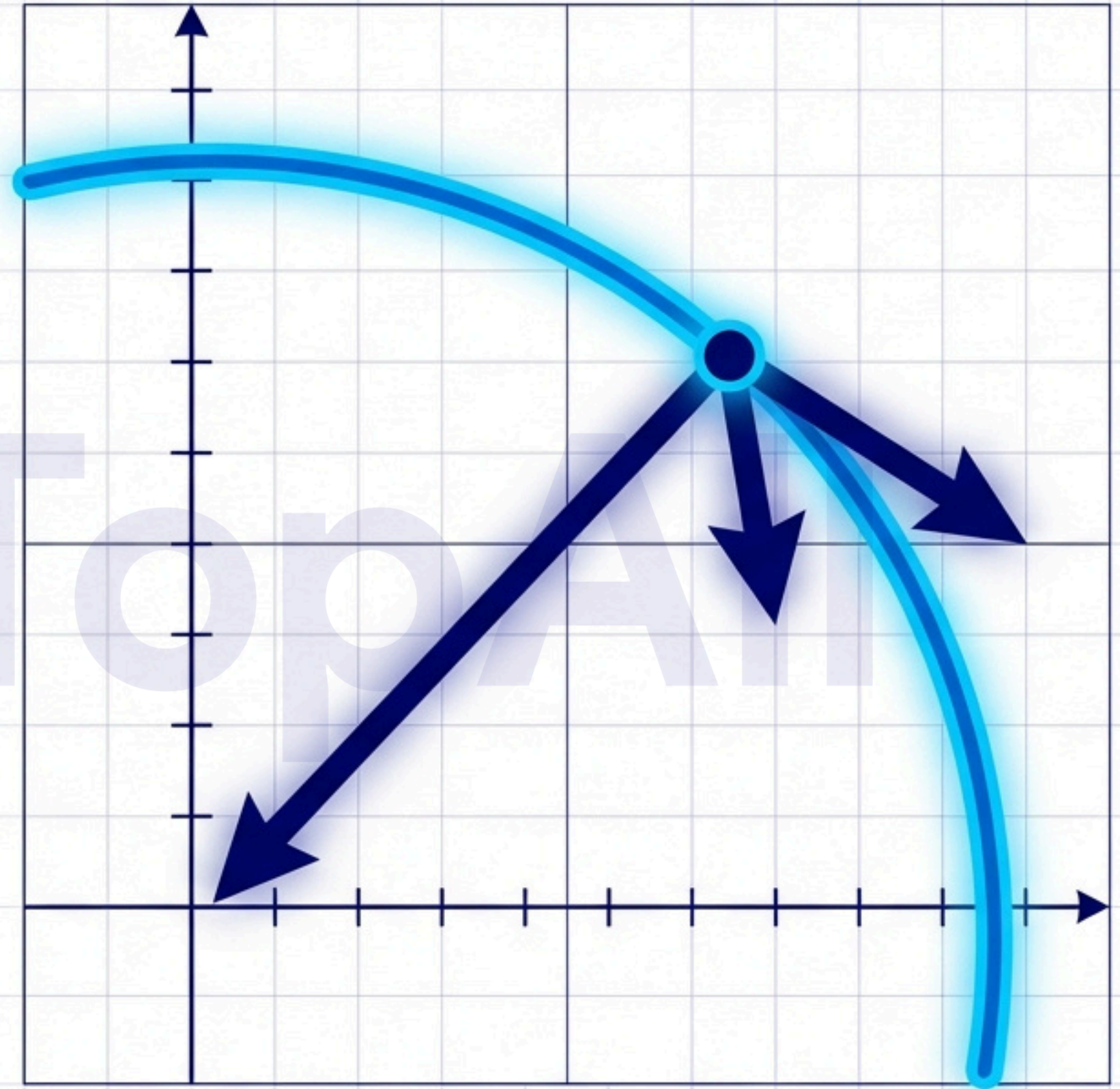




CLASS 11 PHYSICS • CHAPTER 3.7

Motion in a Plane

The geometric reality of two-dimensional kinematics.



