Fundamentals of Physics

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October 10, 2025

2 Motion Along a Straight Line

2.1 Position, displacement, and average velocity

Magnitude $\Rightarrow \Delta x_1 - x_2$

Average velocity $\Rightarrow v_{\text{avg}} = \dfrac{\Delta x}{\Delta t} = \dfrac{x_2 - x_1}{t_2 - t_1}$

Magnitude $\Rightarrow \dfrac{\text{total distance}}{\Delta t}$

2.2 Instantaneous velocity and speed

Instantaneous velocity $\Rightarrow \lim\limits_{\Delta t \to 0} \dfrac{\Delta x}{\Delta t} = \dfrac{\mathrm{d}x}{\mathrm{d}t}$

2.3 Acceleration

Average acceleration $\Rightarrow a_{\text{avg}} = \dfrac{v_2 - v_1}{t_2 - t_1} = \dfrac{\Delta v}{\Delta t}$

Acceleration at a point $\Rightarrow a = \dfrac{\mathrm{d}v}{\mathrm{d}t}$

$\star$ If the signs of the velocity and acceleration of a particle are the same, the speed of the particle increases. If the signs are opposite, the speed decreases.

2.4 Constant acceleration

The following five equations describe the motion of a particle with constant acceleration.

Nr	Equation	Missing quantity
1	$v = v_0 + at$	$x - x_0$
2	$x - x_0 = v_0 t + \frac{1}{2}at^2$	v
3	$v^2 = v_0^2 + 2a(x - x_0)$	t
4	$x - x_0 = \frac{1}{2}(v_0 + v_t)t$	a
5	$x - x_0 = vt - \frac{1}{2}at^2$	v_0

2.5 Free-fall acceleration

$\star$ The free-fall acceleration near Earth's surface is $a = -g = -9.8\ \text{m/s}^2$, and the magnitude of the acceleration is $g = 9.8\ \text{m/s}^2$. Do not substitute $-9.8\ \text{m/s}^2$ for g.

2.6 Graphical integration in motion analysis

• On a graph of acceleration a versus time t, the change in the velocity is given by:

$$v_1 - v_0 = \int_{t_0}^{t_1} a\,dt.$$

• On a graph of velocity v versus time t, the change in the position is given by:

$$x_1 - x_0 = \int_{t_0}^{t_1} v\,dt,$$