The Acceleration Equation

$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$ Where $\Delta \vec{v}$ is the velocity (m/s)

$(\Delta \vec{v} = \vec{v}_f - \vec{v}_i)$ * directions must match to subtract

Δt is the time interval (s)

$\vec{a}$ is the acceleration (m/s/s or m/s^2) ms^{-2}

5 m/s/s

In every second the velocity changes by 5m/s

NOTE that acceleration is a vector quantity (there is no non-vector term) so you must always indicate the direction if directions are given in the question.

Example 1

A skier accelerates on her skis from 6m/s [downhill] ($\vec{v}_i$) to 15m/s [downhill] ($\vec{v}_f$) in 1.5s (Δt). What is her acceleration ($a = ?$) during this time ?

$\vec{v}_i = 6m/s$ [downhill] +
$\vec{v}_f = 15m/s$ [downhill] +
$\Delta t = 1.5s$
$\vec{a} = ??$

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

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

$$\vec{a} = \frac{+15m/s - (+6m/s)}{1.5s}$$

$$\vec{a} = +\frac{9\ m/s}{1.5s}$$

$$\vec{a} = +6\ m/s^2$$

$\vec{a} = 6m/s^2$ [downhill]

UNITS: $\frac{m/s}{s}$

$\frac{m}{s} \div s$

$\frac{m}{s} \cdot \frac{1}{s}$

$\frac{m}{s^2}$

The acceleration of the skier was $6m/s^2$ [downhill]

Example 2

A skateboarder rolls down a hill with an average acceleration of +0.40 m/s^2 ($\vec{a}$). He is on the hill for 4.8 s (Δt) and was going +10.1 m/s ($\vec{v}_f$) at the bottom of the hill. What was his velocity ($\vec{v}_i$) at the start?

$\vec{v}_i = ?$
$\vec{v}_f = +10.1 \text{ m/s}$
$\vec{a} = +0.40 \text{ m/s}^2$
$\Delta t = 4.8 \text{ s}$

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

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

$$\vec{a}\Delta t = \vec{v}_f - \vec{v}_i$$

$$\vec{a}\Delta t - \vec{v}_f = -\vec{v}_i$$

$$\vec{v}_i = \vec{v}_f - \vec{a}\Delta t \quad (\vec{a}\Delta t = \Delta \vec{v})$$

Units: $\frac{m}{s^2} \cdot \frac{s}{1} = \frac{m}{s}$

$$\vec{v}_i = +10.1 \text{ m/s} - \left(+0.40 \frac{m}{s^2}\right)(4.8 \text{ s})$$

$$\vec{v}_i = +10.1 \text{ m/s} - 1.92 \frac{m}{s}$$

$$\vec{v}_i = +8.18 \frac{m}{s}$$

$$\vec{v}_i \doteq +8.2 \frac{m}{s}$$

Example 3

$a = 9.81 m/s^2$ [down] * near earth's surface.

A ball is dropped ($\vec{v}_i = 0$) and falls until it reaches a velocity of 29.8 m/s [down] ($\vec{v}_f$). How long was it falling? (Δt)

$\vec{v}_i = 0 m/s$ (implied)

$\vec{v}_f = 29.8 \frac{m}{s}$ [down]

$\Delta t = ?$

$\vec{a} = 9.81 \frac{m}{s^2}$ [down] (implied)

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

$$\vec{a}\Delta t = \Delta \vec{v}$$

$$\Delta t = \frac{\Delta \vec{v}}{\vec{a}}$$ ← directions must match

$$\Delta t = \frac{\vec{v}_f - \vec{v}_i}{\vec{a}}$$

$$\Delta t = \frac{29.8 \frac{m}{s} \text{[down]} - 0}{9.81 m/s^2 \text{[down]}}$$

$$\Delta t \doteq 3.04 s$$

Units:

$$\frac{\frac{m}{s}}{\frac{m}{s^2}} = \frac{m}{s} \div \frac{m}{s^2} = \frac{m}{s} \cdot \frac{s^2}{m} = s$$