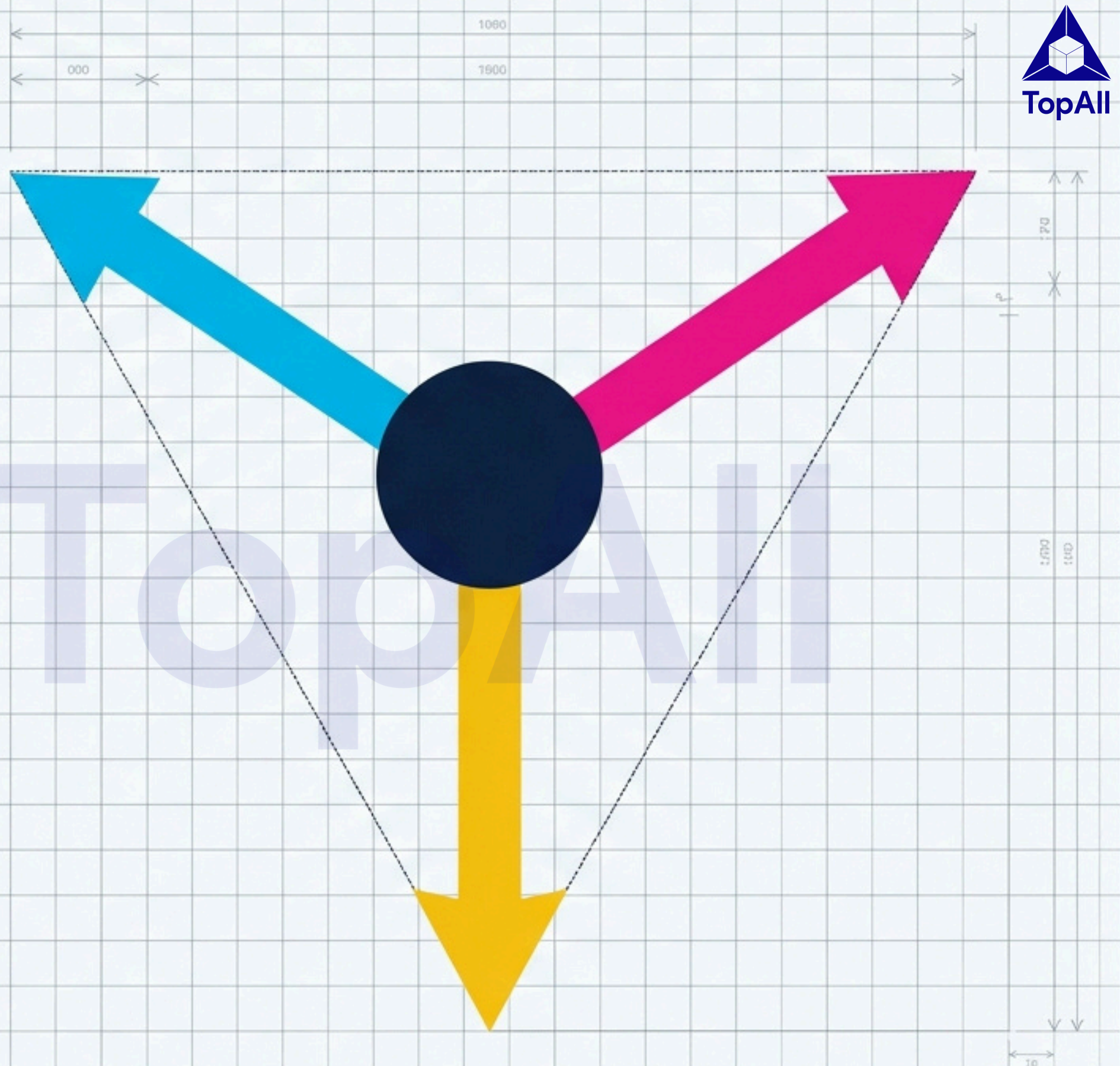


The Blueprint of Balance

Understanding the Equilibrium of a Particle

Class 11 Physics • Section 4.8



Equilibrium Requires Zero Net External Force



State of Rest

Uniform Linear Motion

$$F_{\text{net}} = 0$$

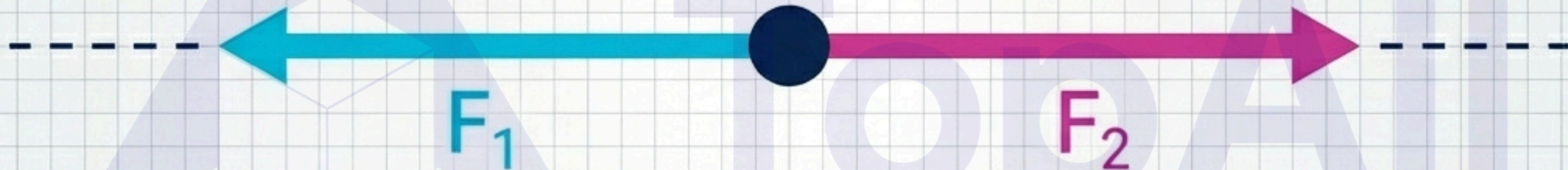
Velocity: $v = 0$
Acceleration: $a = 0$

Velocity: $v = \text{constant}$
Acceleration: $a = 0$

According to the First Law of Motion, a particle is in equilibrium if and only if the net external force acting on it is zero.

