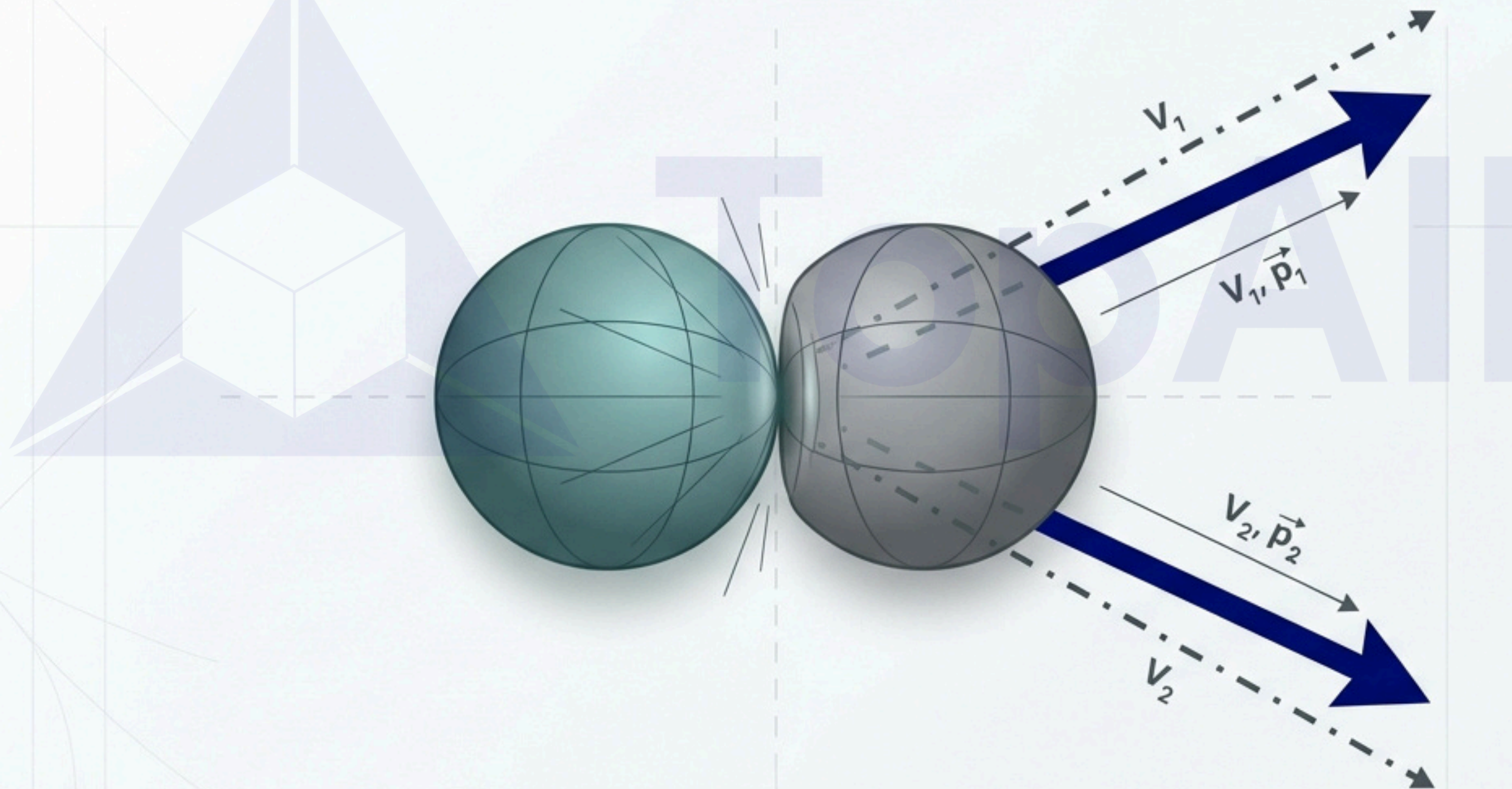


5.11.3 MECHANICS

Collisions in Two Dimensions

Breaking down momentum conservation into independent x and y components.





