \sin\theta$$

The magnitude is the product of their lengths and the sine of the angle θ between them (rotation is taken through the smaller angle $<180^\circ$).

$$c = a \times b$$

[Direction]

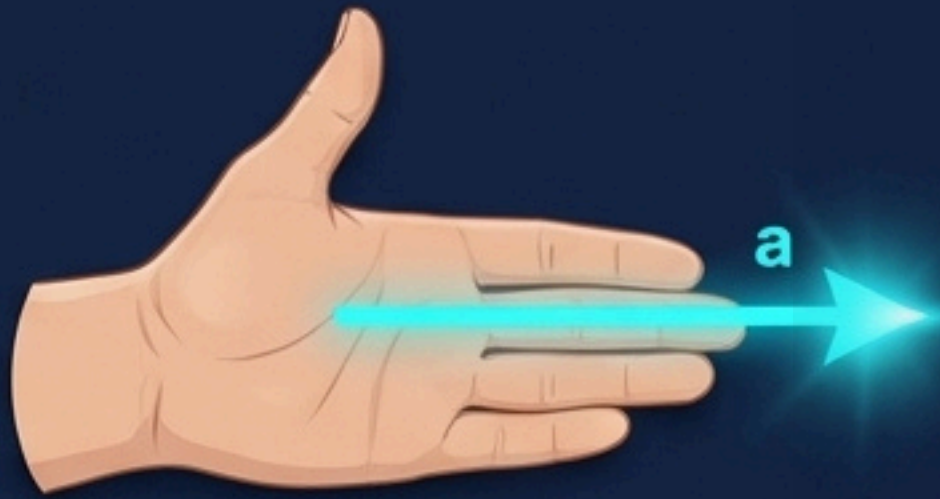
c is strictly perpendicular (90°) to the entire plane containing both **a** and **b**.



The Right-Hand Rule (Defining Direction)



1. Point fingers along first vector (**a**).



2. Curl fingers toward second vector (**b**).



3. Extended thumb points to **a** $\times$ **b**.



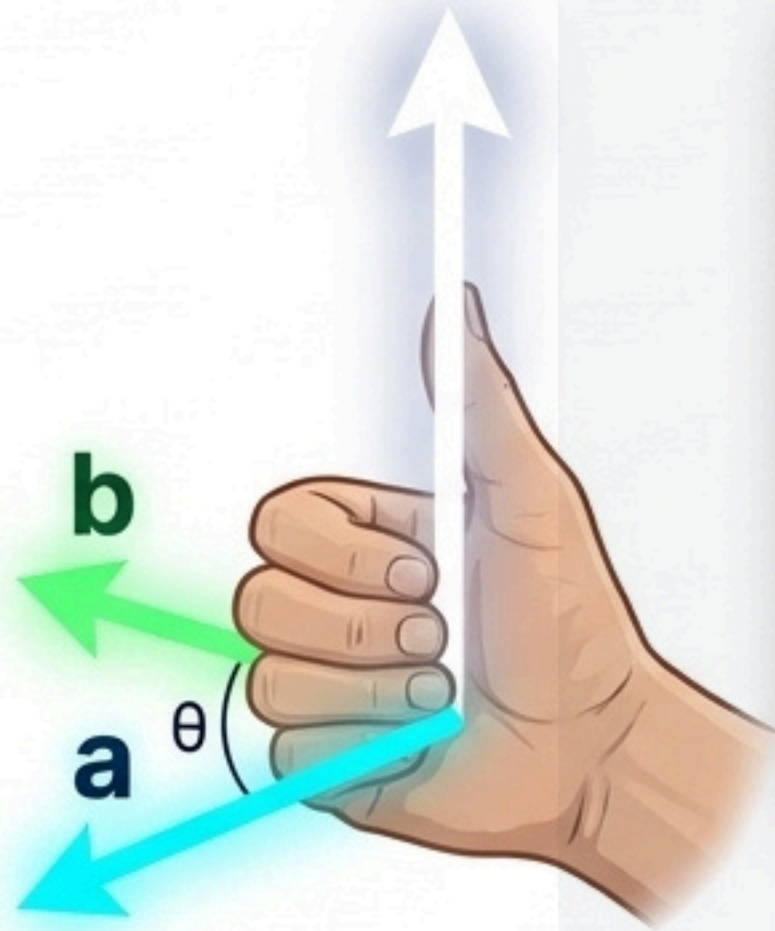
[Alternate: Screw Rule]

Imagine turning a right-handed screw from **a** to **b**. The direction the screw advances is the direction of the vector product.



