Chapter 1

Dimensions and units

The words "dimensions" and "units" are often used interchangebly, but they do have a subtle difference.

	Dimensions	units
fundamental	mass	grams, kg, (not pounds) ↳ unit of force
	length	inches, meters, miles, ...
	time	seconds, minutes, hours, days, ...
	⋮	⋮
	abstract	specifics for quantifying dimensions

	Dimensions	units
non-fundamental	velocity	mph, m/s, kmph
	area	in^2, m^2, ft^2
	volume	gallons, m^3, in^3, ft^3, ...
	⋮	

* Dimensions has another meaning - size

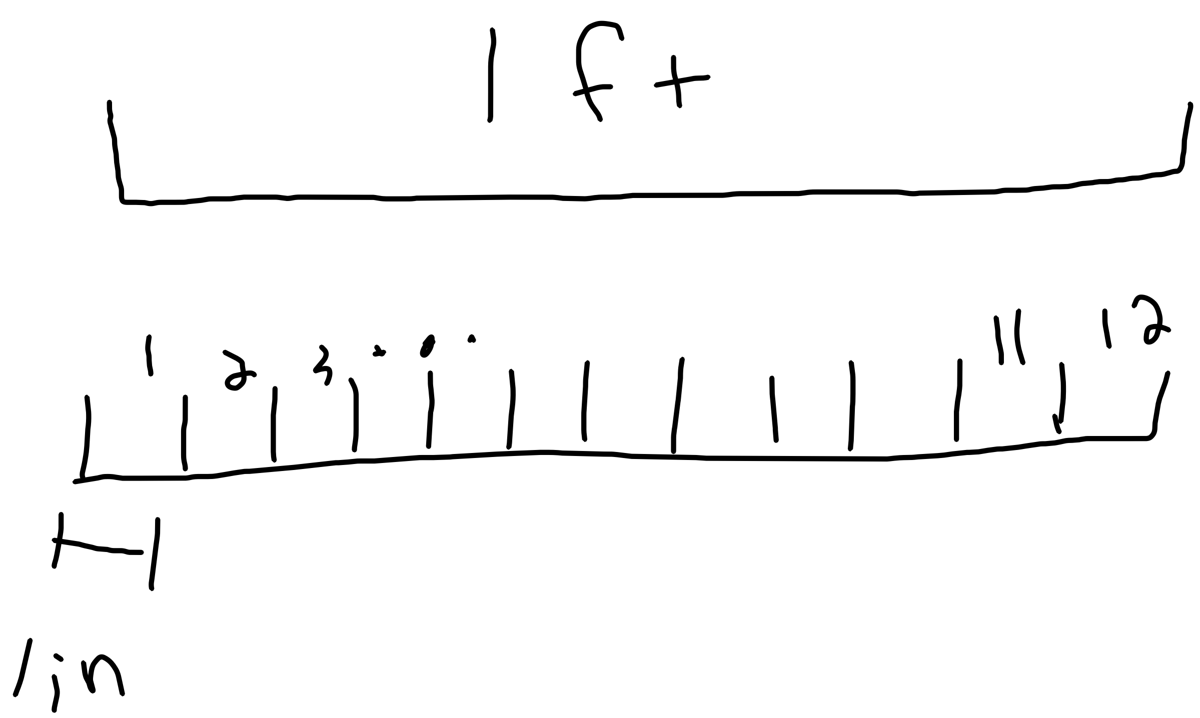
e.g. dimensions of a package: 8in x 10in x 2in