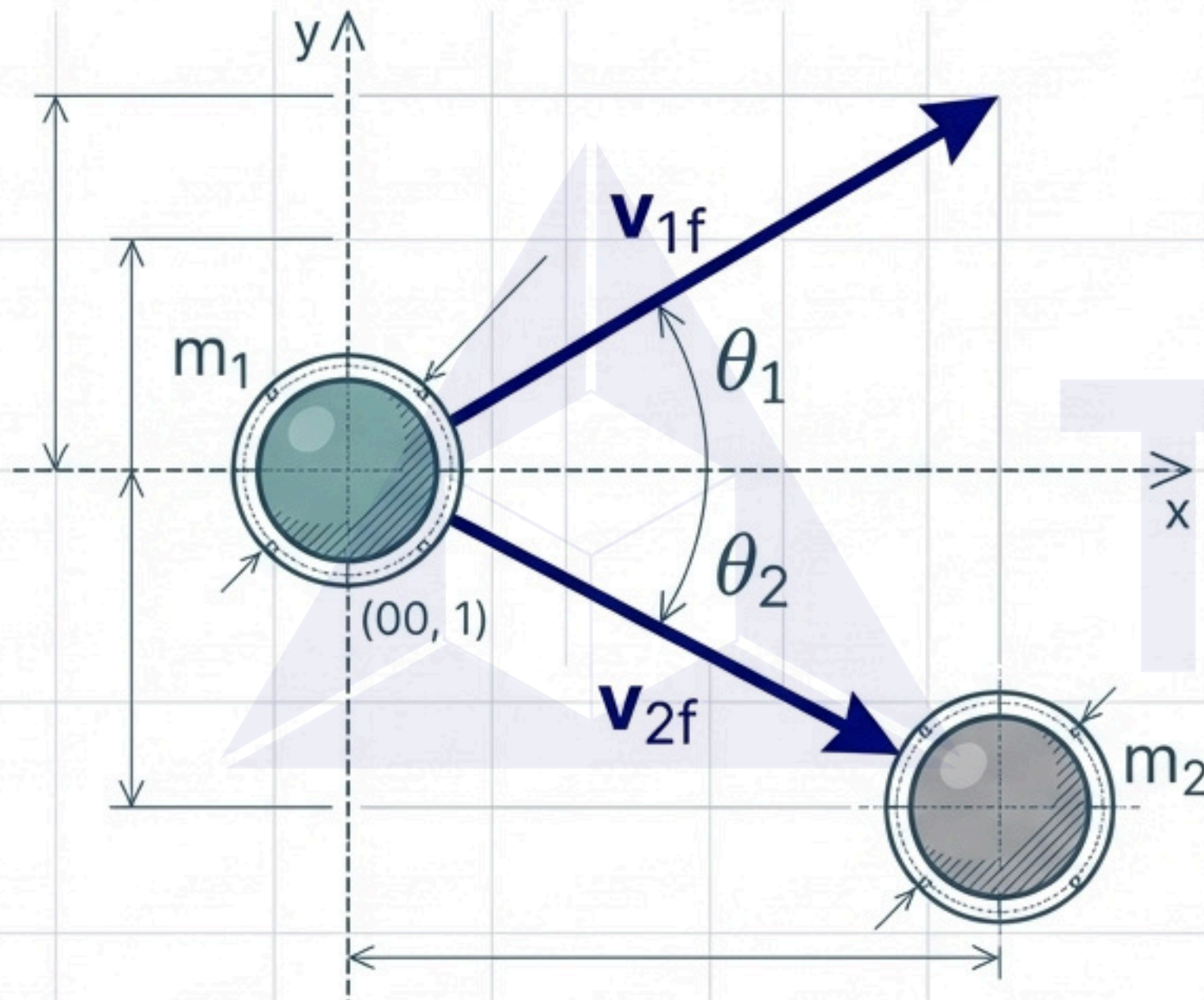
INITIAL STATE

- Target mass 1 (m_1): Moving with initial speed v_{1i} .
- Target mass 2 (m_2): Stationary at the origin.

$p_{ix} = m_1 v_{1i}$ (All initial momentum is concentrated purely on the x-axis)

$p_{iy} = 0$ (Initial y-momentum is absolutely zero)

The Geometry of Deflection



THE 4 UNKNOWNNS OF 2D SCATTERING

- $\mathbf{v}_{1f}$: Final speed of mass 1
- $\mathbf{v}_{2f}$: Final speed of mass 2
- θ_1 : Deflection angle of mass 1
- θ_2 : Deflection angle of mass 2

Planar Motion: The z-component momentum is zero, trapping the entire collision exclusively in the x-y plane.