THE STARTING POINT

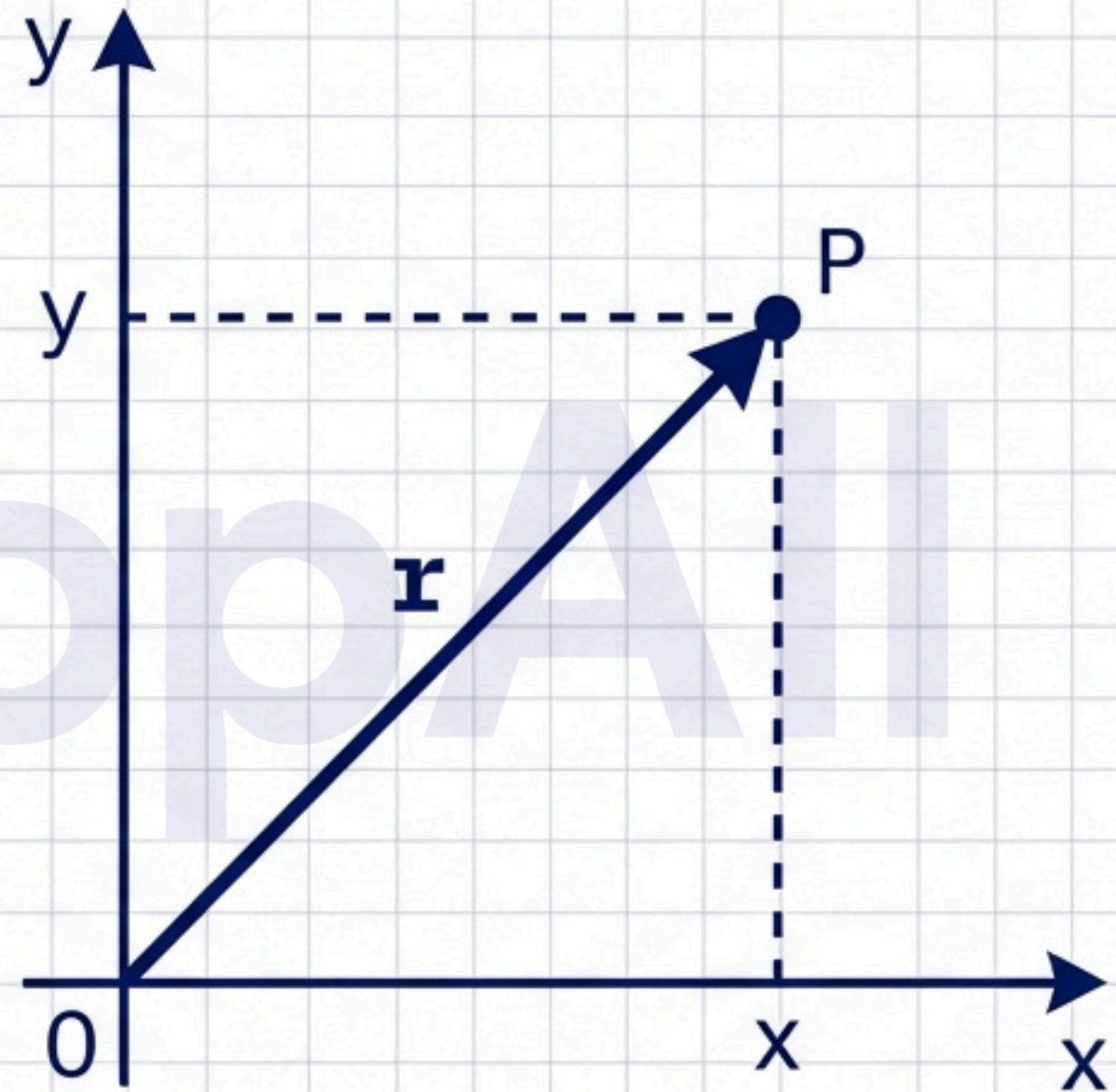
Position Vector in 2D



$$\mathbf{r} = x\hat{i} + y\hat{j}$$

x coordinate →
mapped to the $\hat{i}$
(horizontal)
direction

y coordinate →
mapped to the $\hat{j}$
(vertical)
direction



THE BRIDGE BETWEEN STATES

Displacement in 2D



