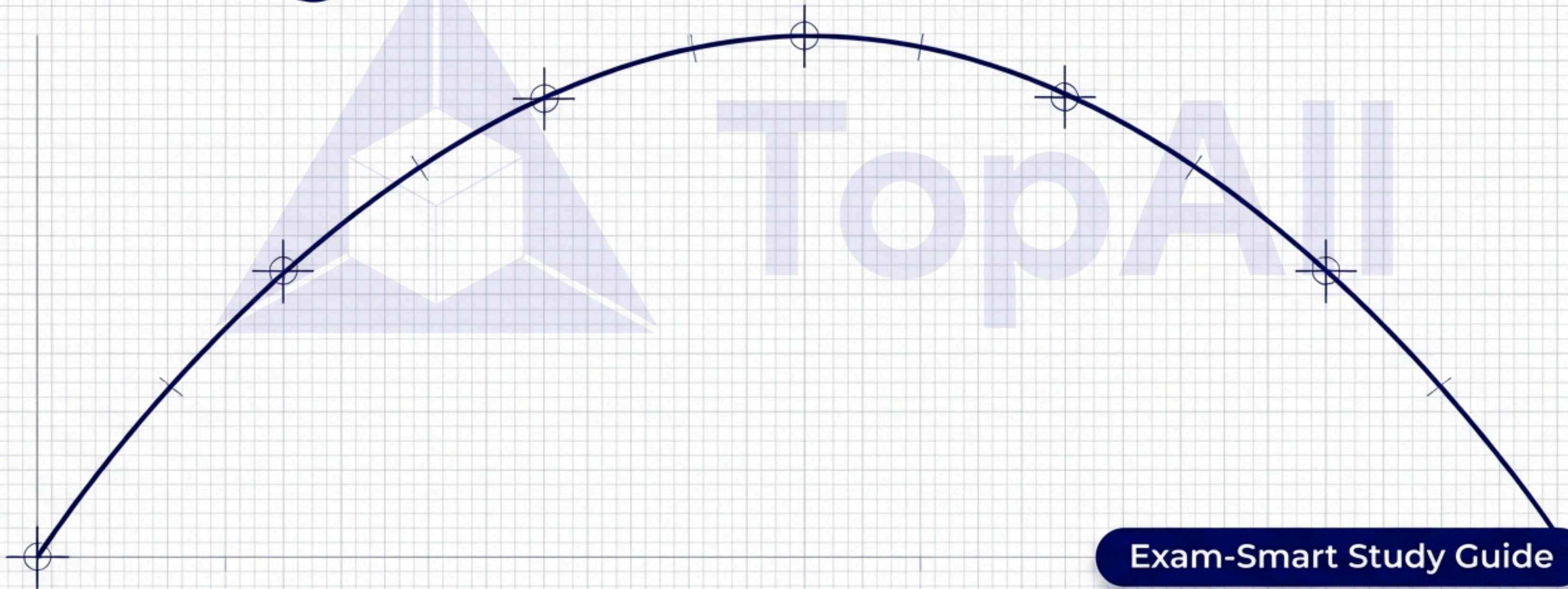


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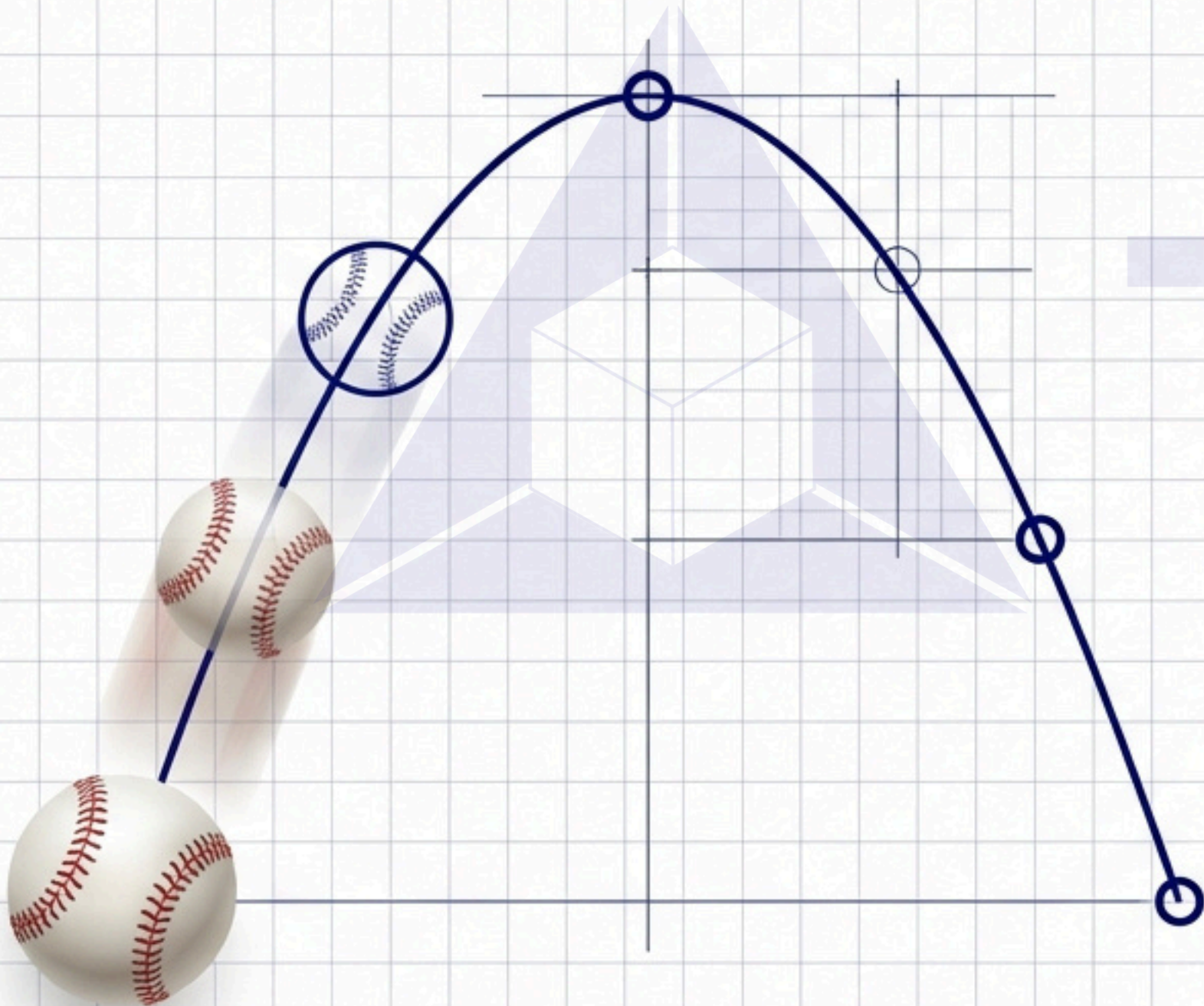


Projectile Motion



CONCEPTUAL FOUNDATION

Objects in Free Flight



DEFINITION

A projectile is any object in flight after being thrown or projected. Once launched, it is no longer propelled by any engine or biological force.

KEY ASSUMPTION

The foundational equations assume the neglect of air resistance. Gravity is the only active force influencing the object's path.

Galileo's Principle of Independent Motions



Horizontal Motion (x-axis)

$$a_x = 0$$

Moves with constant velocity. Without air resistance, nothing slows the projectile down horizontally.



Vertical Motion (y-axis)

$$a_y = -g$$

Moves with constant acceleration. The continuous downward force of gravity constantly alters vertical speed.

Crucial Insight: These two motions occur simultaneously but act entirely independently of each other.