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Let's Test Them Now.**

$$E=mc^2$$



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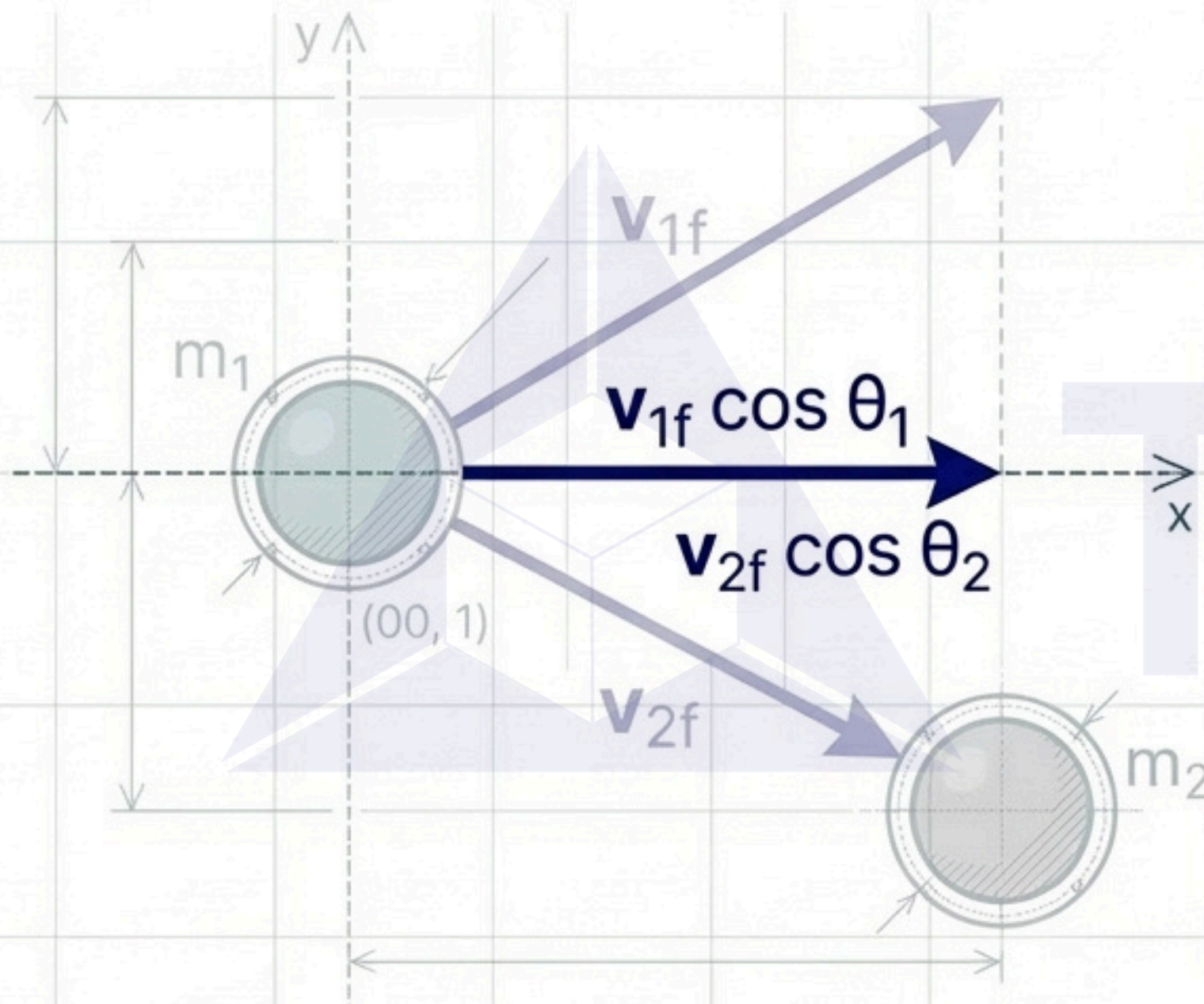
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Conserving the Horizontal