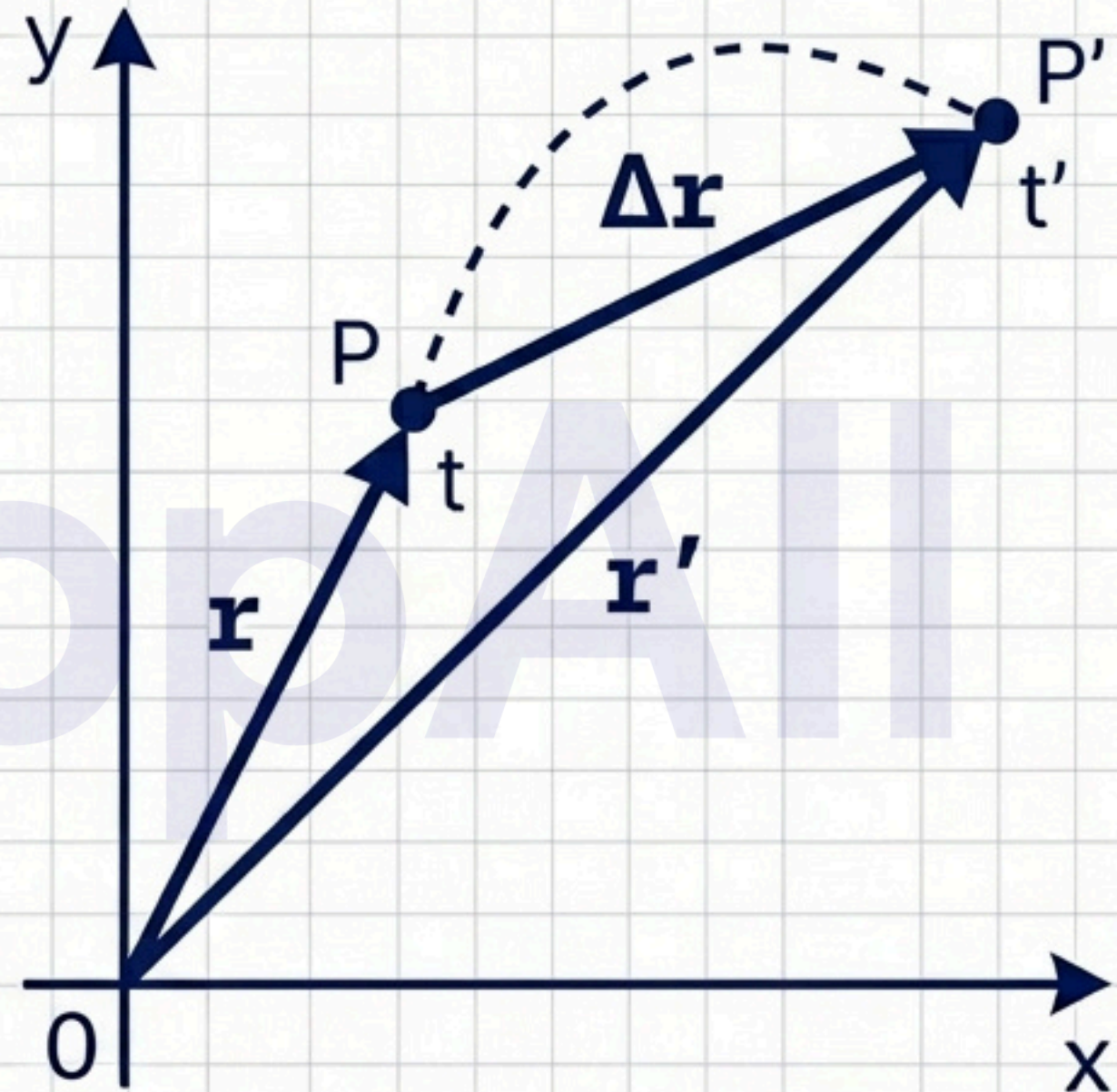
$$\Delta \mathbf{r} = \mathbf{r}' - \mathbf{r}$$

Displacement
(Vector $\Delta \mathbf{r}$)

The shortest straight line.
Depends only on initial
and final positions.

Path Length
(Scalar)

The actual journey.
Always $\geq$ magnitude
of displacement.





