1-Dimensional Motion of Objects

Position

Position **(x) is the separation between an object and a reference point. Position is a vector quantity and can be negative (behind the reference point) or positive (ahead of the reference point).**

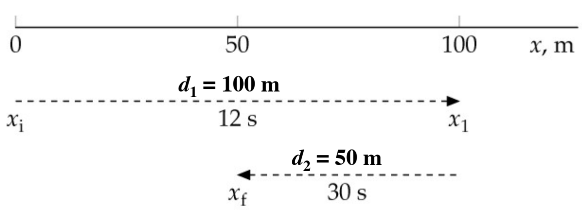
Displacement

Displacement **(x_f -x_i) is the change in position of an object. Displacement is a vector quantity because an object can move both negatively (backwards) and positively (forwards) with respect to its initial position.**

Distance

Distance **is the** ***total path length*** **traversed in moving from one point to another. Distance is a scalar quantity and is always positive.**

Distance versus Displacememt



Distance is $d_1 + d_2 = 100\text{ m} + 50\text{ m} = 150\text{ m}$

Displacement is $\Delta x = x_f - x_i = 50\text{ m} - 0 = 50\text{ m}$

Velocity (m/s)

The ***velocity*** **(v) of an object is a measure of the relative motion of the object with respect to a reference point.**

Velocity is a vector quantity.

Speed (m/s)

The *speed* of an object is the magnitude of its velocity.

Speed is a scalar quantity.

Average Velocity (m/s)

The *average velocity* (v_{av}) is the displacement of an object, divided by the time interval during which the displacement occurs.

$$v_{av} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

Average Speed (m/s)

The *average speed* is the distance an object travels, divided by the time interval.

$$\text{average speed} = \frac{\text{distance}}{\text{time}}$$

$$s = \frac{d}{t}$$

Instantaneous Velocity (m/s)

The *instantaneous velocity* (v) is the velocity of an object at a specific instant of time.

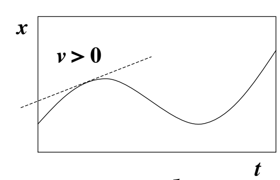
$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

Instantaneous Velocity (m/s)

The *instantaneous velocity* can be found from *a graph of position versus time*. It is equal to the slope of the tangent to the curve at a particular instant of time.

Position versus Time Profiles

The slope of a position-time profile gives the instantaneous velocity.



$$\text{slope} = \frac{dx}{dt} = v$$

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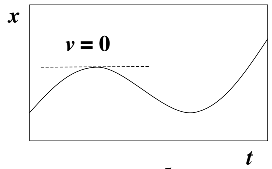

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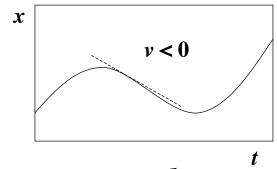


$$\text{slope} = \frac{dx}{dt} = v$$

Average Acceleration (m/s^2)

The *average acceleration* (a_{av}) of a particle is the change in velocity divided by the time interval.

$$a_{av} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

Instantaneous Acceleration (m/s^2)

The *instantaneous acceleration* (a) is the acceleration of an object at a specific instant of time.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = \frac{d^2 x}{dt^2}$$

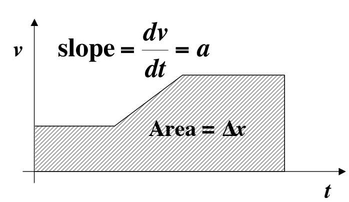
Instantaneous Acceleration (m/s^2)

The *instantaneous acceleration* can be found from *a graph of velocity versus time*.

Velocity versus Time Profiles

The *instantaneous acceleration* is equal to the slope of the tangent to the curve at a particular instant of time.

The area under a velocity-time graph gives the displacement during that time period.



Graphical Analysis

Graph Type	Slope $\left(\frac{d}{dt}\right)$	Area $(\int dt)$
x vs t	v	------
v vs t	a	Δx
a vs t	------	Δv

Motion with Constant Acceleration

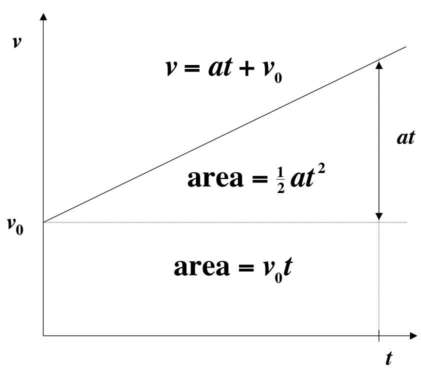
Constant acceleration is the special case in which the velocity changes at the same rate throughout the motion.

$$a = \frac{v - v_0}{t - t_0}$$

$$v = a(t - t_0) + v_0$$

$$\boxed{v = at + v_0}$$

Motion with Constant Acceleration



Motion with Constant Acceleration

The area under a velocity-time graph gives the displacement of the object.

$$x - x_0 = \tfrac{1}{2}at^2 + v_0 t$$

$$\boxed{x = \tfrac{1}{2}at^2 + v_0 t + x_0}$$

Motion with Constant Acceleration

Other useful relationships:

$$v_{av} = \frac{v_0 + v}{2}$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$x = \left(\frac{v + v_0}{2}\right)t + x_0$$

Freely Falling Objects

An object falling under the influence of the earth's gravitational attraction is a situation in which there is constant acceleration towards the earth.

The ideal case in which there is no air resistance or decrease in acceleration with height is referred to as free fall. This includes rising as well as falling motion. For this idealized case the magnitude of the acceleration is:

$$a = g = 9.8\ \frac{\text{m}}{\text{s}^2}$$