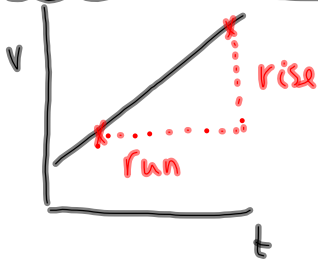


Acceleration + Velocity-Time Graphs

Constant Acceleration (Uniform)



$$\text{slope} = \frac{\text{rise}}{\text{run}}$$

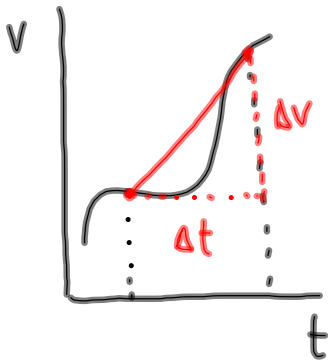
$$\text{slope} = \frac{\Delta v}{\Delta t}$$

Slope = acceleration

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

This slope is constant since the graph is linear.

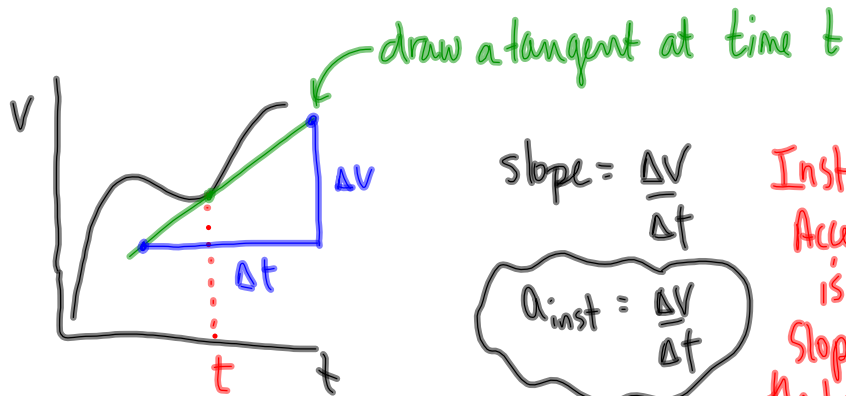
Non-Constant (Non-Uniform) Acceleration



$$\text{slope} = \frac{\Delta v}{\Delta t}$$

$$a_{\text{ave}} = \frac{\Delta v}{\Delta t}$$

Average Acceleration is the slope between two points on the v-t graph.



$$\text{slope} = \frac{\Delta v}{\Delta t}$$

$$a_{\text{inst}} = \frac{\Delta v}{\Delta t}$$

Instantaneous Acceleration is the slope of the tangent drawn out!

- Eyeball the tangent
- use calculus!

The Acceleration Equation

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} \quad \text{where } \Delta \vec{v} \text{ is the velocity change (m/s)}$$

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

Δt is the time interval (s)

\vec{a} is the acceleration (m/s^2)

Example 1

A skier accelerates on her skis from 6 m/s [forward] to 15 m/s [forward] in 1.5 s . What is her acceleration \vec{a} during this time?

$$\vec{v}_i = 6 \text{ m/s [forward]} = +6 \text{ m/s}$$

$$\vec{v}_f = 15 \text{ m/s [forward]} = +15 \text{ m/s}$$

$$\Delta t = 1.5 \text{ s}$$

$$a = ??$$

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

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

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

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

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

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

$$6 \text{ m/s}^2$$

IMPT = 7 UNITS

$$\frac{\text{m/s}}{\text{s}} = \frac{\text{m}}{\text{s}} \div \text{s}$$

$$= \frac{\text{m}}{\text{s}} \times \frac{1}{\text{s}}$$

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

Example 2

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

$$\vec{a} = +0.40 \text{ m/s}^2$$

$$\vec{v}_f = +10.1 \text{ m/s}$$

$$\Delta t = 4.8 \text{ s}$$

$$\vec{v}_i = ?$$

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

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

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

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

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

UNITS:

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

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

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

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

$$\vec{v}_i = +8.2 \text{ m/s}$$

$$\vec{v}_i = 8.2 \text{ m/s [downhill]}$$

Example 3

A ball is dropped and falls until it reaches a ^{near the Earth's surface} velocity of 29.8 m/s [down]. How long was it falling?

v_f

$$\vec{v}_i = 0$$

$$\vec{a} = 9.81 \text{ m/s}^2 [\text{down}] = -9.81 \text{ m/s}^2$$

$$\vec{v}_f = 29.8 \text{ m/s} [\text{down}] = -29.8 \text{ m/s}$$

$$\Delta t = ?$$

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

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

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

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

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

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

$$\Delta t = 3.037716616 \dots \text{ s}$$

$$\Delta t = 3.04 \text{ s}$$

UNITS

$$\frac{\text{m/s}}{\text{m/s}^2} = \frac{\text{m}}{\text{s}} \div \frac{\text{m}}{\text{s}^2}$$

$$= \frac{\cancel{\text{m}}}{\text{s}} \cdot \frac{\text{s}^2}{\cancel{\text{m}}}$$

$$= \text{s}$$