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

$$E=mc^2$$



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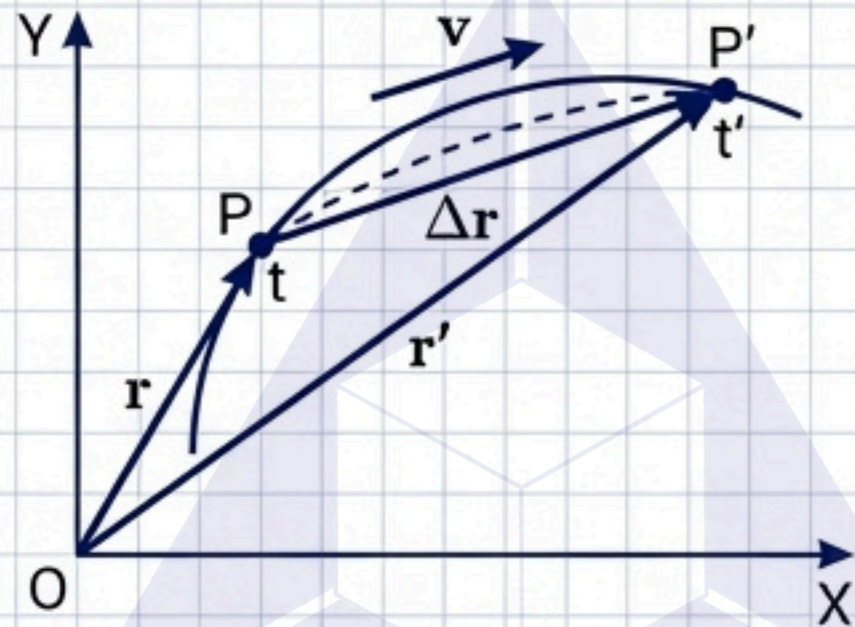
Key Highlights

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Average vs. Instantaneous Velocity

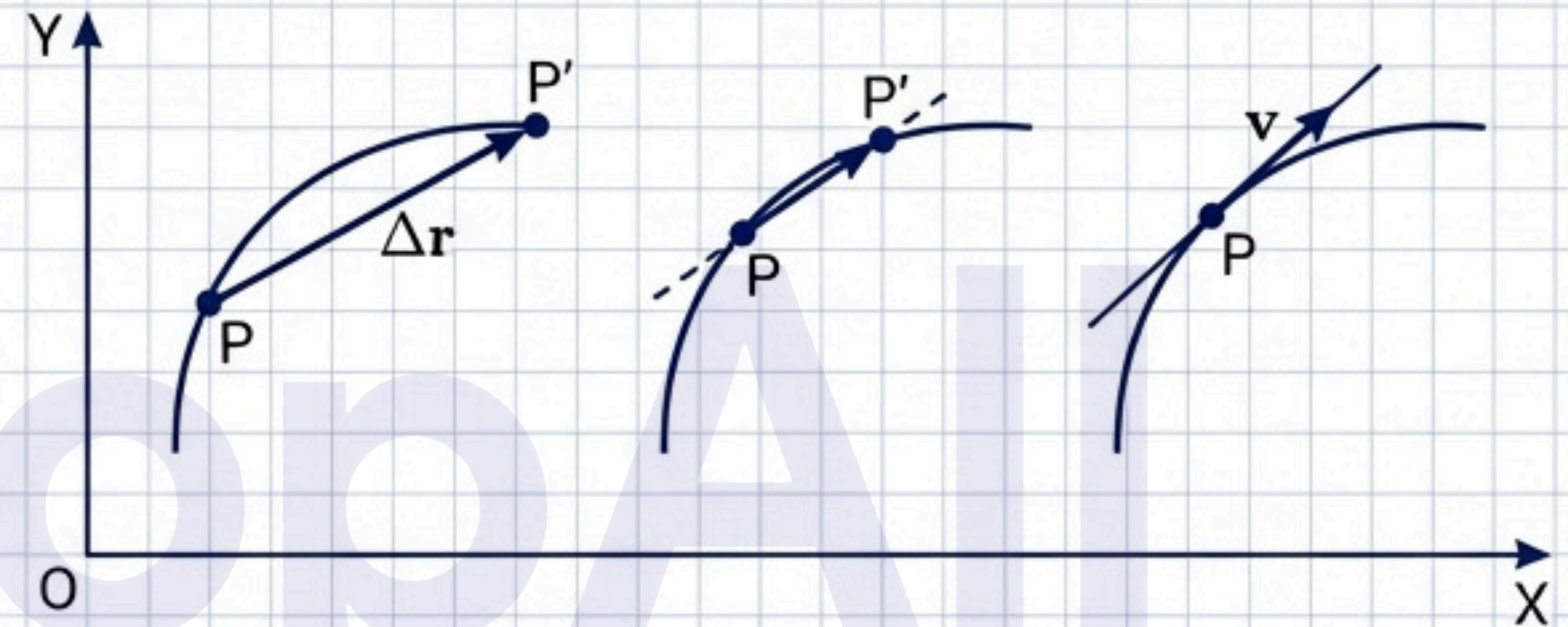
AVERAGE VELOCITY



$$\vec{v} = \frac{\Delta \vec{r}}{\Delta t}$$

Average (Displacement over finite time)

INSTANTANEOUS VELOCITY



$$\vec{v} = \frac{d\vec{r}}{dt}$$

Instantaneous (The limit as $\Delta t \rightarrow 0$)

The limiting process forces the displacement vector line curve's trajectory.
The limiting process forces the displacement vector to shrink and align perfectly with the curve's trajectory.

