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 $\mathbf{v_i}$, *initial velocity*, to $\mathbf{v_f}$, *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

$$v_f = v_i + at$$

don't need to know x (pos)

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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:

$$v_{avg} = \frac{v_i + v_f}{2}$$

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

$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$

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

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Equation 3 for constant acceleration

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

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

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

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

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

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Equation 4 for constant acceleration

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

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

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

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

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

$$V = \frac{\Delta x}{\Delta t}$$

const. vel

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

① $V_f = V_i + a\Delta t$

Therefore:

$$v_f^2 = v_i^2 + 2ax$$

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

x

v_f

v_i

a

t

const. acc.

$$v_f = v_i + a\Delta t$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a(\Delta t)^2$$

$$\Delta x = v_f \Delta t + \frac{1}{2} a(\Delta t)^2$$

$$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$$

$$v_f^2 = v_i^2 + 2a\Delta x$$

a_g (acc due to grav.) $= \boxed{-9.8 \frac{m}{s^2}}$

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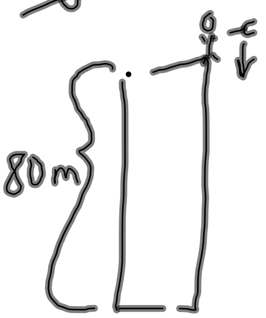

$v_i = 0 \frac{m}{s}$

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

$\Delta t = ?$

$v_f = ?$

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

H/W #31 + 32

Assumption: ignore air resistance

target quant.: v_f const. acc.

$$v_f^2 = \cancel{v_i^2} + \frac{1}{2} a\Delta x$$

$$v_f = \sqrt{\frac{1}{2} a\Delta x} = \sqrt{\frac{1}{2}\left(-9.8\frac{m}{s^2}\right)(-80\,m)} = \boxed{19.8 \frac{m}{s}}$$

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