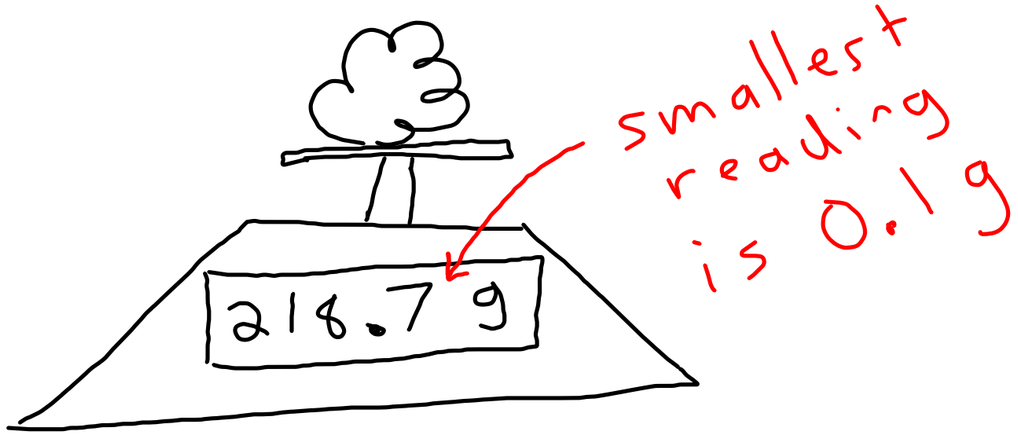
Uncertainty, cont.

example #2 - digital scale



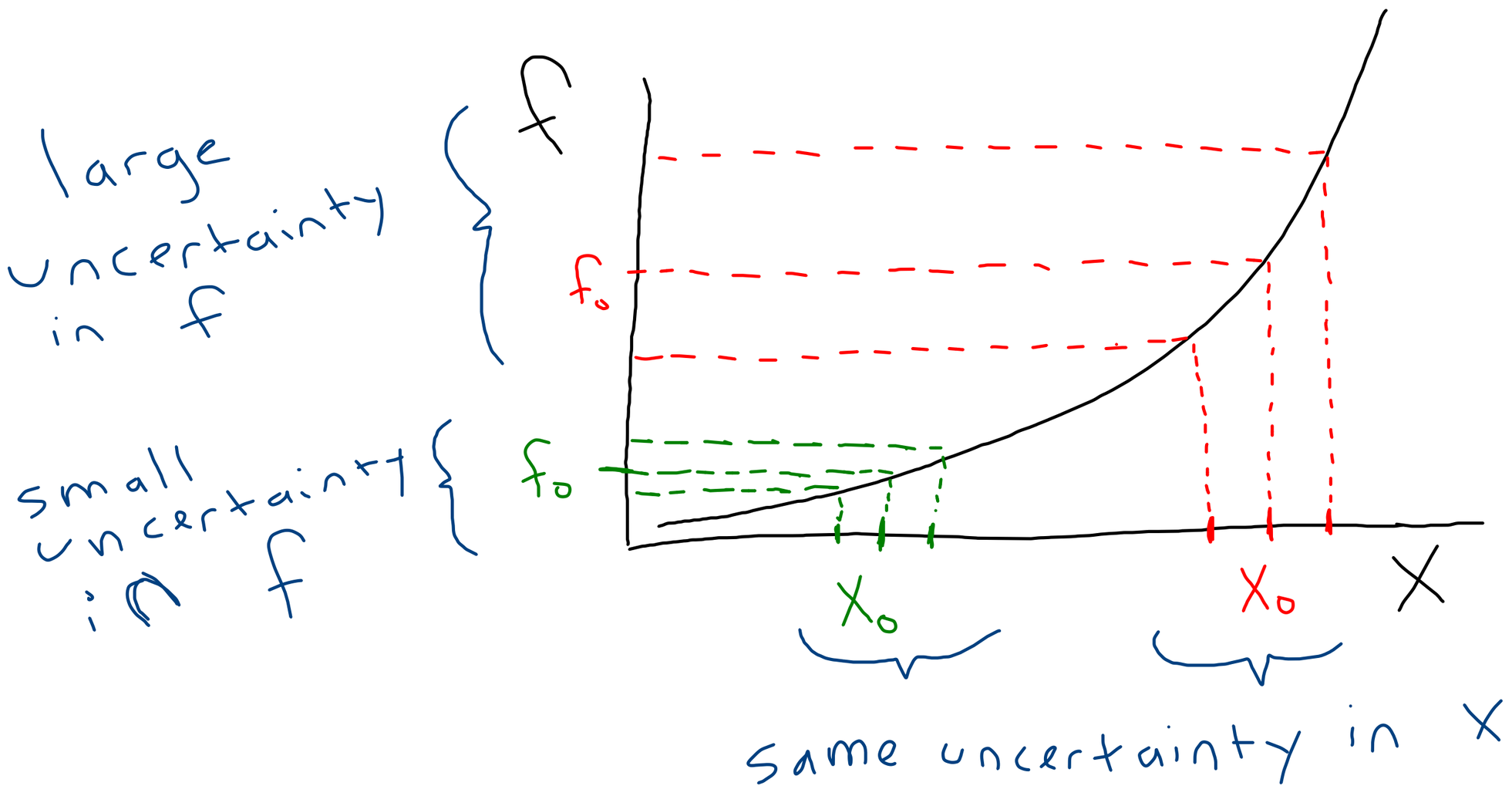
$\Rightarrow m = 218.7 \pm 0.05$ g

* You can assign larger uncertainty if you have reason to believe it's larger. E.g.
  - tape measure with a bend in it
  - manual stop watch