Order Matters: The Spatial Flip

$$\mathbf{a} \times \mathbf{b}$$

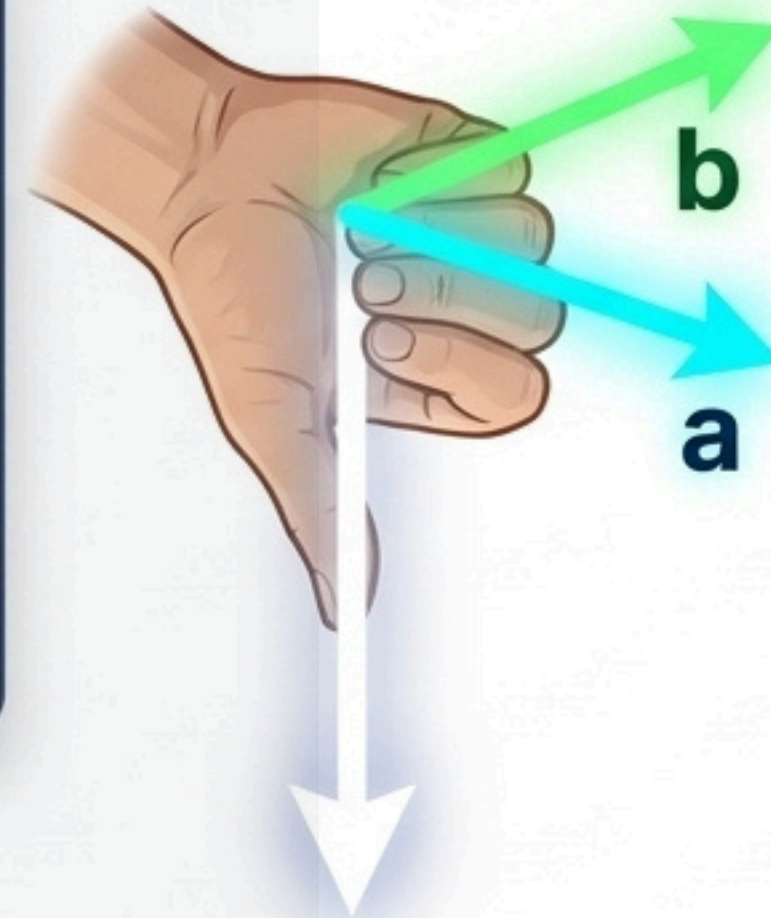


[Anti-Commutative]

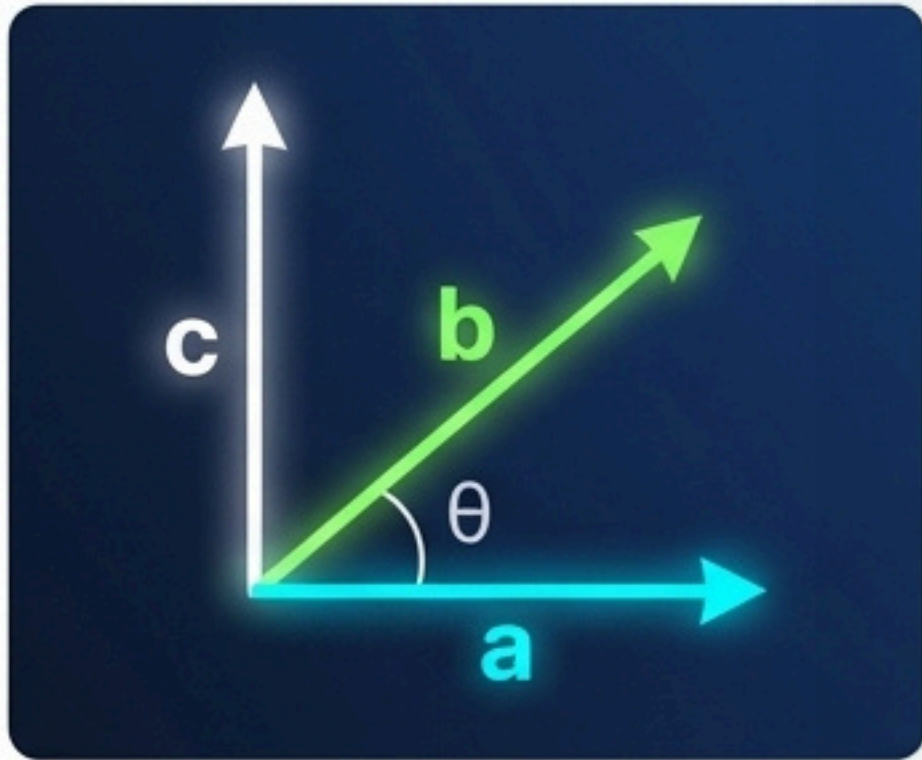
$$\mathbf{a} \times \mathbf{b} = -\mathbf{b} \times \mathbf{a}$$

The magnitudes ($ab \sin\theta$) are identical, but reversing the order precisely reverses the direction in 3D space.

