

Kinematics of Rigid Bodies

What kind of motion can a rigid body have?

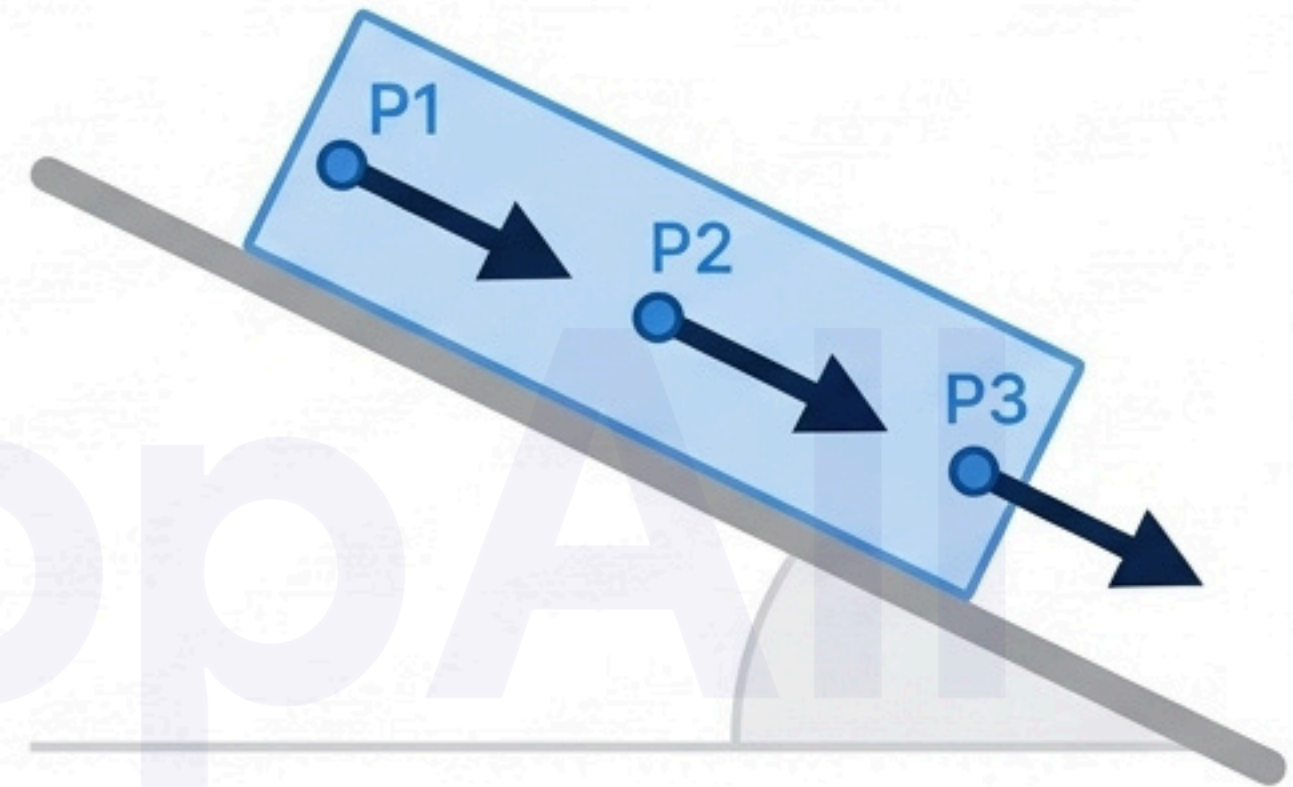


Pure Translational Motion

The Core Rule

At any instant of time, all particles of the body have the **exact same velocity**.

The body moves as a single, unified whole without any twisting or turning.

