

Balancing Point

Centre of Mass

Systems of Particles & The Balancing Point

Class 11 physics - 6.2 Centre of Mass

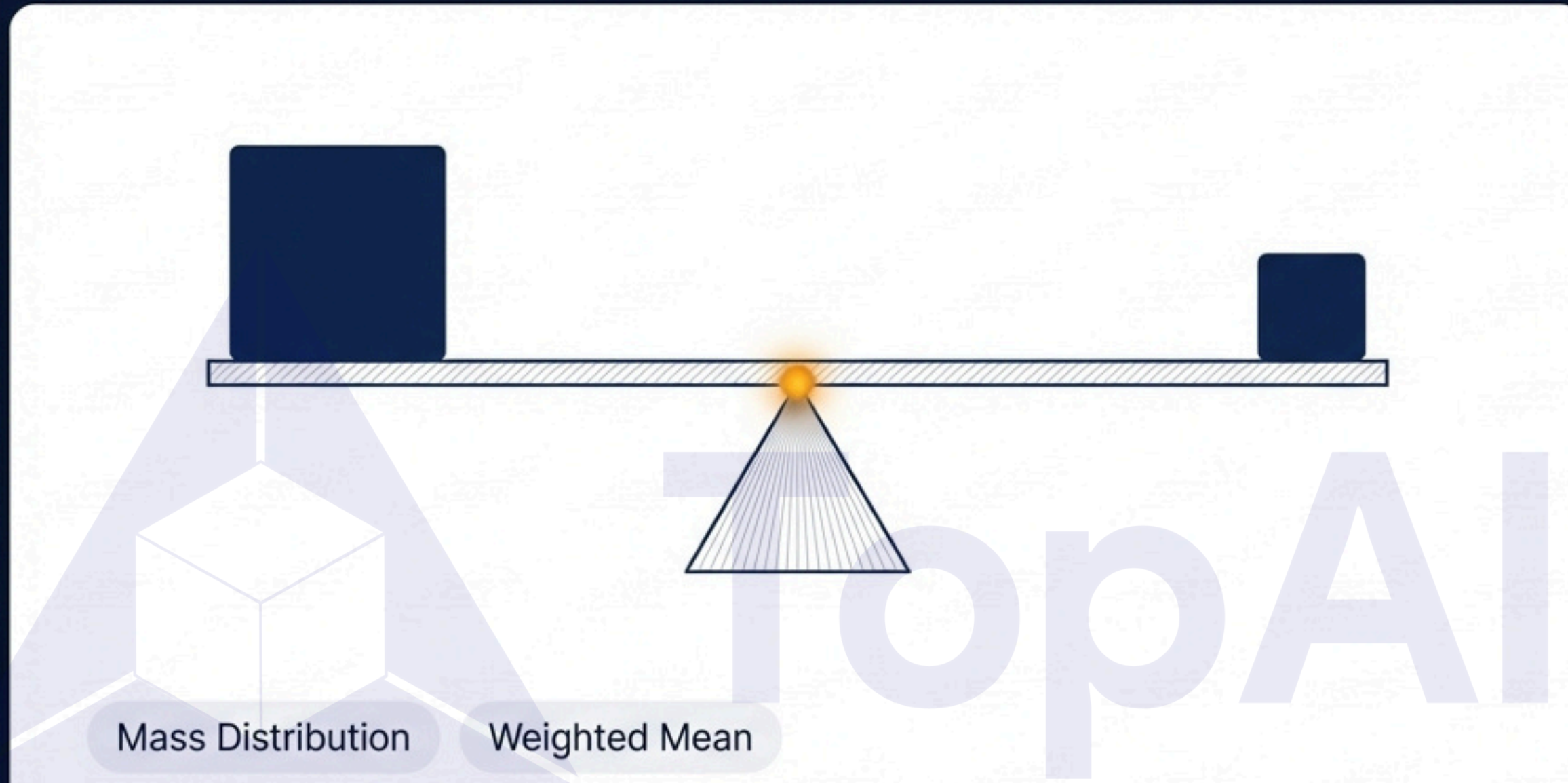
3D System



Balancing Point



Physical Reality



The centre of mass of a system of particles is the specific point where the entire mass of the system can be assumed to be concentrated. It acts as the mass-weighted average position of all particles in the system.