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

$$E=mc^2$$



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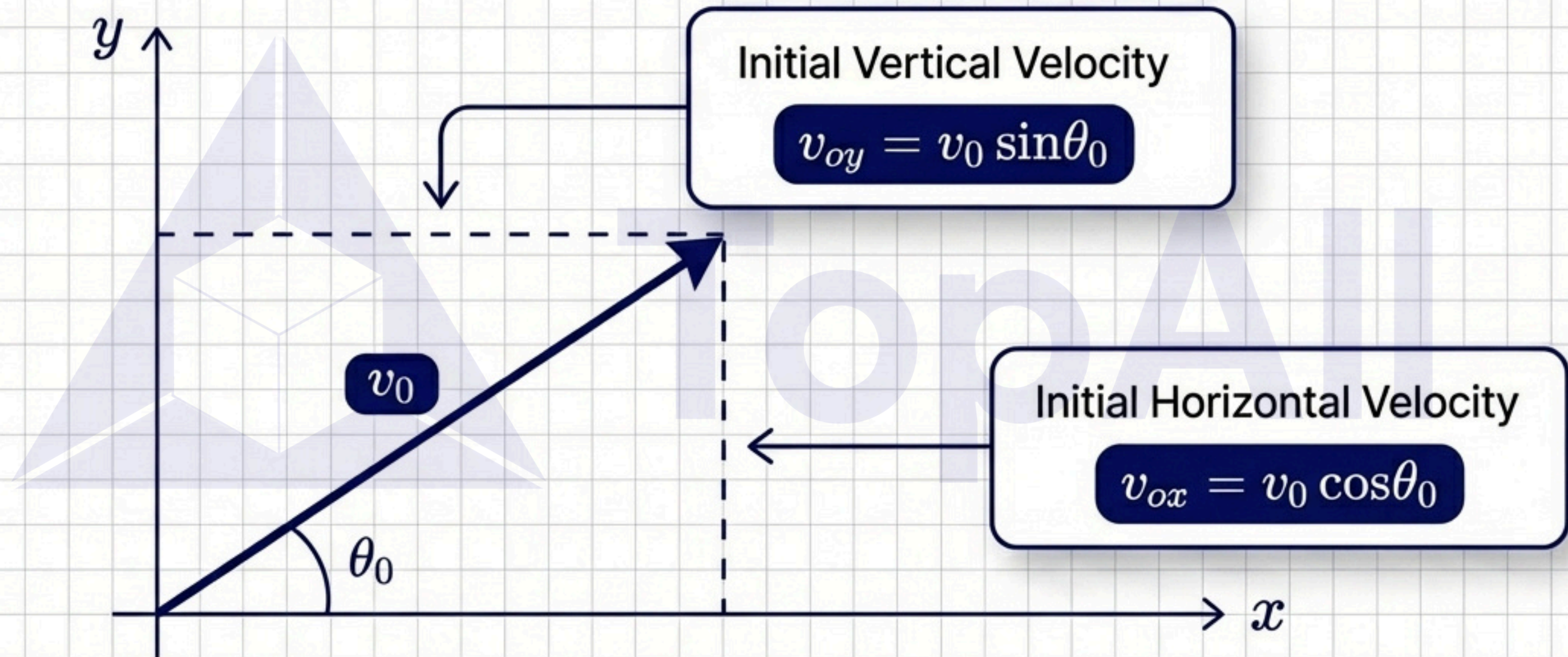
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- » Climb the Leaderboard Among Fellow Aspirants
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Establishing the Launch Vector



All subsequent kinematic equations are built upon these initial trigonometric components.