Two-Force Systems Demand Equal and Opposite Vectors

$$F_1 = -F_2 \text{ (Eq. 4.10)}$$



- If only two forces act on a particle, equilibrium is only possible if they are equal in magnitude and opposite in direction.
- They must act along the exact same line of action.



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

$$E=mc^2$$



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Key Highlights

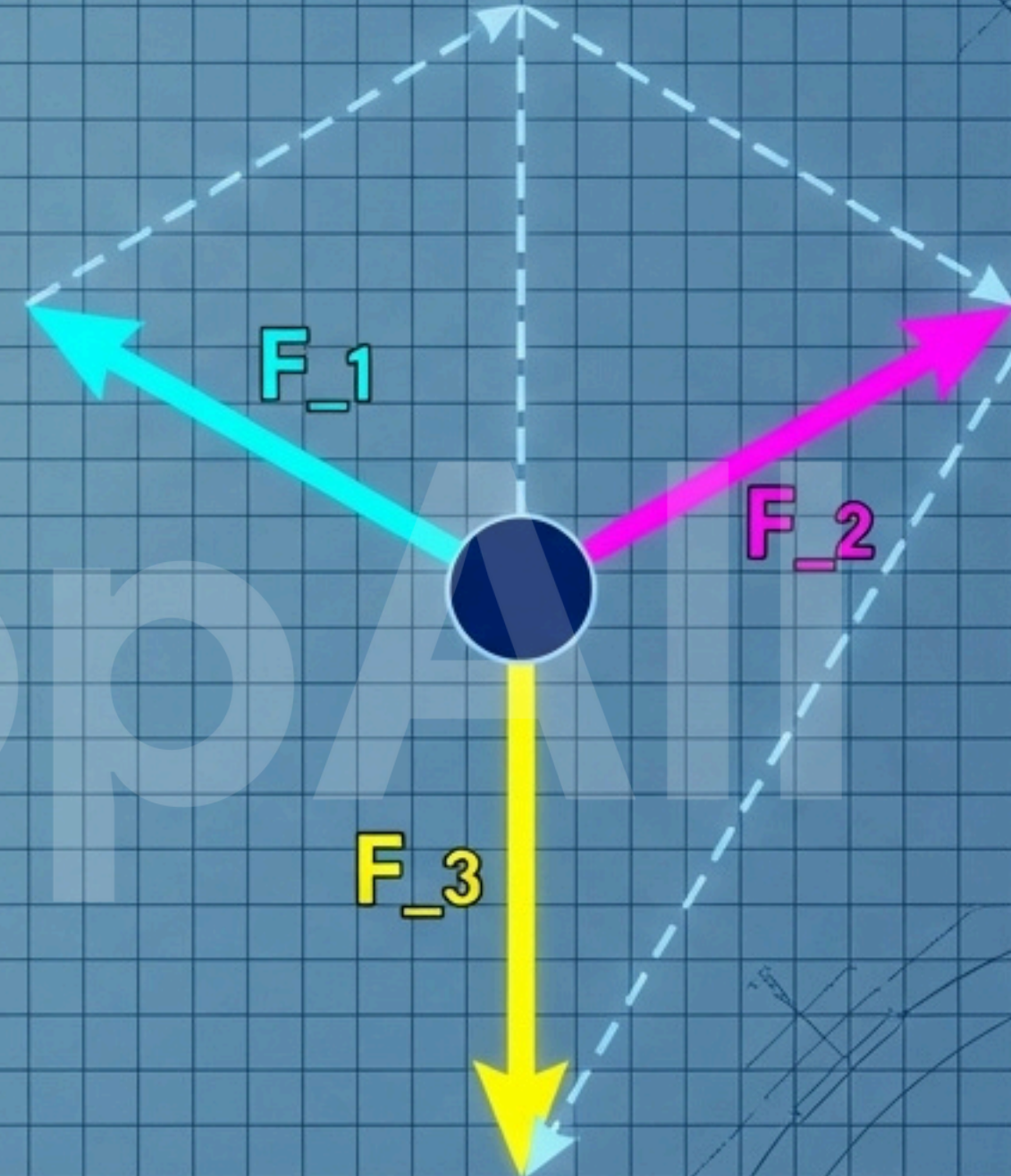
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Three Concurrent Forces Must Sum to Zero

