Acceleration - Part 2

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Note: Always watch your units. They have to match up!

only **Velocity**

$\frac{km}{h} \leftrightarrow \frac{m}{s}$

$\frac{m}{s} \times \frac{1\,km}{1000\,m} \times \frac{3600\,s}{1\,h} = \frac{km}{h}$

$\downarrow$

$\frac{m}{s} \times 3.6 = \frac{km}{h}$

$\frac{km}{h} \times \frac{1000\,m}{1\,km} \times \frac{1\,h}{3600\,s} = m/s$

$\frac{km}{h} \div 3.6 = m/s$

Shortcut: $\frac{km}{h} \xrightarrow{\div 3.6} m/s$, $m/s \xrightarrow{\times 3.6} \frac{km}{h}$

This **only** works for velocity

Converting acceleration Different!

$\frac{m}{s^2} \times \frac{1\,km}{1000\,m} \times \frac{3600\,s}{1\,h} \times \frac{3600\,s}{1\,h^2} = \frac{km}{h^2}$

We know:

#1

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

#2

$\vec{d} = \frac{\vec{v}_i + \vec{v}_f}{2} \cdot t$

What if we don't know v_f?

#1 → solve for $\vec{v}_f$

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

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

$+v_i \qquad +v_i$

$\vec{v}_f = (\vec{v}_i + \vec{a}t)$ ← Substitute this into Eq^n #2

$$\vec{d} = \frac{\vec{v}_i + \vec{v}_f}{2} \cdot t$$

$$\vec{d} = \frac{\vec{v}_i + \vec{v}_i + \vec{a}t}{2} \cdot t \Rightarrow \vec{d} = \frac{2\vec{v}_i + \vec{a}t}{2} \cdot t$$

$$\vec{d} = \left(\frac{2\vec{v}_i}{2} + \frac{\vec{a}t}{2}\right) \cdot t \Rightarrow \vec{d} = \vec{v}_i \cdot t + \frac{1}{2}\vec{a}t^2$$

Kinematics Equation #3

$$\boxed{\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2}$$

Ex. Jacob suddenly slows down. He slides 27m in 3s. He is accelerating at a rate of $-4.2 m/s^2$. What was Jacob's velocity before slowing down?

$v_i = ?$
$a = -4.2 m/s^2$
$d = 27m$
$t = 3s$

$$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$
$$-\frac{1}{2}at^2 \quad -\frac{1}{2}at^2$$
$$\frac{d - \frac{1}{2}at^2}{t} = \frac{v_i t}{t}$$

$$\vec{v}_i = \frac{\vec{d} - \frac{1}{2}\vec{a}t^2}{t}$$

$$\vec{v}_i = \frac{27 - \frac{1}{2}(-4.2)(3)^2}{3}$$

$$\vec{v}_i = \frac{27 + 18.9}{3} = \frac{45.9}{3} = 15.3 m/s$$

Jacob was travelling 15.3 m/s before slowing down.

What if we don't know t?

Eq#1 $\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$ Solve for t

$t = \left(\frac{\vec{v}_f - \vec{v}_i}{\vec{a}}\right)$ Substitute into Eq. 2

$\vec{d} = \frac{\vec{v}_i + \vec{v}_f}{2}(t)$

$\vec{d} = \left(\frac{\vec{v}_i + \vec{v}_f}{2}\right)\left(\frac{\vec{v}_f - \vec{v}_i}{\vec{a}}\right) \Rightarrow 2\vec{a} \times \vec{d} = \frac{(\vec{v}_i + \vec{v}_f)(\vec{v}_f - \vec{v}_i)}{2\vec{a}} \times 2\vec{a}$

$2\vec{a}\vec{d} = (v_i + v_f)(v_f - v_i)$

$2\vec{a}\vec{d} = \cancel{v_i v_f} - \vec{v}_i^2 + v_f^2 - \cancel{v_i v_f} = v_i^2 + 2ad = v_f^2$

$+v_i^2$ $\quad + v_i^2$

Kinematics Equation #4

$$\boxed{\vec{v}_f^2 = \vec{v}_i^2 + 2\vec{a}\vec{d}}$$

Ex. Hanna is on planet VC7-259. She Throws a puppy upwards at a velocity of 1.3 m/s. Gravity on VC7-259 accelerates objects downward at 4.72 m/s². How high does the puppy go when it reaches the top of its "flight"?

0 m/s

$v_i = 1.3 m/s$

$v_f = 0 m/s$

$a = -4.72 m/s^2$

$d = ?$

$$\vec{v}_f^2 = \vec{v}_i^2 + 2\vec{a}\vec{d}$$

$$-v_i^2 \quad -v_i^2$$

$$\frac{\vec{v}_f^2 - \vec{v}_i^2}{2a} = \frac{2\vec{a}\vec{d}}{2a}$$

$$\vec{d} = \frac{\vec{v}_f^2 - \vec{v}_i^2}{2\vec{a}} = \frac{0^2 - 1.3^2}{2(-4.72)} = \frac{-1.69}{-9.44}$$

$$\vec{d} = 0.18 m$$

Hanna tossed the puppy 0.18m upward.