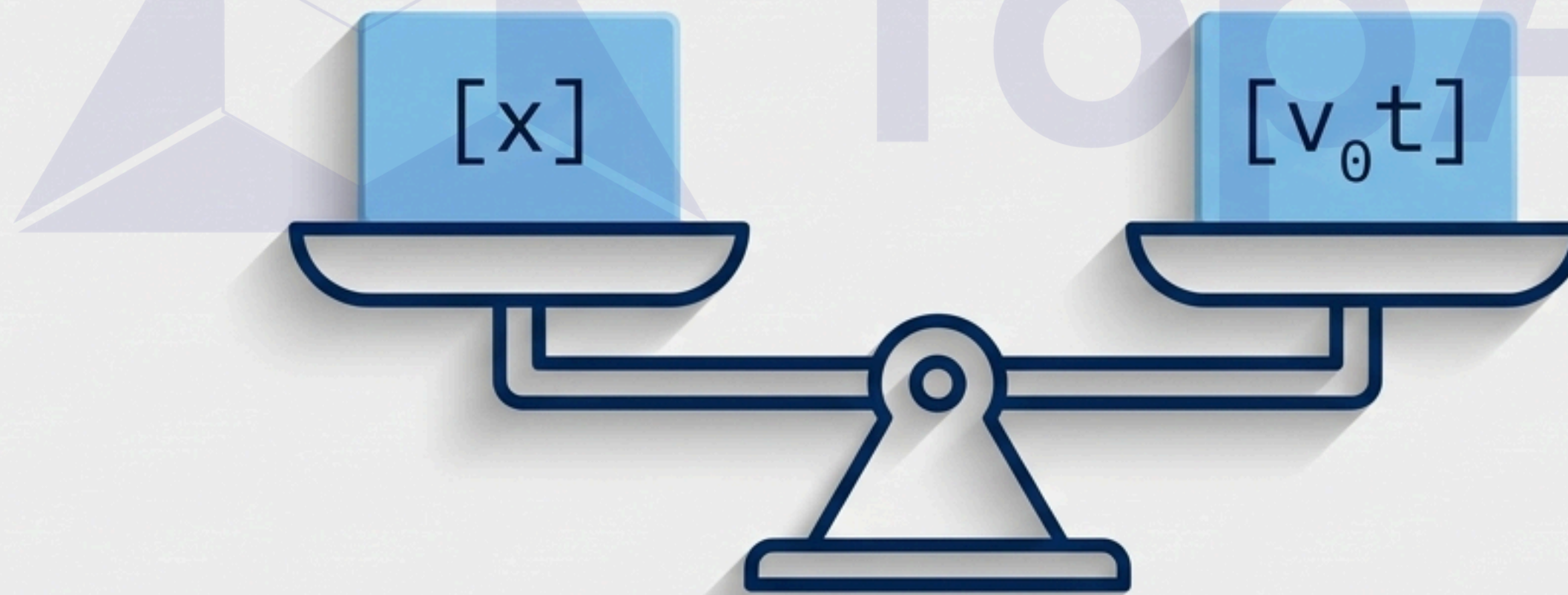


Checking Dimensional Consistency of Equations

Using the Principle of Homogeneity to verify physical formulas and instantly eliminate incorrect options.



The Principle of Homogeneity

You cannot add velocity to force, just as you cannot subtract current from temperature. In physics, magnitudes of physical quantities may be added or subtracted only if they have the exact same dimensions.