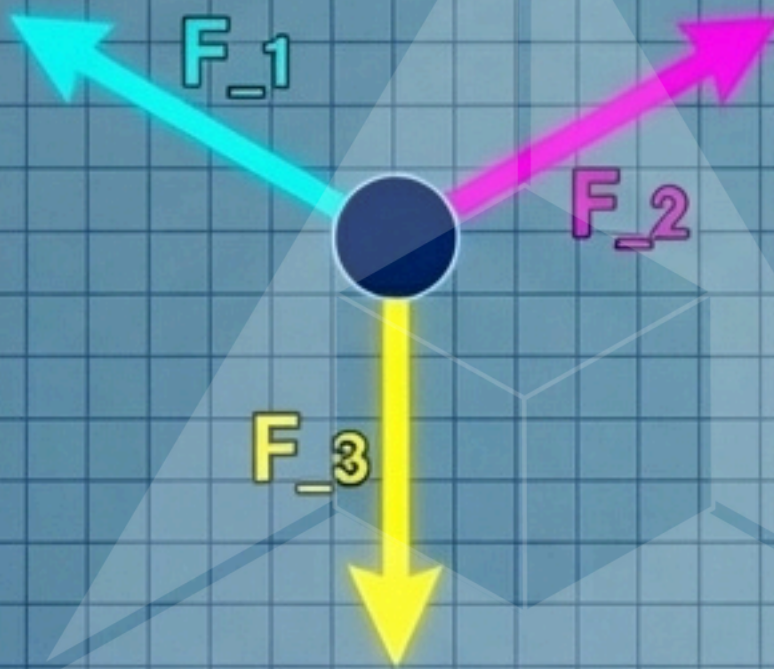
$$F_1 + F_2 + F_3 = 0 \text{ (Eq. 4.11)}$$

- “Concurrent forces” means all vector lines of action pass through the exact same particle.
- For equilibrium, the vector sum of all three forces must completely cancel out.
- The resultant of any two forces (e.g., $F_1 + F_2$) is exactly equal and opposite to the third force (F_3).