Locating the Projectile in Space



Constant Velocity Logic

X-Position

Because horizontal acceleration is zero, position is simply velocity multiplied by time.

$$x = (v_0 \cos\theta_0)t$$

Accelerated Motion Logic

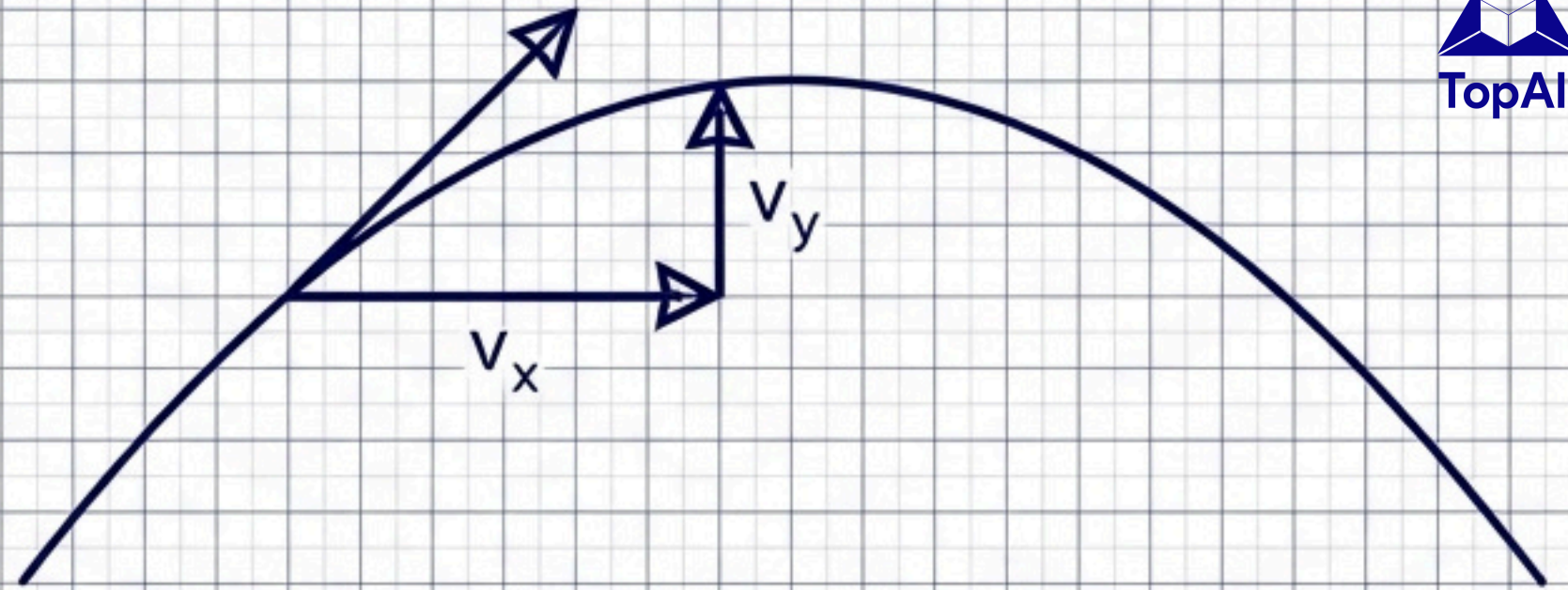
Y-Position

Vertical position must account for the initial upward velocity minus the displacement caused by gravity over time.

$$y = (v_0 \sin\theta_0)t - \frac{1}{2}gt^2$$

KINEMATICS AT TIME T

Calculating Speed and Direction Over Time



Unchanging

X-Velocity

Horizontal velocity remains completely constant throughout the entire duration of the flight.

$$v_x = v_0 \cos\theta_0$$

Gravity Dependent

Y-Velocity

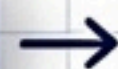
Vertical velocity continuously decreases on the way up, hits zero at the peak, and increases negatively on the way down.

$$v_y = v_0 \sin\theta_0 - gt$$

The Equation of the Path

Derivation Flow

Step 1: Isolate time (t) from the x-position equation.