The Two-Particle System

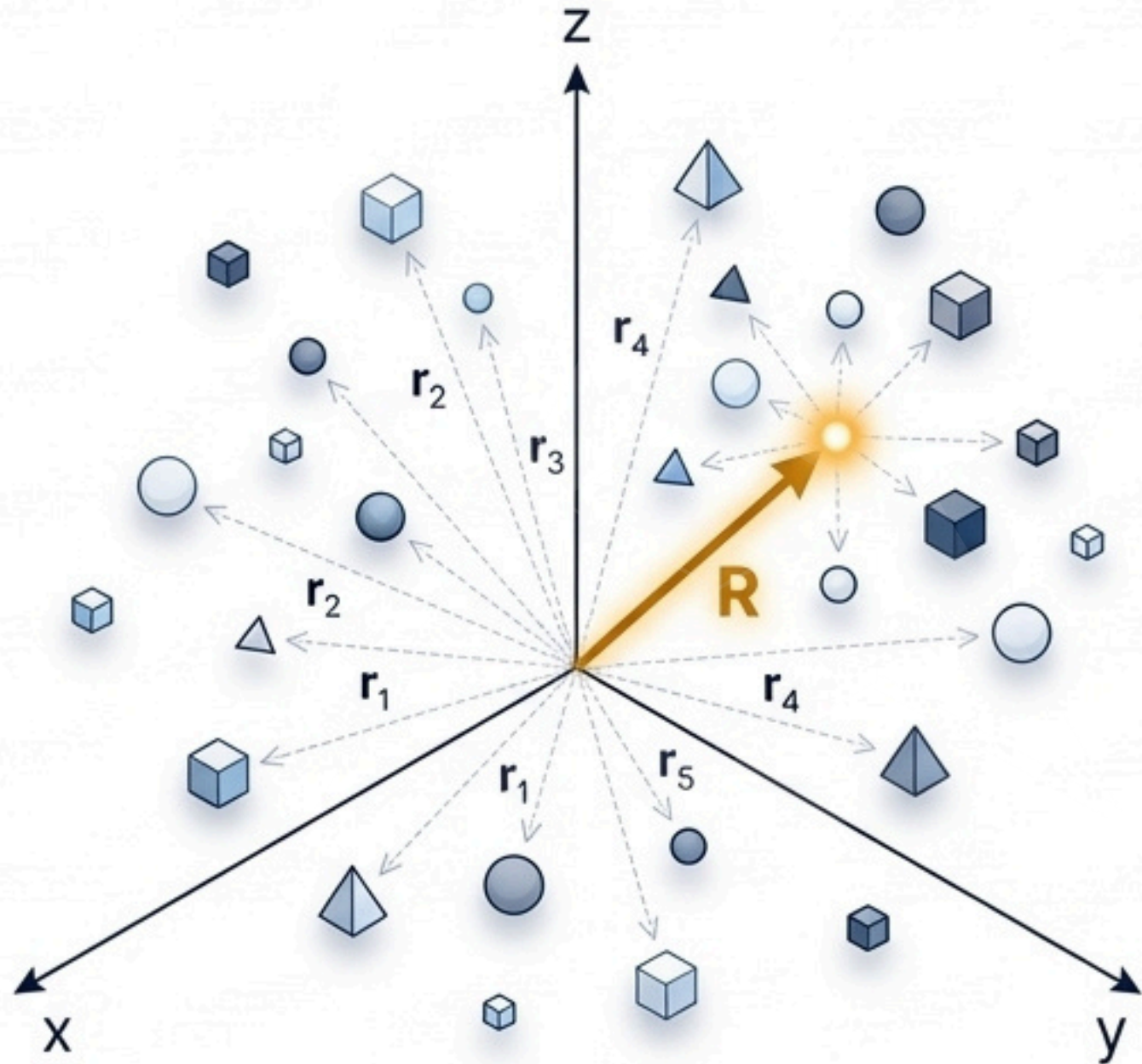


$$X = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

The centre of mass always shifts toward the heavier mass.

If $m_1 = m_2$, the COM lies exactly **midway** between them.

H1: Scaling to Many Particles (n-system)