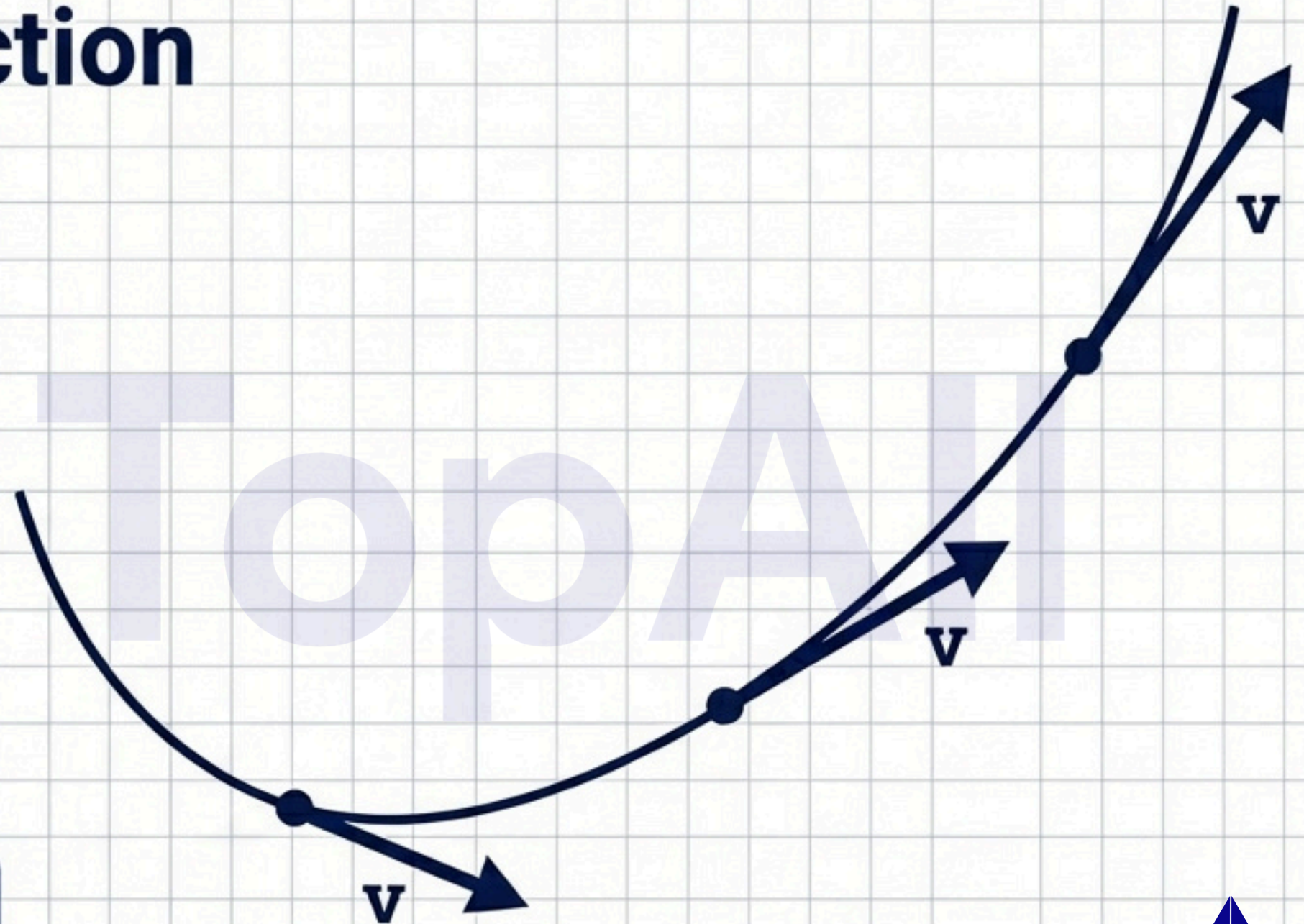
GEOMETRY OF MOTION

The Tangential Direction

As Δt approaches zero, the direction of $\Delta \mathbf{r}$ aligns with the tangent to the path. Therefore, instantaneous velocity is always perfectly tangential.

 **Exam-Smart**

Exam Tip: Velocity vectors never cross the trajectory curve; they always point exactly where the object is heading at that exact millisecond.