error propagation

measure $X = X_0 \pm \delta x$

calculate $f(x) \pm \delta f$



Optional:

$f(x, y, z, \ldots)$

$x = x_0 \pm \delta x$

$y = y_0 \pm \delta y$

$z = z_0 \pm \delta z$

$\vdots$

$f = f_0 \pm \delta f$

$\downarrow$

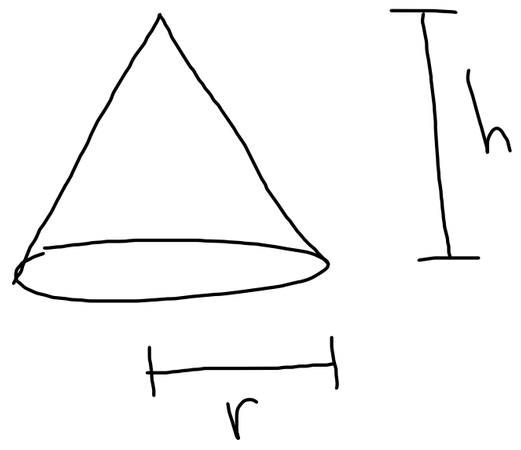
$f_0 = f(x_0, y_0, z_0, \ldots)$

$$\delta f = \sqrt{\left(\left.\frac{\partial f}{\partial x}\right|_{x_0,y_0,z_0,\ldots} \cdot \delta x\right)^2 + \left(\left.\frac{\partial f}{\partial y}\right|_{x_0,y_0,z_0,\ldots} \cdot \delta y\right)^2 + \ldots}$$

example - cone

$$A = \pi r^2 + \pi r\sqrt{h^2 + r^2}$$

$$V = \frac{1}{3}\pi r^2 h$$



measured values: $r = 2.1 \pm 0.05$ cm

$h = 4.4 \pm 0.1$ cm

$$A = \pi (2.1)^2 + \pi (2.1)\sqrt{(2.1)^2 + (4.4)^2} = 46.02 \text{ cm}^2$$

$$V = \frac{1}{3}\pi (2.1)^2 (4.4) = 20.32 \text{ cm}^3$$

$\delta A = 1.68 \text{ cm}^2$

$\delta V = 1.07 \text{ cm}^3$

} see class02/uncert.sage

Chapter 2 - 1-D motion

Definitions -

- An object's position (x) is its location on some chosen coordinate system

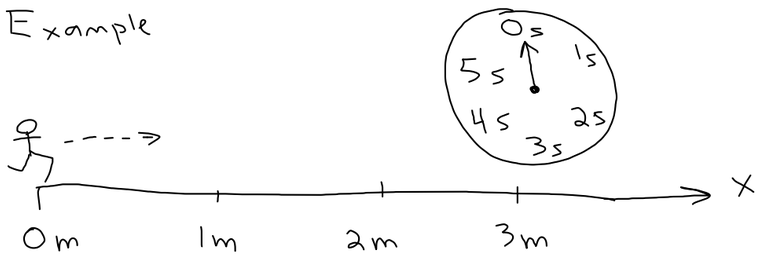
- time is also measured w.r.t. some reference time t_0 (usually $t_0 = 0$).

Example

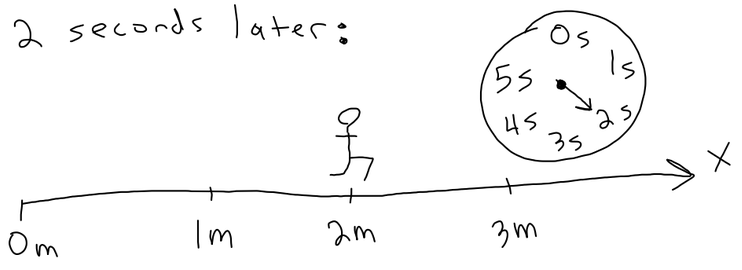
* the tree's position is $X = 2\,m$ when $t = 4\,s$.

* positions can change as time moves forward

Example



2 seconds later:



the person is at $X = 0m$ when $t = 0s$ and $X = 2m$ when $t = 2s$.