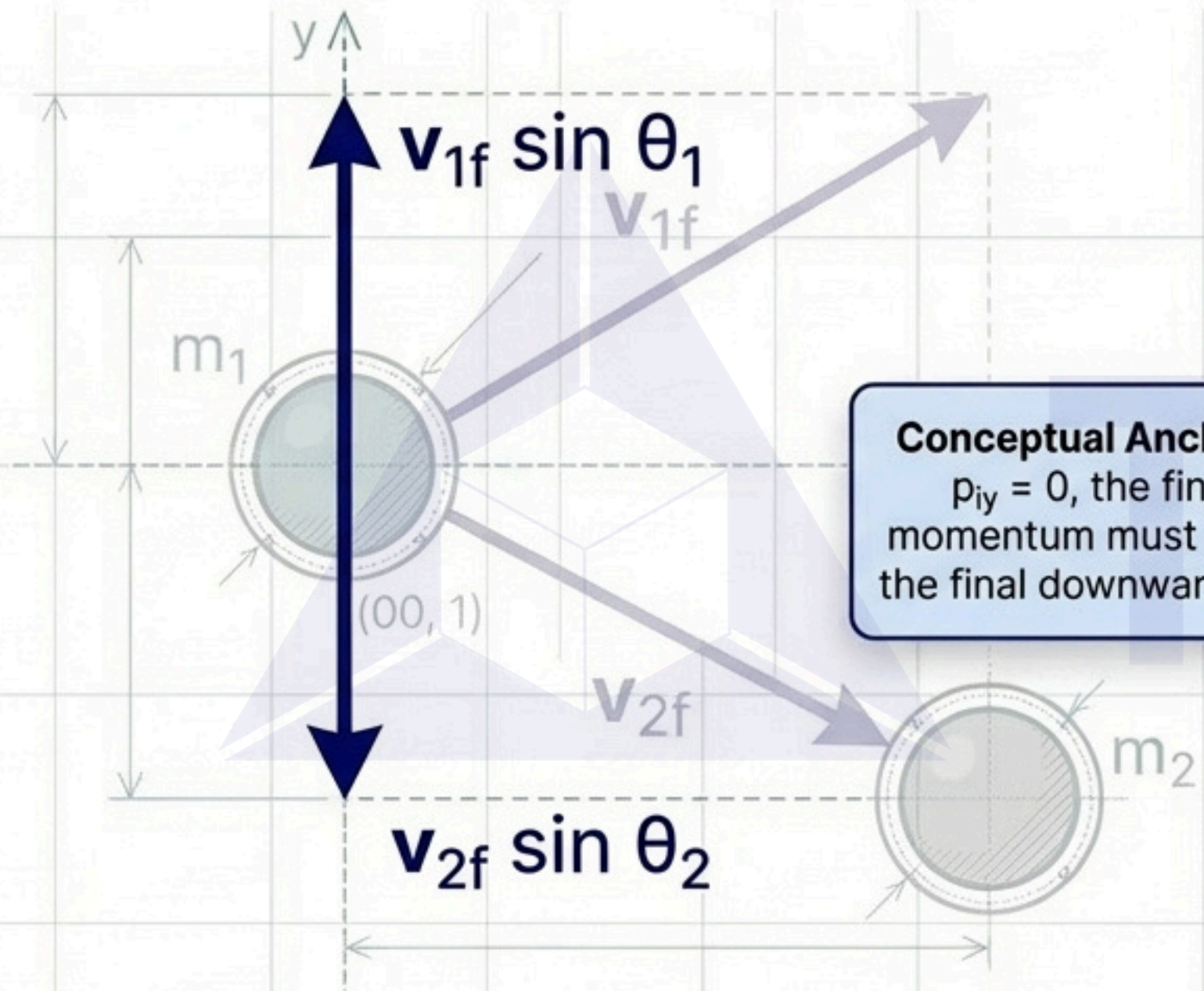


X-AXIS RESOLUTION

$$m_1 v_{1i} = m_1 v_{1f} \cos \theta_1 + m_2 v_{2f} \cos \theta_2$$

Translation: The initial x-momentum of the moving mass perfectly equals the sum of the horizontal components of both final momenta.

Canceling the Vertical



Conceptual Anchor: Because $p_{iy} = 0$, the final upward momentum must exactly equal the final downward momentum.

Y-AXIS RESOLUTION

$$0 = m_1 v_{1f} \sin \theta_1 - m_2 v_{2f} \sin \theta_2$$

Translation: Notice the minus sign. The downward projection of m_2 physically subtracts from the upward projection of m_1 to net zero.

Exam Synthesis: Solving 2D Systems

Orthogonal Independence

The x and y axes are solved completely separately. Treat one 2D collision as two independent 1D math problems.

The Equation Deficit

You have 4 unknowns (v_{1f} , v_{2f} , θ_1 , θ_2) but only 2 momentum equations. You cannot solve the system unless the question provides additional data (like one of the scattering angles).

The Elasticity Bonus

If the prompt states the collision is perfectly elastic, Kinetic Energy is conserved ($K_i = K_f$). This unlocks a crucial 3rd equation: $\frac{1}{2}m_1v_{1i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$



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