

Velocity

by Boyang Zhao

Linear Velocity

Velocity is a vector that has both magnitude and direction. Speed has only magnitude (how fast an object is moving). Furthermore, the magnitude of velocity is speed. The average velocity is the displacement of an object over the elapsed time. The SI unit for average velocity is **meter per second (m/s)**.

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

Average velocity does not provide the velocity at any instant of time, but rather the average velocity of the whole trip. The instantaneous velocity, on the other hand, provides the magnitude and direction of an object at a certain time.

Instantaneous velocity can be obtained when the elapsed time is infinitesimally small. Then, during this very small interval, the instantaneous velocity is approximately equal to the average velocity. Thus, the following equation is used to find the instantaneous velocity of an object:

$$v = \lim_{\Delta t \rightarrow 0} \frac{\Delta x}{\Delta t}$$

When velocity changes as time goes on, acceleration is then considered.

Angular Velocity

Angular velocity is very similar to linear velocity. When a rigid object is rotating with an axis of rotation, the object has angular motion or angular velocity. The direction of angular velocity points along the axis of rotation. In a counterclockwise rotation, the vector for angular velocity points upward, while in a clockwise rotation, the vector for angular velocity points downward.

The average angular velocity is the angular displacement (the angle measured in radians) over the elapsed time. The SI unit for angular velocity is **radian per second (rad/s)**.

$$\bar{\omega} = \frac{\Delta \theta}{\Delta t}$$

Other units for angular velocity include **revolutions per minute (rpm)**. Note that a counterclockwise rotation has a positive angular displacement and a clockwise rotation has a negative angular displacement.

Using the same concept found above for instantaneous linear velocity, the instantaneous angular velocity happens when there is a small time interval, and the average angular velocity is approximately equal to the instantaneous angular velocity.

$$\omega = \lim_{\Delta t \rightarrow 0} \frac{\Delta \theta}{\Delta t}$$

When angular velocity changes with respect to time, then angular acceleration is concerned.

As the rigid object rotates around in a circle, the linear velocity at a point r meters away from the center of the circle is the tangential velocity. Please see tangential velocity for more information.

Linear velocity can be related to angular velocity (ω must be in rad/s) in rolling motion, where an object does not slip against the surface of which it is rolling, with the following formula,

$$v = r\omega$$

Because tangential velocity is also equal to r times ω , therefore, linear velocity is equal to the tangential velocity of the object in any rolling motion.

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