$$\mathbf{R} = \frac{\sum m_i \mathbf{r}_i}{M}$$

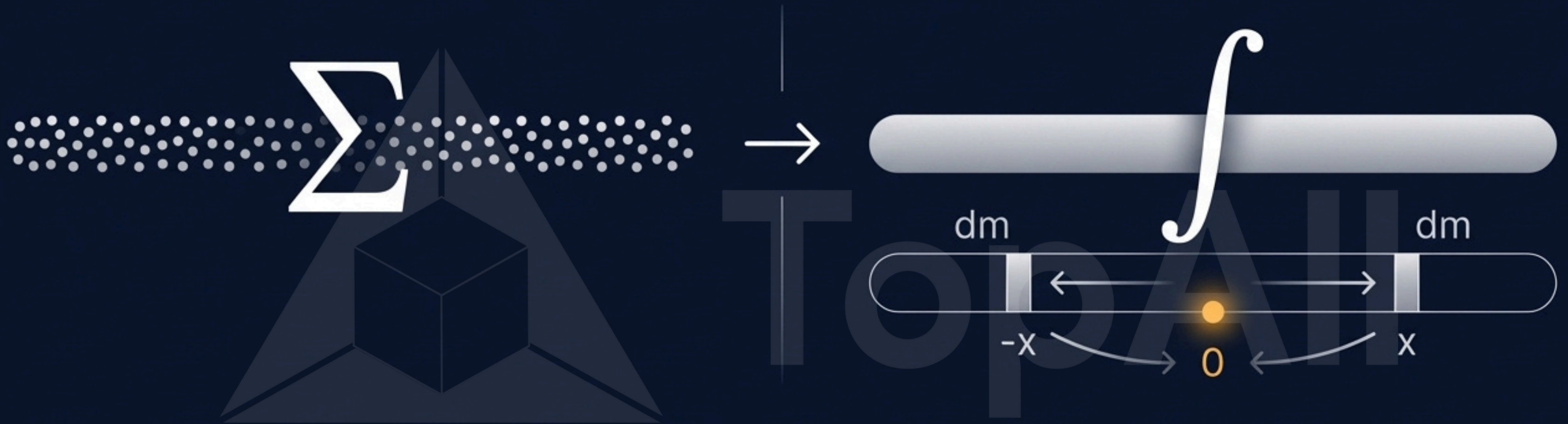
For n particles distributed in space, the COM is the vector sum of individual mass moments divided by the total mass M.

Insight: If the origin is chosen to be the centre of mass, then $\sum m_i \mathbf{r}_i = 0$.

Continuous Bodies & The Role of Symmetry



Symmetry



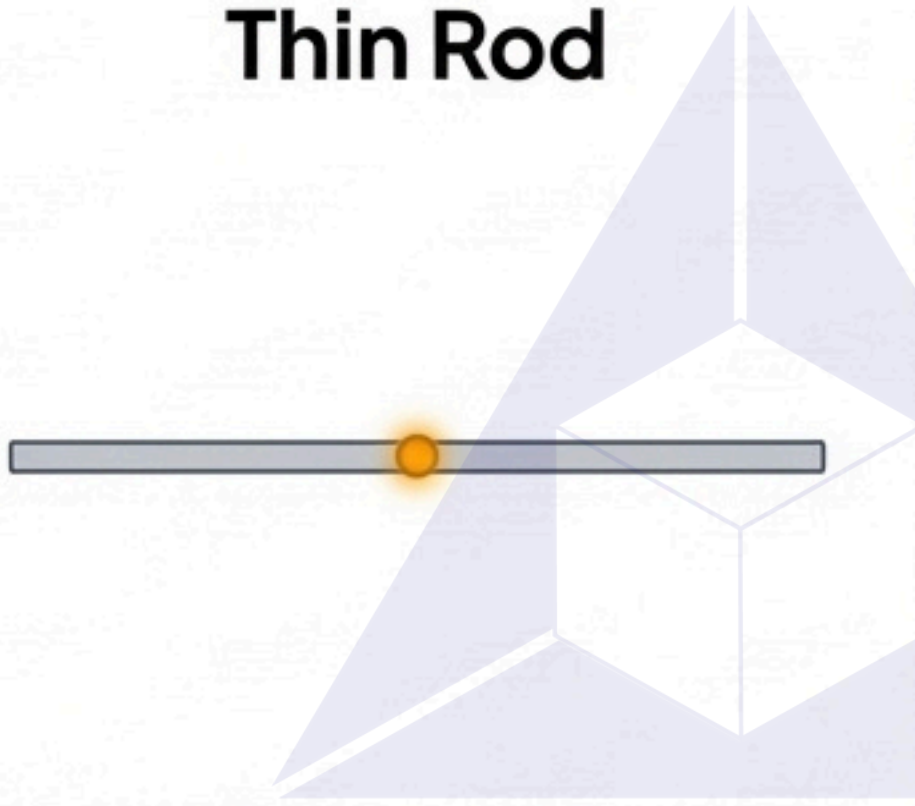
When particles pack closely,
summation becomes integration:

$$X = \frac{1}{M} \int x \, dm$$

For homogeneous bodies, reflection symmetry dictates that for every element dm at x , an identical element exists at $-x$. The net integral is zero, placing the COM precisely at the geometric centre.

