Acceleration

Acceleration is **the rate at which velocity changes.**

Acceleration can result from a change in speed **(increase or decrease)**, a change in direction (back, forth, up, down left, right), or changes in both.

The pitcher throws. The ball speeds toward the batter. Off the bat it goes. It's going, going, gone! A home run!

> Before landing, the ball went through several changes in motion. It sped up in the pitcher's hand, and lost speed as it traveled toward the batter. The ball stopped when it hit the bat, changed direction, sped up again, and eventually slowed down. Most examples of motion involve similar changes. In fact, rarely does any object's motion stay the same for very long.

In science, **acceleration refers to increasing speed, decreasing speed, or changing direction.**

Examples:

- A car decelerates when it stops at a red light. A water skier decelerates when the boat stops pulling.
- A softball accelerates when it changes direction as it is hit.

Calculating Acceleration

$$\text{Acceleration} = \frac{change\ in\ velocity}{time\ taken}$$

$$\text{Acceleration} = \frac{final\ velocity - initial\ velocity}{time\ taken}$$

$$a = \frac{Vf - Vi}{t}$$

Since velocity is the rate at which position changes, and acceleration is the rate at which velocity changes, acceleration is a "rate of a rate".

= TWO time units (m/s/s or m/s^2, km/h/s)

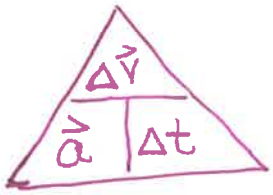
Examples:

1. As a roller-coaster car starts down a slope, its speed is 4 m/s. But 3 seconds later, at the bottom, its speed is 22 m/s. What is its average acceleration?

2. A roller coasters velocity at the top of the hill is 10 m/s. Two seconds later it reaches the bottom of the hill with a velocity of 26 m/s. What is the acceleration of the coaster?

3. The velocity of a train is 39 m/s. At an acceleration of -2.0 m/s^2, how much time is required for the train to decrease its velocity to 8.5 m/s^2 ?

4. A snowboarder, starting at rest, accelerates at 2.1 m/s^2. How fast is the snowboarder going at 12 seconds?



$\Delta t = t_f - t_i$

$\Delta\vec{v} = v_f - v_i$

Examples:

1. As a roller-coaster car starts down a slope, its speed is 4 m/s. But 3 seconds later, at the bottom, its speed is 22 m/s. What is its average acceleration?

$t_i = 0s$
$t_f = 3s$
$v_i = 4m/s$
$v_f = 22m/s$
$\vec{a} = ?$

$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$
$= \frac{v_f - v_i}{t_f - t_i}$
$= \frac{22-4}{3-0}$
$= 18/3$
$= 6m/s/s \rightarrow 6m/s^2$

2. A roller coasters velocity at the top of the hill is 10 m/s. Two seconds later it reaches the bottom of the hill with a velocity of 26 m/s. What is the acceleration of the coaster?

$v_i = 10m/s$
$v_f = 26m/s$
$t_i = 0s$
$t_f = 2s$
$\vec{a} = ?$

$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$
$= \frac{26-10}{2-0}$
$= \frac{16}{2}$
$= 8m/s/s = 8m/s^2$

3. The velocity of a train is 39 m/s. At an acceleration of -2.0 m/s^2, how much time is required for the train to decrease its velocity to 8.5 m/s ?

$v_i = 39m/s$
$v_f = 8.5m/s$
$t_i = 0s$
$t_f = ?$
$\vec{a} = -2.0m/s^2$

Because we are solving for time rearrange the equation to isolate the time term.

$\Delta t = \frac{\Delta\vec{v}}{\vec{a}}$
$t_f - 0 = \frac{8.5 - 39}{-2m/s^2}$
$t_f = \frac{-30.5m/s}{-2m/s^2} \rightarrow 15.25s = 15s$

4. A snowboarder, starting at rest, accelerates at 2.1 m/s^2. How fast is the snowboarder going at 12 seconds?

$t_i = 0s$
$t_f = 12s$
$v_i = 0m/s$
$v_f = ?$
$\vec{a} = 2.1m/s^2$

$\Delta v = \vec{a} \times \Delta t$
$v_f - 0 = 2.1(12-0)$
$v_f = 2.1m/s^2 \times 12s$
$= 25.2m/s \rightarrow 25m/s$