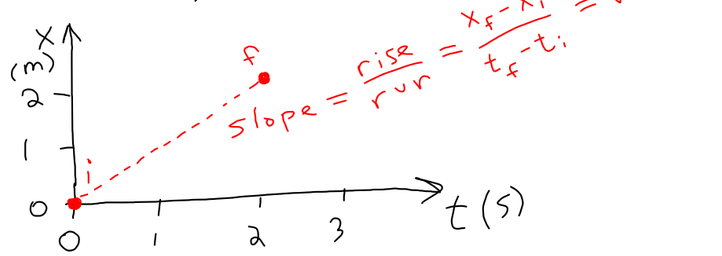
- Velocity tells you how much distance is covered in one unit of time.

  units: m/s

  - average velocity: $V_{ave} = \frac{\Delta X}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$

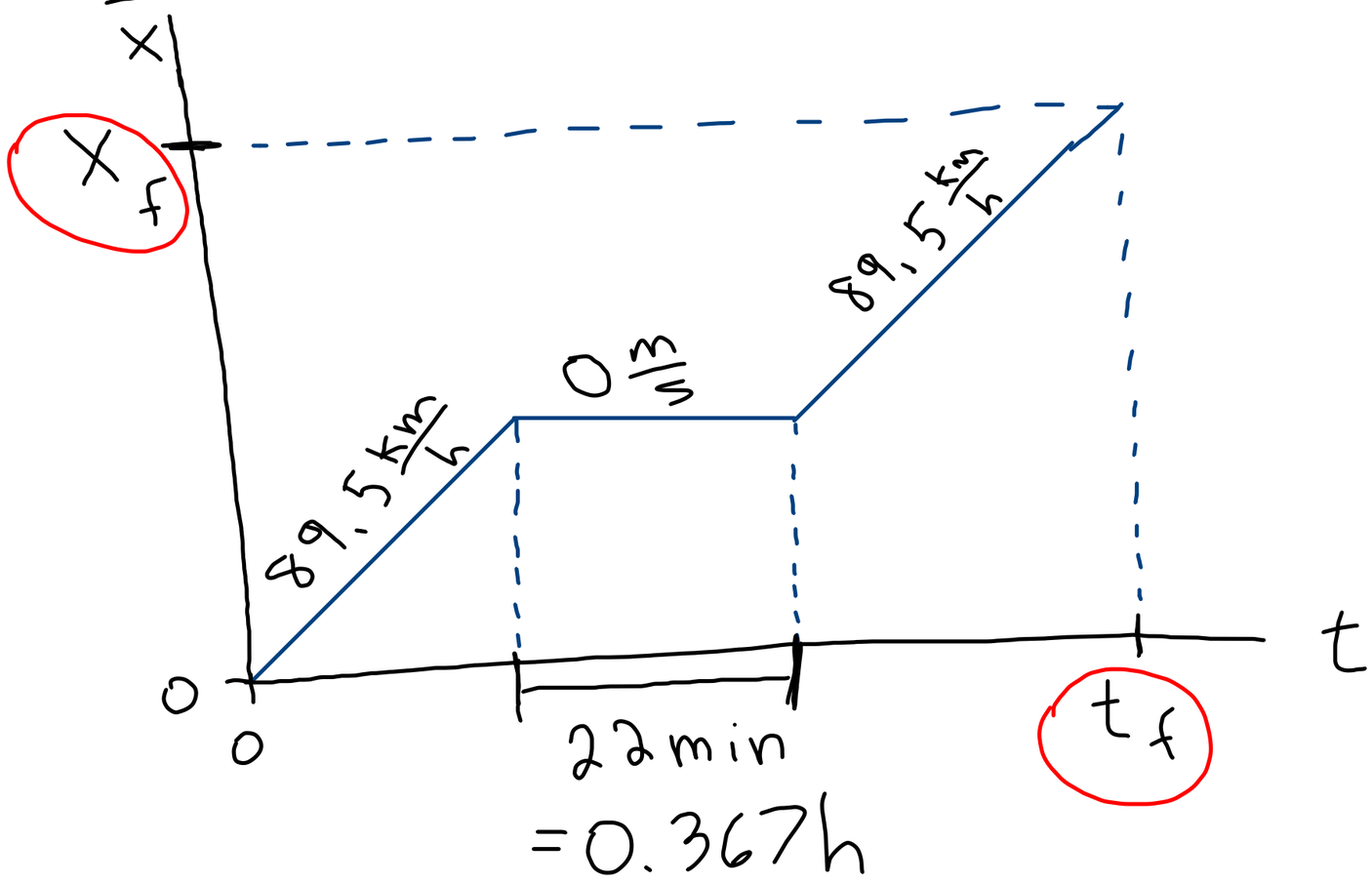
    ↳ above example: $V_{ave} = \frac{2m - 0m}{2s - 0s} = 1 \frac{m}{s}$

Graphically:



github.com/naharrison/motion-tracker/releases
* download motrack-app.zip
* extract it
* complete the activity
* find the average velocity for each time interval

Example:



$V_{ave} = 77.8 \frac{km}{h}$

find x_f and t_f.

Answer: $t_f = 2.8\,h$

$x_f = 217.8\,km$