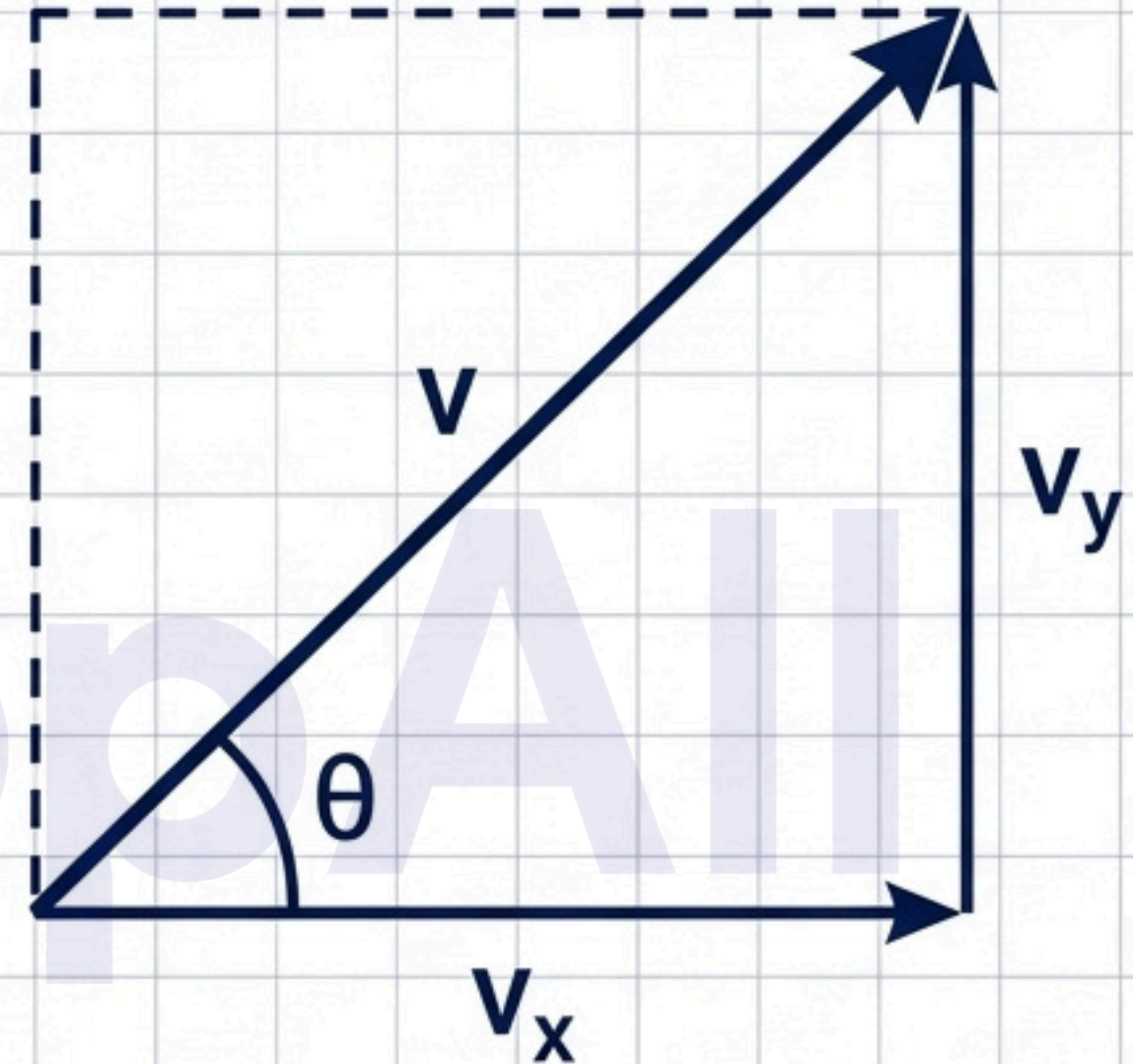
Velocity Components

$$v_x = dx/dt$$

$$v_y = dy/dt$$

$$v = \sqrt{v_x^2 + v_y^2}$$

$$\tan\theta = v_y / v_x$$



2D motion is just two independent 1D motions happening simultaneously.
Treat X and Y as entirely separate worlds.

THE SECOND DERIVATIVE

Acceleration in 2D

Acceleration is the rate of change of velocity. In a plane, this can mean a change in speed, a change in direction, or both simultaneously.