$$\mathbf{b} \times \mathbf{a}$$

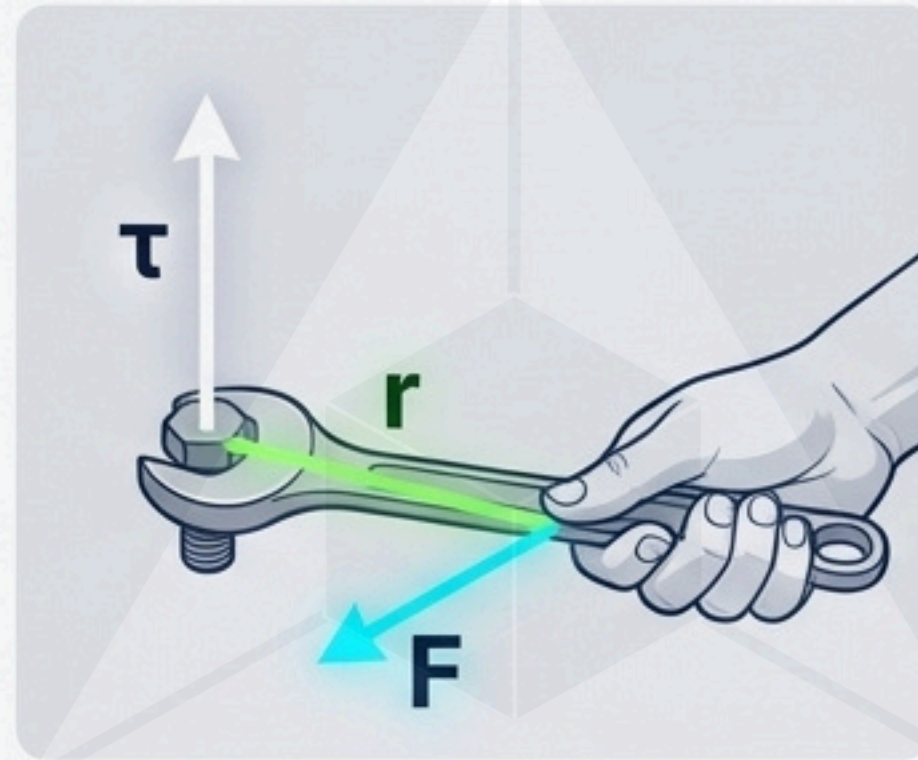


The Physics Bridge: Why We Need This



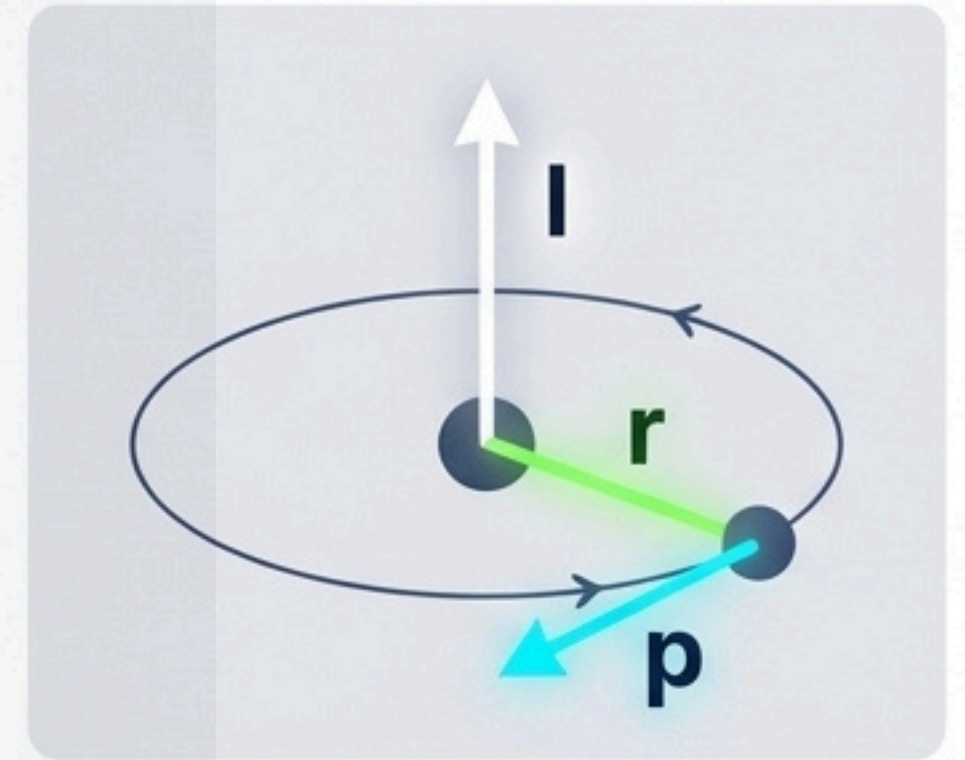
The Mathematical Tool.

$$\mathbf{c} = \mathbf{a} \times \mathbf{b}$$



Moment of Force (Torque).
The rotational analogue of force.

$$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$$



Moment of Momentum.
The rotational analogue of linear momentum.

$$\mathbf{l} = \mathbf{r} \times \mathbf{p}$$

The Cross Product transforms 2D linear actions into 3D rotational realities.