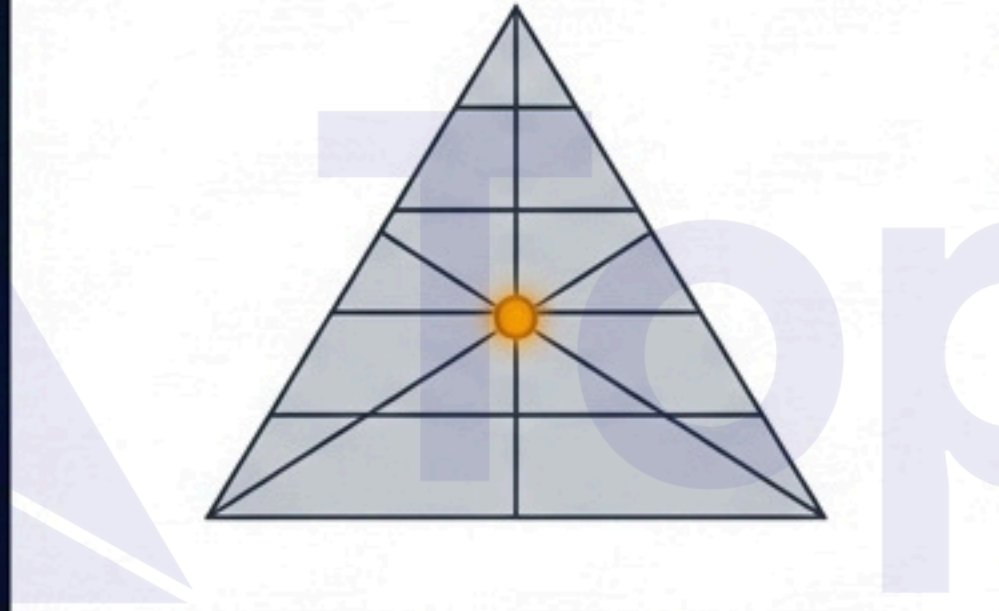
Standard Geometric Geometries

Thin Rod



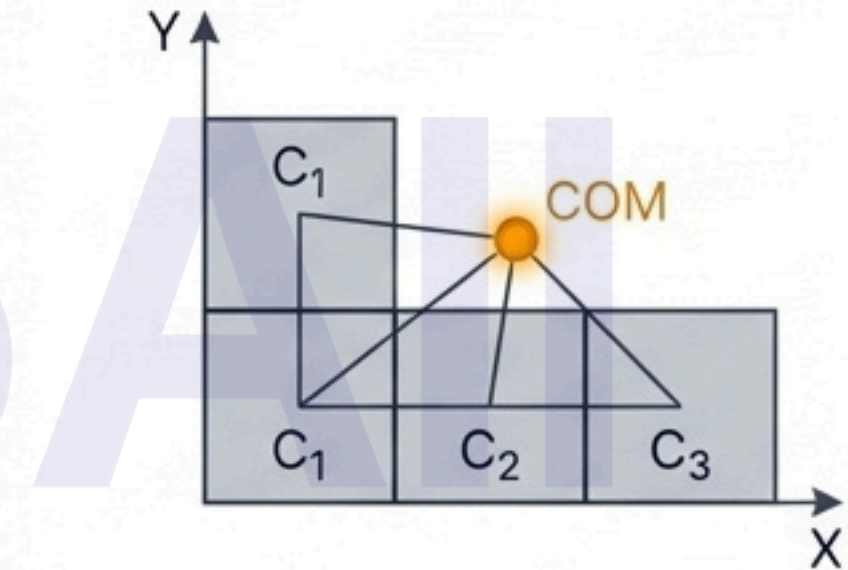
COM at the Midpoint.
(Derived via reflection symmetry).

Triangular Lamina



COM at the Centroid (the
point of concurrence of
the three medians).

L-Shaped Lamina



COM found by treating the
body as 3 distinct point
masses at the centers of
its composite squares.

Key Takeaways

1. The Centre of Mass is strictly a **mass-weighted average position**.
2. For bodies with **uniform mass distribution, symmetry** dictates the COM location (e.g., the geometric centre).
3. The concept applies equally to **2-particle systems, 3D particle clouds**, and **continuous integrated bodies**.

Common Pitfalls

- ✗ **Mistake:** Assuming the COM is always the geometric center.
Correction: This is only true if the mass density is uniform.
- ✗ **Mistake:** Believing the COM must lie inside the physical object.
Correction: The COM can exist in empty space outside the body (e.g., an L-shaped lamina or a uniform ring).