Average

$$a = \Delta v / \Delta t$$

Instantaneous

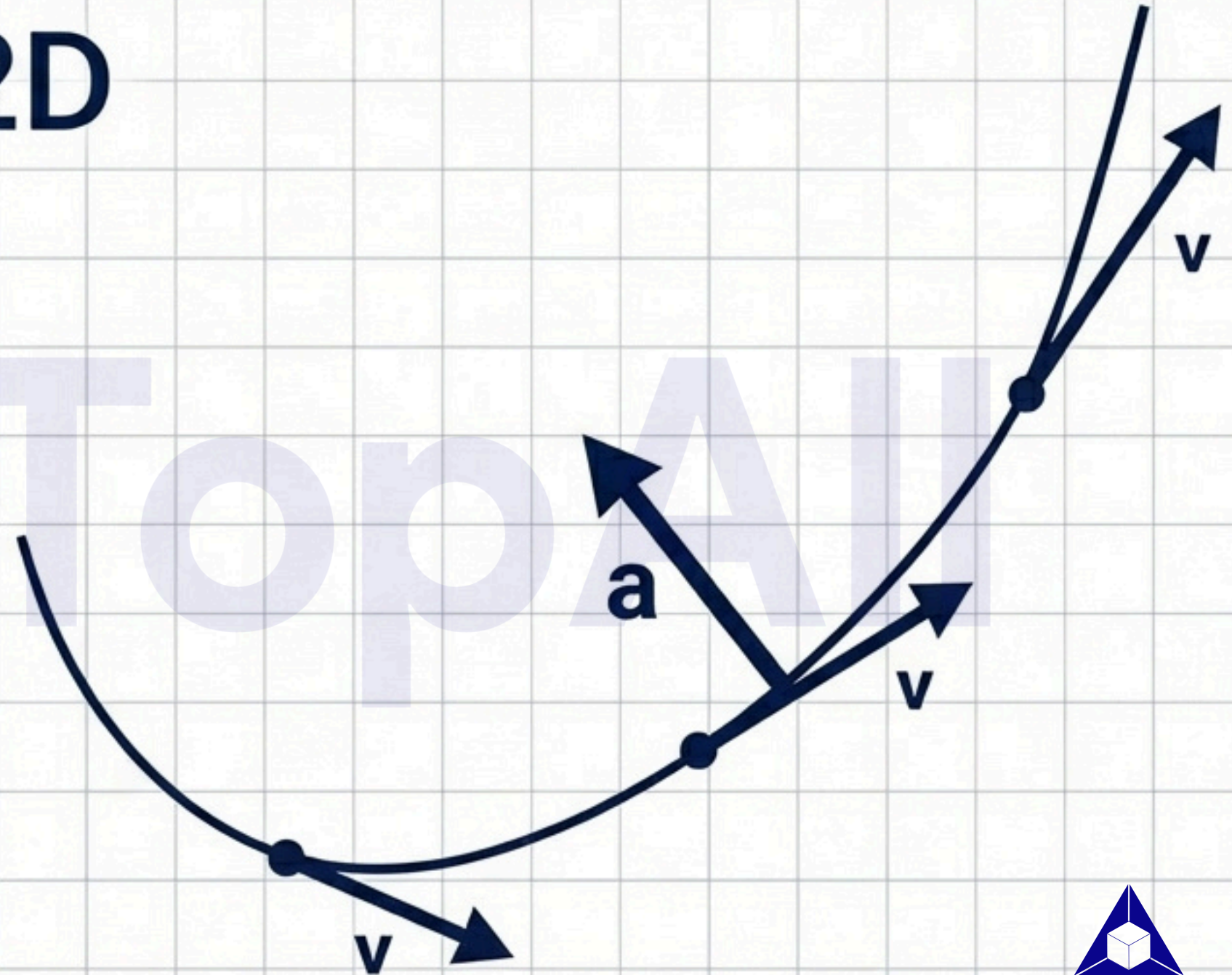
$$a = dv/dt$$

X-Component

$$a_x = dv_x/dt$$

Y-Component

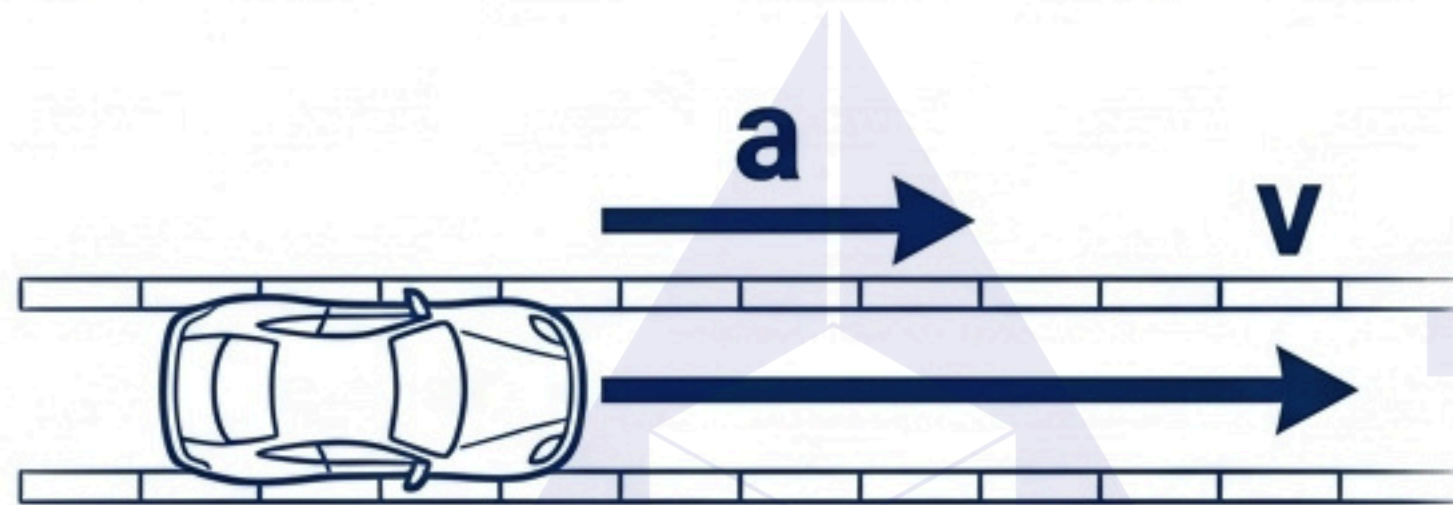
$$a_y = dv_y/dt$$



THE BIG INSIGHT

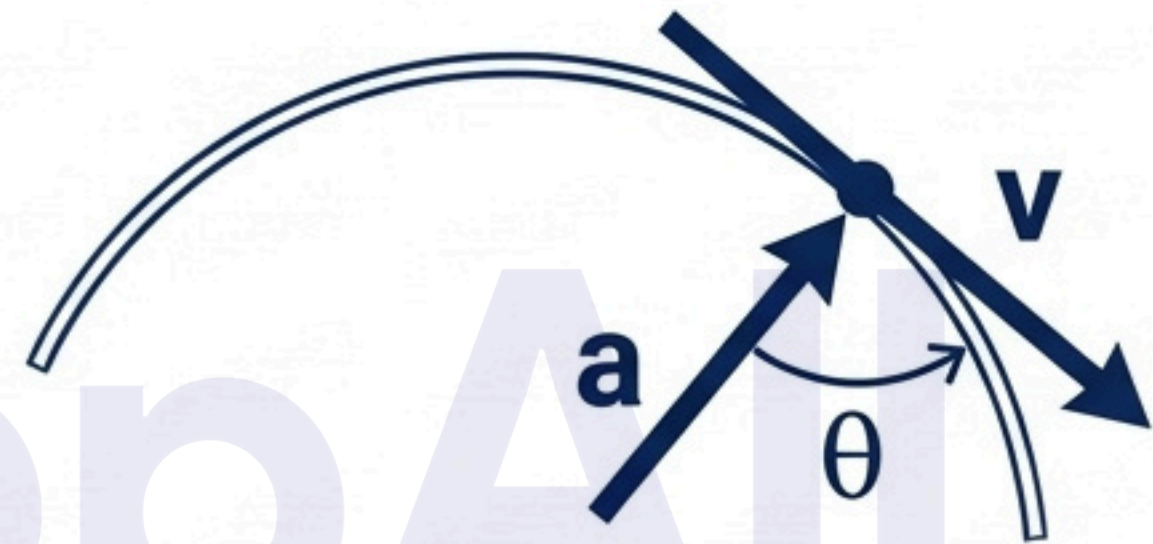
1D vs. 2D Kinematics

1D Motion



Confined to a straight line.
Angle between velocity and
acceleration is strictly 0° or 180° .

2D Motion



Freedom to turn.
Velocity and acceleration exist at an
arbitrary angle θ .

In 1D, acceleration can only change an object's speed. In 2D, acceleration can change both speed AND direction. Therefore, velocity and acceleration do not have to align.



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