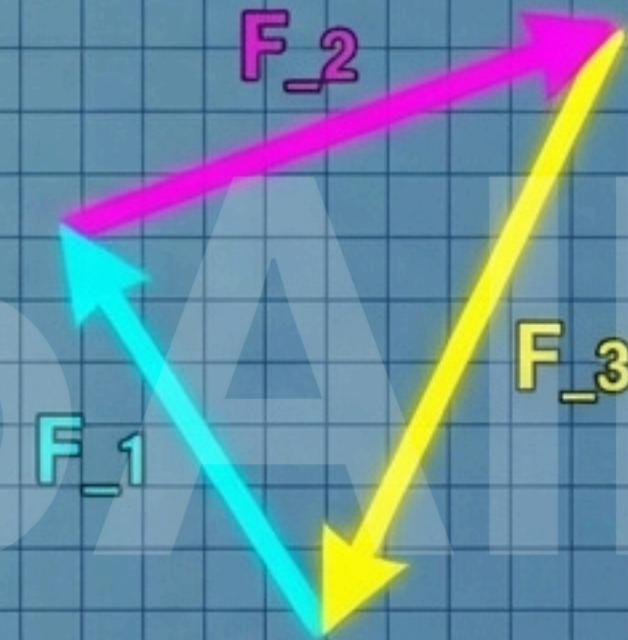


Balanced Forces Form a Closed Geometric Polygon

Concurrent Forces
Acting on a Particle



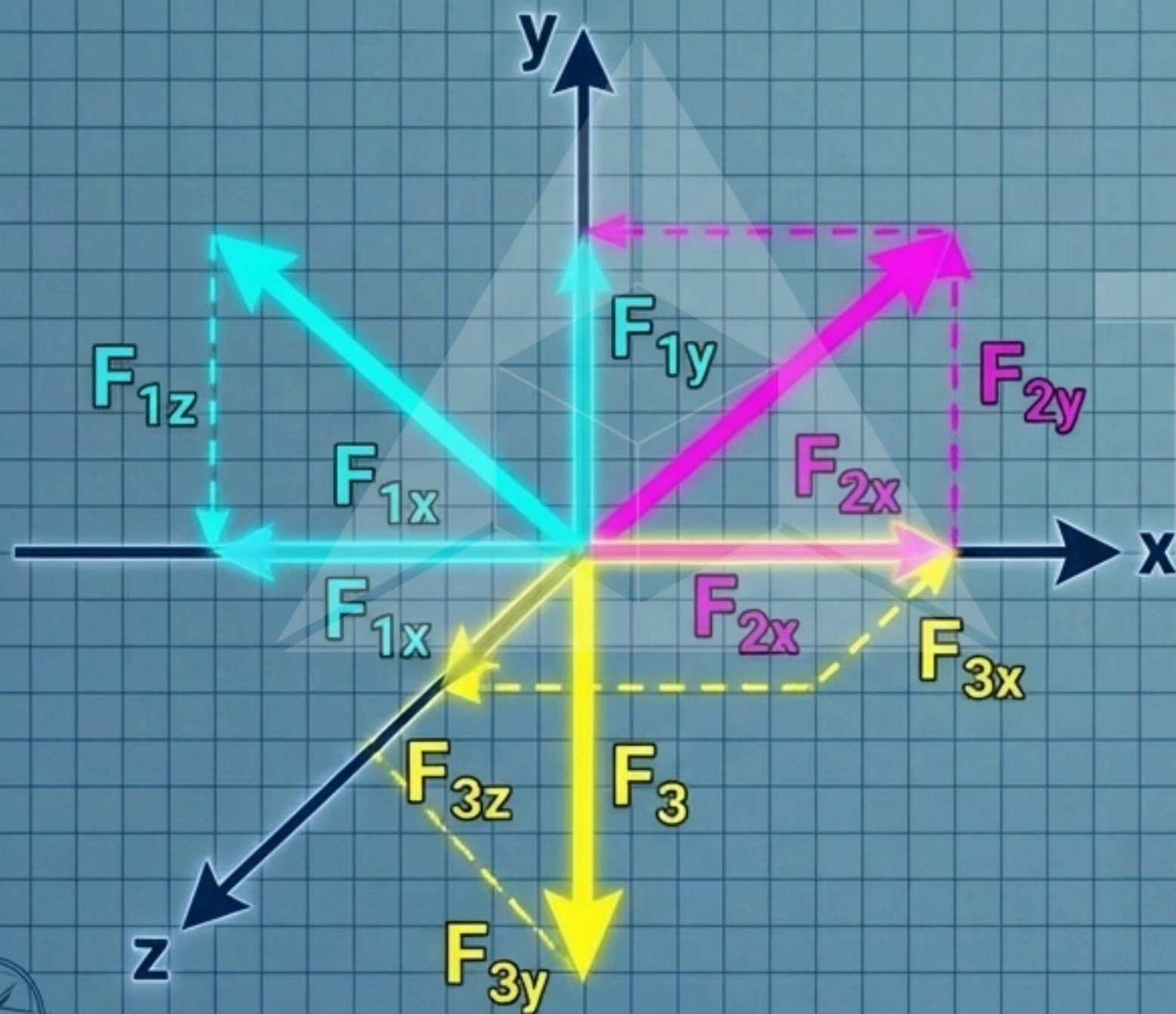
The Force Triangle
(Head-to-Tail Vector Addition)



The Polygon Rule: A particle is in equilibrium under the action of forces $F_1, F_2, \dots, F_n$ if their vectors can be arranged to form a closed, gapless n -sided polygon.

Vector Balance Translates to Algebraic Components

Equation (4.11) implies that forces must independently sum to zero along every axis of space.



$$\sum F_x = F_{1x} + F_{2x} + F_{3x} = 0$$

$$\sum F_y = F_{1y} + F_{2y} + F_{3y} = 0$$

$$\sum F_z = F_{1z} + F_{2z} + F_{3z} = 0$$

If a particle is in equilibrium, you can break any complex angled force into its perpendicular components and set each axis to zero.