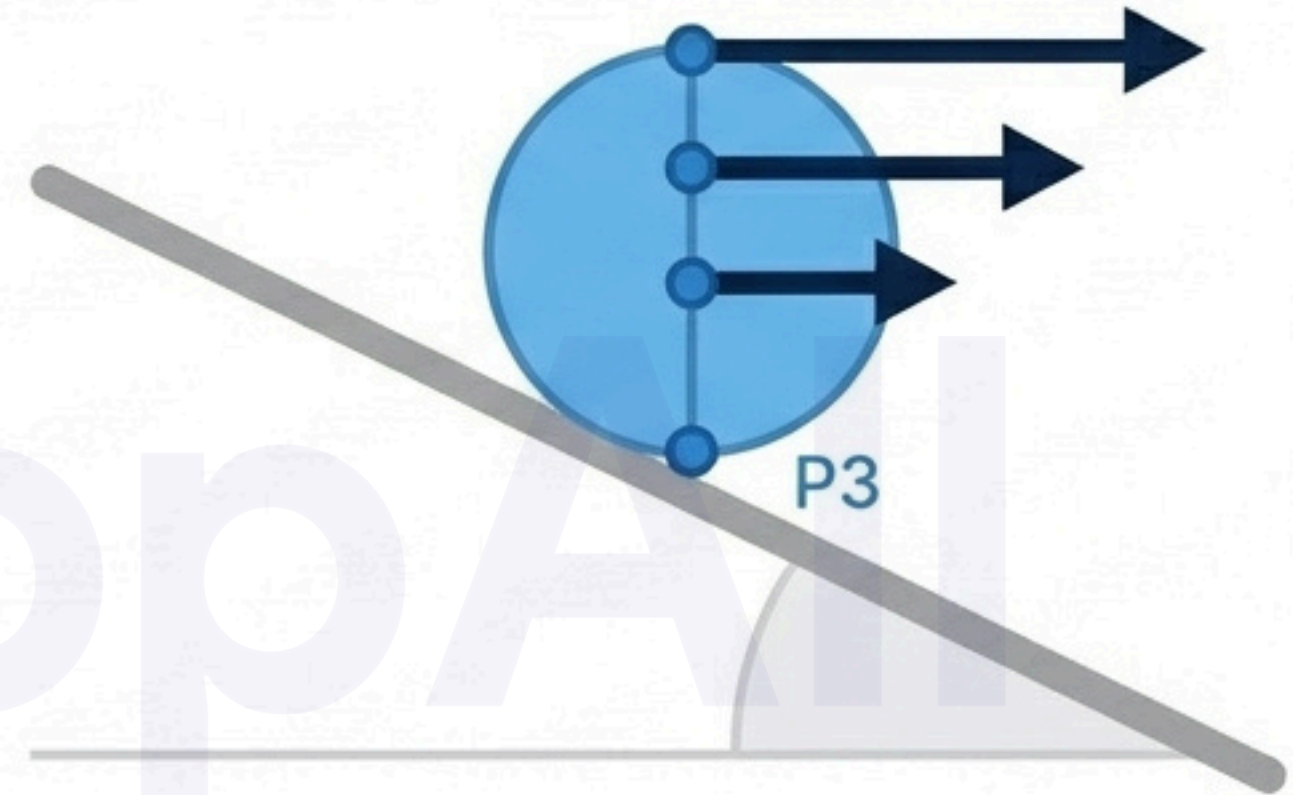


The Rolling Anomaly

The Anomaly

When a cylinder rolls down an incline, its particles do **NOT** move with the same **velocity**.

Because the velocities differ, this is not pure translation. The motion is translation plus "something else".