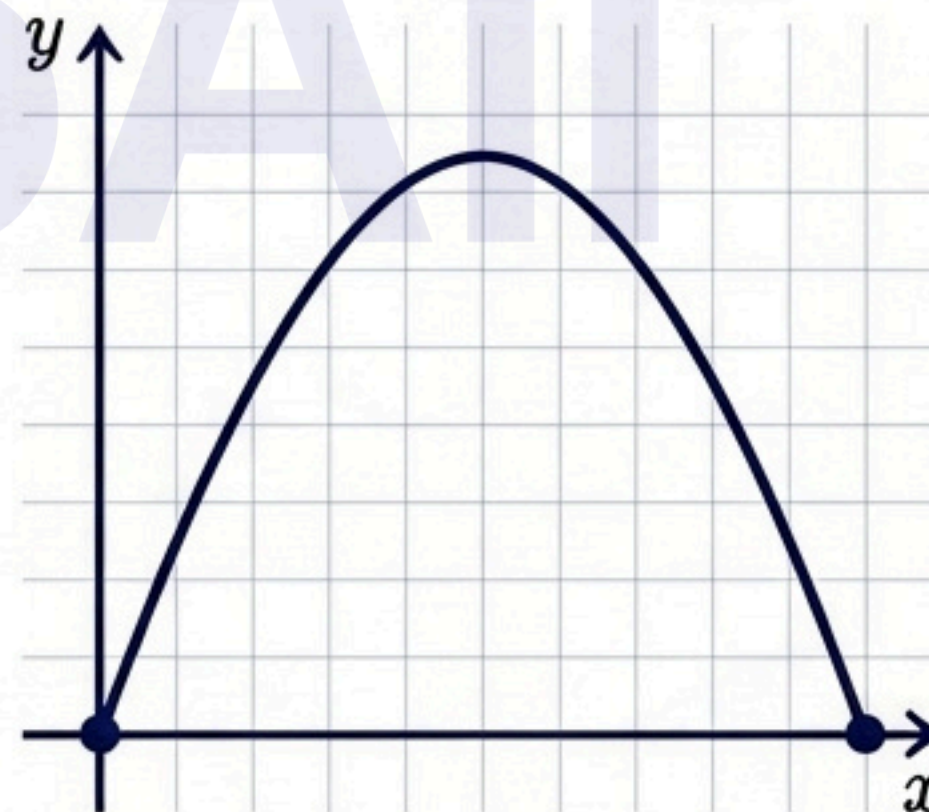


Step 2: Substitute that t value into the y -position equation.

Mathematical Proof of the Parabola

$$y = x \tan \theta_0 - \frac{gx^2}{2v_0^2 \cos^2 \theta_0}$$

Because g , θ_0 , and v_0 are constants, this equation matches the standard quadratic form ($y = ax - bx^2$). This mathematically proves that the trajectory of a projectile is always a parabola.



The Four Core Macro Equations



Time to Maximum Height (t_m)

Occurs precisely when vertical velocity (v_y) reaches zero.

$$t_m = v_0 \sin\theta_0 / g$$



Total Time of Flight (T_f)

Because the parabola is perfectly symmetrical, total time is exactly double the time to the peak.

$$T_f = 2v_0 \sin\theta_0 / g$$



Maximum Height (h_m)

The peak vertical displacement achieved during the flight.