Concept Panel

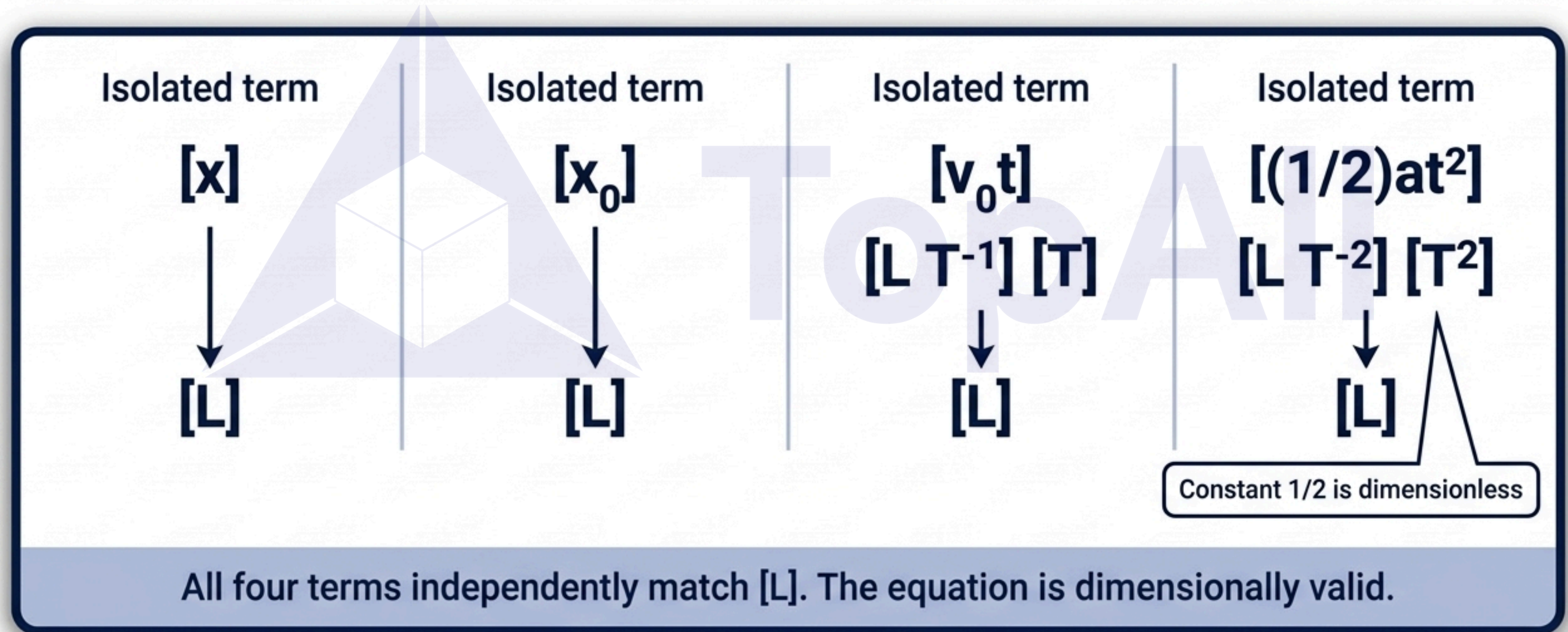
If the dimensions of all terms in an equation are not identical, the equation is physically impossible.

Mismatched dimensions =
A proven wrong equation.


$$\underset{\text{Velocity}}{[L T^{-1}]} + \underset{\text{Force}}{[M L T^{-2}]} = ?$$

Breaking Down an Equation Term-by-Term

Inspecting the kinematics equation: $x = x_0 + v_0 t + (1/2)at^2$





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Let us consider an equation $(1/2)mv^2 = mgh$ where m is mass, v is velocity, g is acceleration due to gravity, and h is height. Is this equation dimensionally correct?

LHS Panel

$$(1/2)mv^2$$

$$[M] [L T^{-1}]^2$$

$$\text{Result: } [M L^2 T^{-2}]$$

RHS Panel

$$mgh$$

$$[M] [L T^{-2}] [L]$$

$$\text{Result: } [M L^2 T^{-2}]$$

LHS = RHS. The equation is dimensionally correct.

Using Dimensions to Eliminate Wrong Options

The dimensions of Kinetic Energy (K) are $[M L^2 T^{-2}]$. Which of the following candidate formulas can we rule out?

~~(a) $K = m^4 v^3 \rightarrow$ Evaluates to $[M^4 L^3 T^{-3}]$~~

(b) $K = (1/2)mv^2 \rightarrow$ Evaluates to $[M L^2 T^{-2}]$ ✓

~~(c) $K = ma \rightarrow$ Evaluates to $[M L T^{-2}]$~~

(d) $K = (3/16)mv^2 \rightarrow$ Evaluates to $[M L^2 T^{-2}]$ ✓

~~(e) $K = (1/2)mv^2 + ma \rightarrow$ Mismatched terms ($[M L^2 T^{-2}] + [M L T^{-2}]$)~~

Callout Note: Notice: Dimensions alone cannot pick between the valid options (b) and (d). Constants like 1/2 and 3/16 have no dimensions!



TRAP ALERT

The Limit of Dimensional Consistency

“Passing the dimensional check does NOT prove an equation is exactly correct — it only proves a failing equation is wrong.”

The Blind Spot

Dimensional analysis completely ignores dimensionless constants (like π , $1/2$, pure numbers) and **dimensionless functions** (like $\sin \theta$ or $\log x$).

The Rule of Thumb

If it fails the check, it is **100% wrong**.

If it passes, it is only **possibly right**.

Concept 8 Summary

1

The Rule

Principle of homogeneity: only quantities with the exact same dimensions can be added or subtracted.

2

The Math

The dimensions of every individual term on both sides of a mathematical equation must be identical.

3

The Verdict

Mismatched dimensions = wrong equation; matched dimensions = only possibly right. Final formula verification requires the actual physical definition.



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