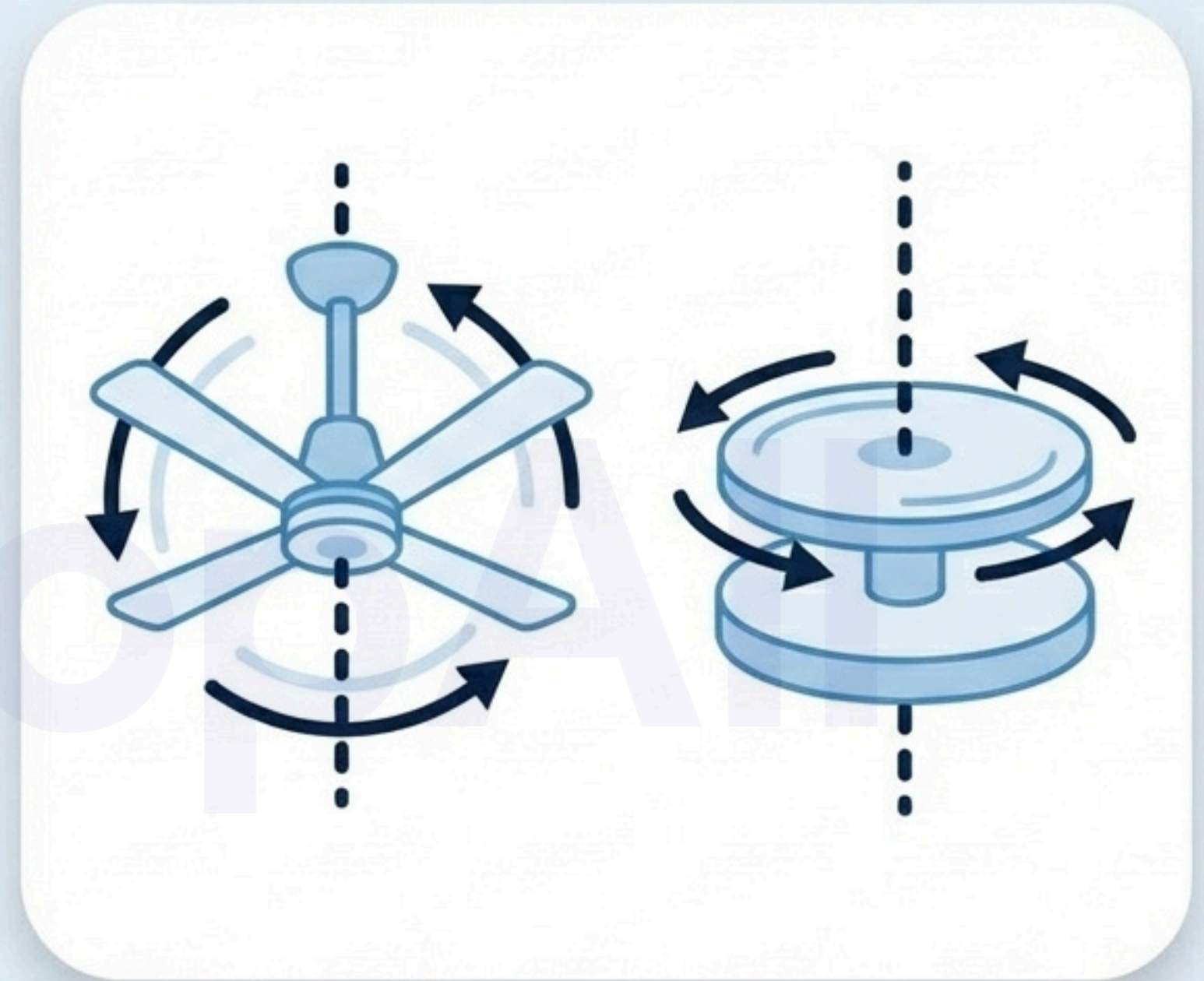


Pure Rotational Motion

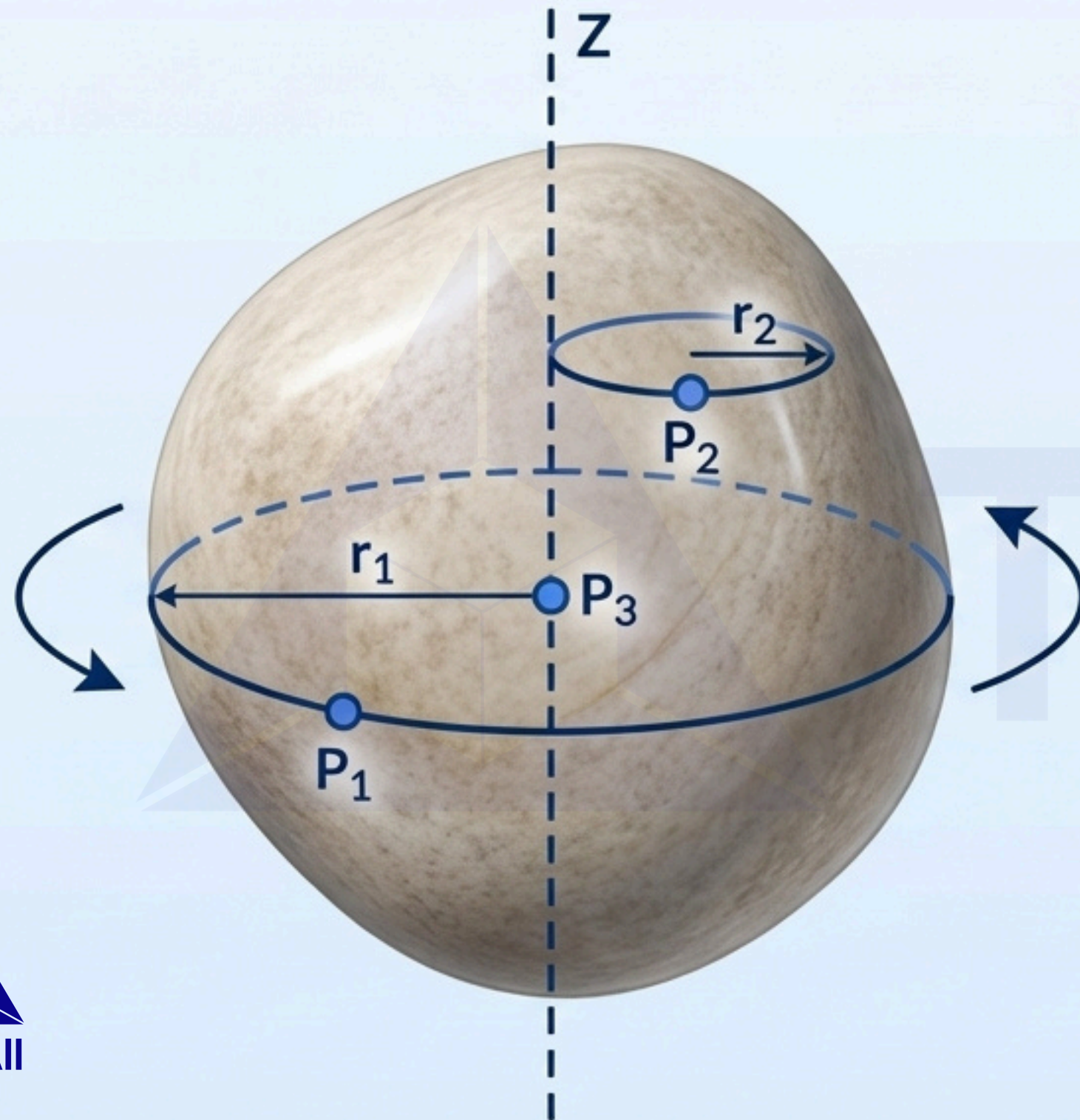
The Constraint

To isolate the 'something else', we constrain the rigid body along a straight line so it cannot translate.