$$h_m = v_0^2 \sin^2\theta_0 / 2g$$

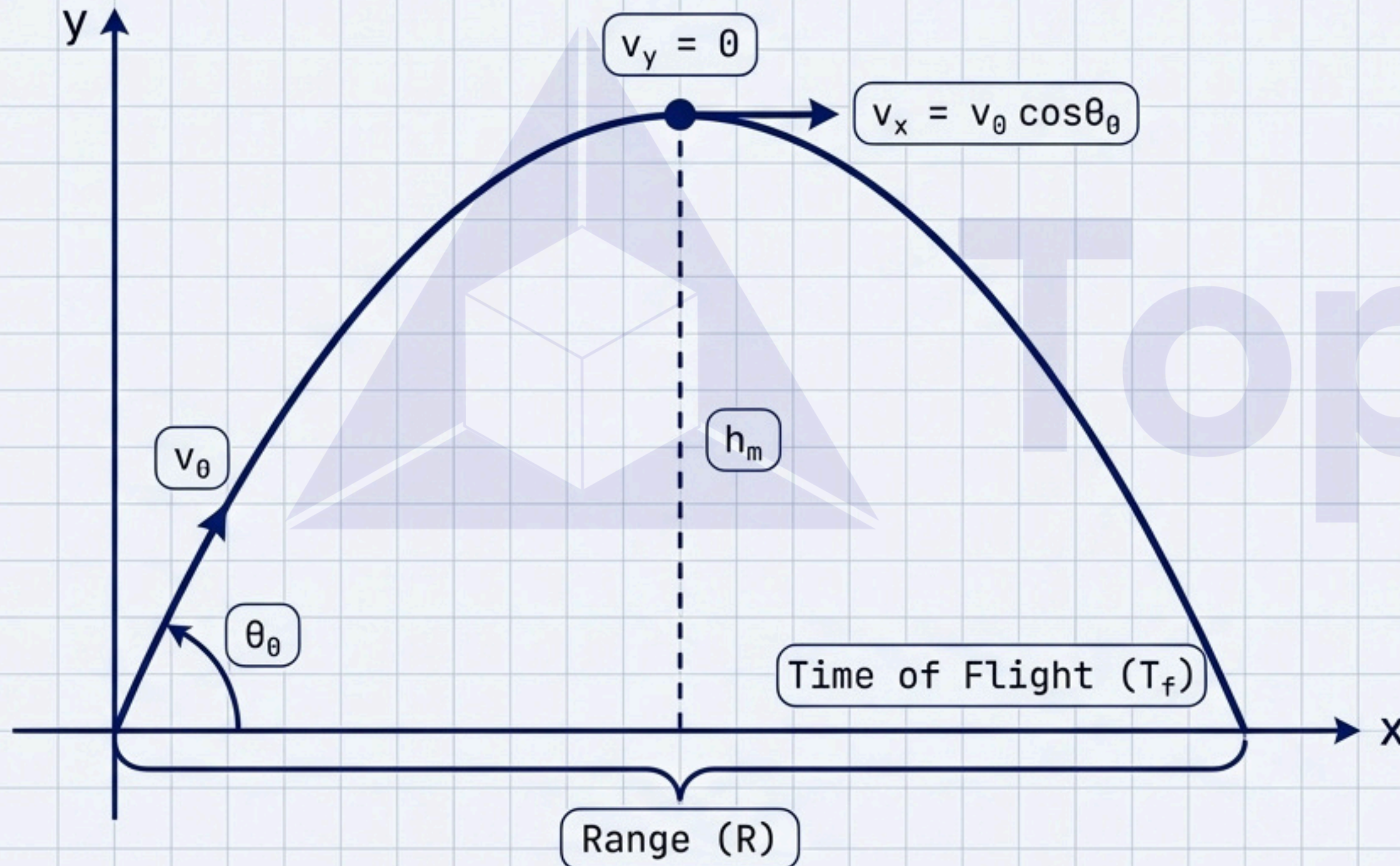


Horizontal Range (R)

Total horizontal distance covered. Maximum range is achieved at a 45° launch angle.

$$R = v_0^2 \sin 2\theta_0 / g$$

Projectile Motion Master Schematic



Exam-Ready Summary

1. Horizontal (x) and vertical (y) motions are 100% independent.
2. Horizontal velocity never changes ($a_x = 0$).
3. Vertical velocity is dictated purely by gravity ($a_y = -g$).
4. Time (t) is the only variable linking the x and y axes together.



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