The Problem-Solver's Workflow



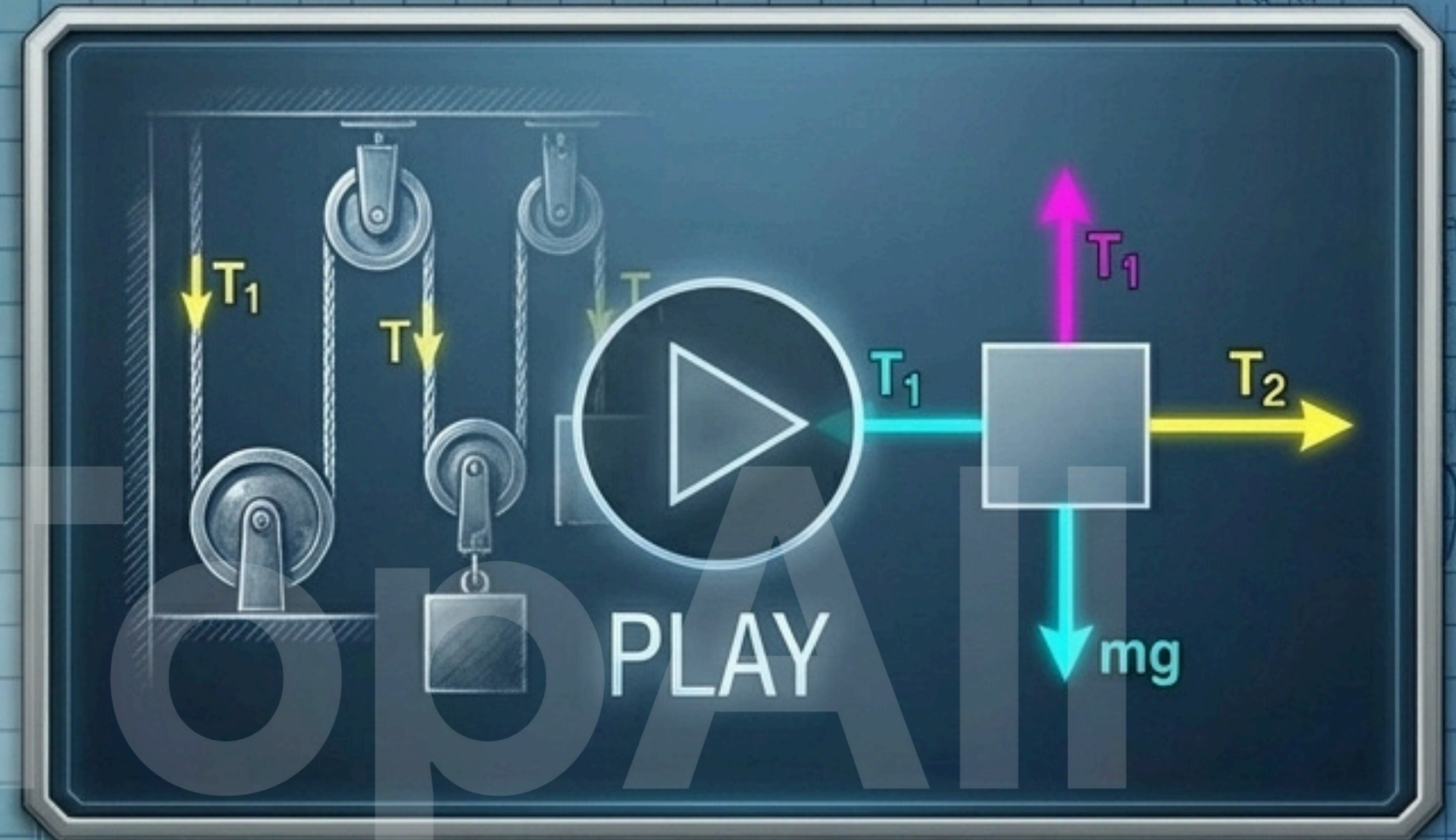
1. Isolate: Choose the particle as your specific system.



2. Map: Draw all external forces acting *on* it (Free-Body Diagram).

$$\begin{aligned}\sum F_x &= 0 \\ \sum F_y &= 0 \\ \sum F_z &= 0\end{aligned}$$

3. Resolve: Break forces into x, y, z components and equate to zero.



WATCH THE VIDEO: How to Actually Solve Mechanics Problems

See how Free-Body Diagrams turn chaotic multi-body assemblies into solvable, balanced systems.



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