

## Velocity

A vector from  $A$  to  $B$ ; a speed with direction. The first derivative of position:

$$v = \dot{s} = \frac{ds}{dt} = \frac{\Delta s}{\Delta t} = \frac{s_2 - s_1}{t_2 - t_1}$$

## Acceleration

The first derivative of velocity, second derivative of position:

$$a = \ddot{s} = \frac{d^2s}{dt^2} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

## Examples

A ball is thrown up with  $v = 40 \text{ m/s}$ . The velocity is recorded in 1 second increments as:  $\{40, 30, 20, 10, 0\}$ . What is the acceleration?

We set  $v_2 = 0$  as it's the last velocity and  $v_1 = 40$  as it's the first velocity.

$$N = 5, \Delta t = 1: \quad v_1 = 0, \quad t_2 = \sum_{i=1}^{N-1} \Delta t = 4$$

$$\frac{v_2 - v_1}{t_2 - t_1} \implies \frac{0 - 40}{4 - 0} = -10$$

Therefore, the acceleration is:  $a = -10 \text{ m/s}^2$