This fixed line is the Axis of Rotation.



The Geometry of Rotation



Circular Path:

Every particle moves in a circle.

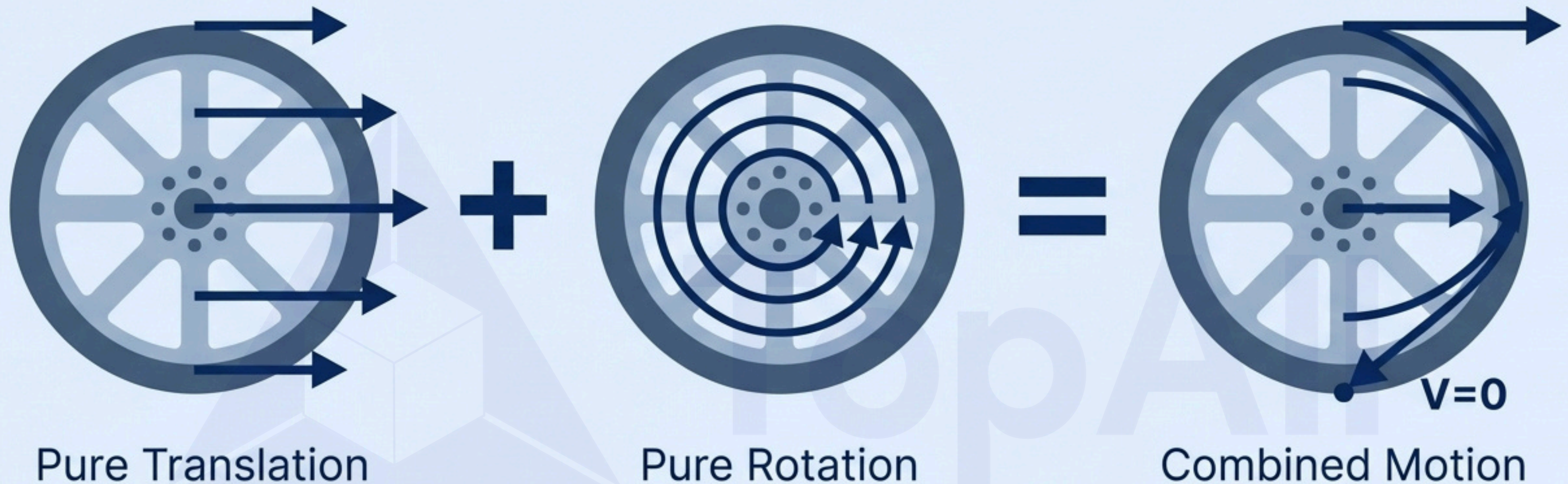
Perpendicular Plane:

The circle lies in a plane perpendicular to the axis, with its center on the axis.

