Equation 1 for constant acceleration

We understand acceleration as the change in velocity. To simplify our model, we'll always assume **constant acceleration (*a*)**.

Now imagine its velocity increases from $\boldsymbol{v_i}$, *initial velocity*, to $\boldsymbol{v_f}$, *final velocity,* in a given amount of *time*, *t*:

$$a = \frac{\text{change of velocity}}{\text{time}} = \frac{v_f - v_i}{t}$$

This equation can be rearranged to:

$$at = v_f - v_i$$

or even better

$$v_f = v_i + at$$

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Equation 2 for constant acceleration

Looking at our graphs of accelerating objects, we recognize uniform acceleration as a steady increase in velocity.

The *average velocity* (v_{avg}) will equal the sum of the initial velocity plus the final velocity, divided by two:

$$\frac{\Delta x}{\Delta t} \qquad v_{avg} = \frac{v_i + v_f}{2}$$

The average velocity can also be displacement/time as we've defined in our graphs. Therefore,

$$\frac{\Delta x}{t} = \frac{v_i + v_f}{2} \quad \text{or} \quad \Delta x = \frac{(v_i + v_f)}{2}t$$

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Equation 3 for constant acceleration

If you take equation 1 ($v_f = v_i + at$) and add into equation 2

$$x = \frac{(v_i + v_f)}{2}t \longrightarrow x = \frac{(v_i + v_i + at)}{2}t$$

$$= \frac{(2v_i + at)}{2}t$$

$$= (v_i + \tfrac{1}{2}at)\,t$$

no V_f

$$= \boxed{x = v_i t + \tfrac{1}{2}at^2}$$

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Equation 4 for constant acceleration

If you take equation 1 ($v_f = v_i + at$) and square it, you get

who cares

$$v_f^2 = (v_i + at)^2$$

$$v_f^2 = (v_i + at)(v_i + at)$$

$$v_f^2 = v_i^2 + 2v_i at + a^2t^2$$

$$v_f^2 = v_i^2 + 2a(\mathbf{v_i}t + \tfrac{1}{2}at^2)$$

Notice equation 3 ($x = v_i t + \tfrac{1}{2}at^2$) appears when simplified. Therefore:

$$\boxed{v_f^2 = v_i^2 + 2ax}$$

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$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

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

$$\Delta\vec{x} = \vec{v}_i\Delta t + \frac{1}{2}\vec{a}t^2$$

$$\Delta\vec{x} = \vec{v}_f\Delta t - \frac{1}{2}\vec{a}t^2$$

$$\Delta\vec{x} = \frac{1}{2}(\vec{v}_i + \vec{v}_f)t$$

$$\vec{v}_f^{\,2} = \vec{v}_i + 2\vec{a}\Delta\vec{x}$$

Δx

v_f

v_i

a

t

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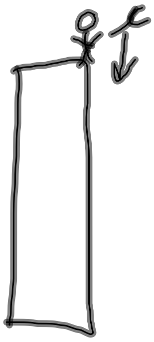

$t =$

$x_i = 80m$ $\Delta x = 0m - 80m$
$= -80 m$

$x_f = 0 m$

$a = -9.8 \frac{m}{s^2}$

$v_i = 0 \frac{m}{s}$

assumptions: no air resistance

const. acc. target Quantity: v_f

$$v_f^2 = \cancel{v_i^2} + 2a\Delta x$$

$$v_f = \pm\sqrt{2a\Delta x} = \pm\sqrt{2\left(-9.8\frac{m}{s^2}\right)(-80m)} = \pm\sqrt{1568\frac{m^2}{s^2}} = \boxed{-39.6\frac{m}{s}}$$

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