Stationary Axis:

Particles exactly on the axis ($r=0$) remain completely stationary.

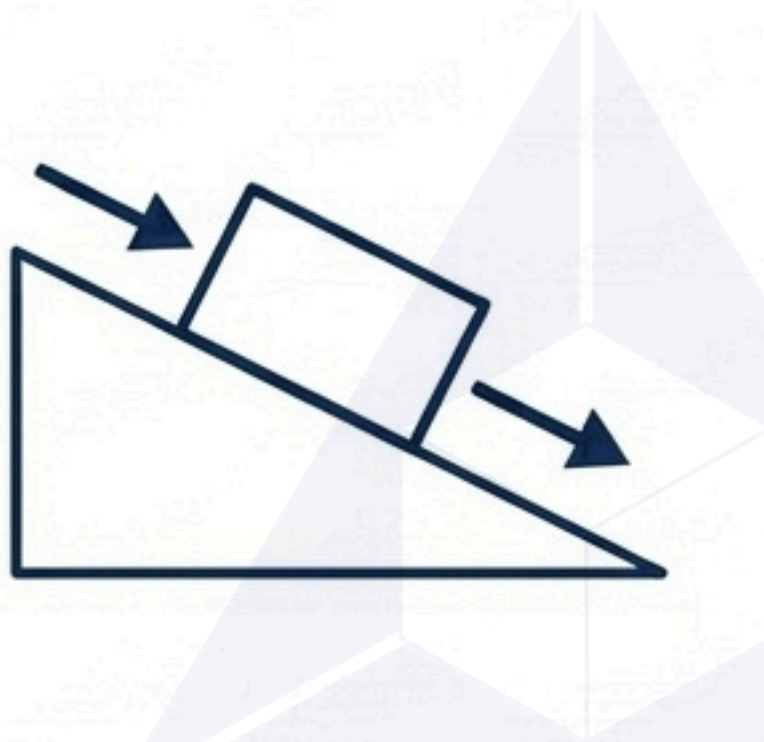
Kinematic Synthesis: Mixed Motion



Rolling = translation + rotation

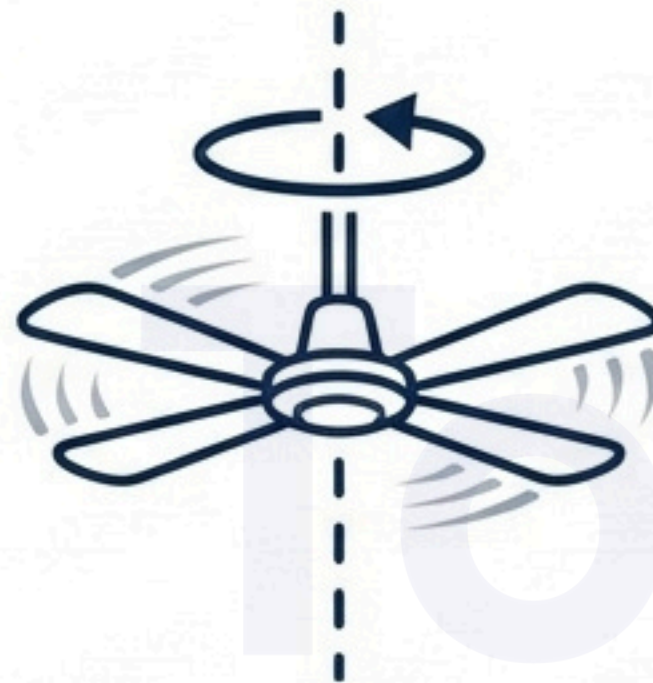
Kinematic States of a Rigid Body

Pure Translation



All particles
same velocity

Pure Rotation



Particles move in
circles around axis

Combined Motion



Rolling =
translation + rotation

Master these rigid body constraints for kinematics problem-solving.