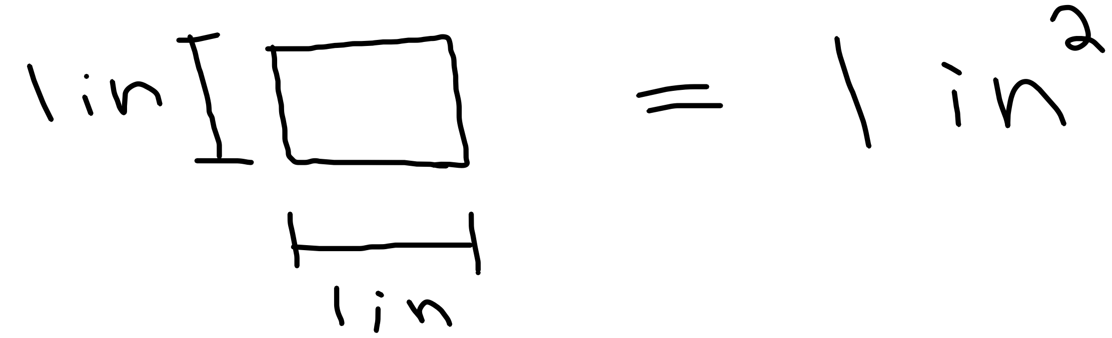
Unit conversion

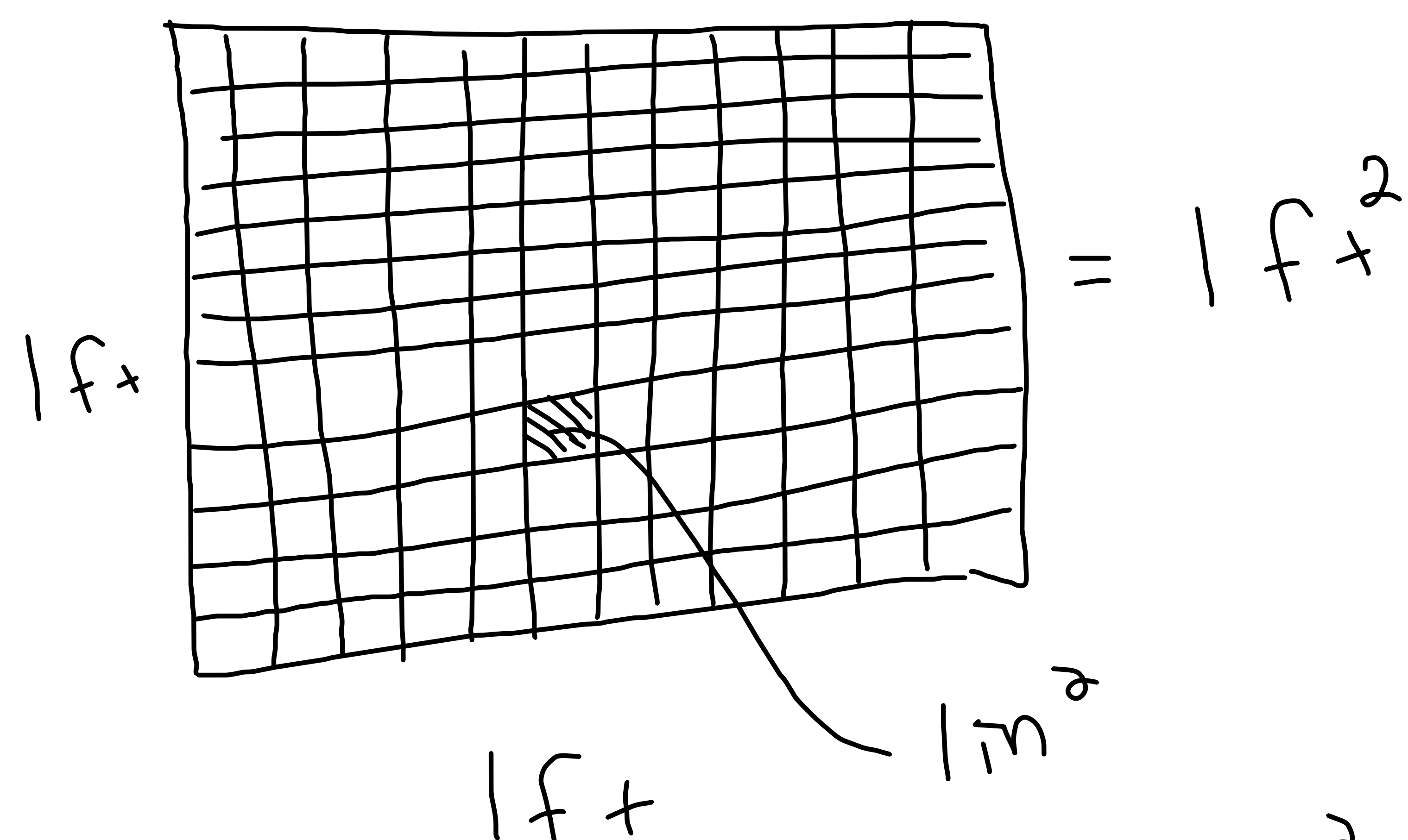
1 year = 365 days

1 day = 24 hours

1 ft = 12 in







$1\,ft \times 1\,ft = 12\,in \times 12\,in = 144\,in^2$

Example: convert $3\,kg/m^3$ to g/cm^3.

trick - multiply by 1

$$\left(\frac{3\,\cancel{kg}}{\cancel{m^3}}\right)\cdot\underbrace{\left(\frac{1000\,g}{1\,\cancel{kg}}\right)}_{1}\cdot\underbrace{\left(\frac{1\,\cancel{m}}{100\,cm}\right)}_{1}\cdot\underbrace{\left(\frac{1\,\cancel{m}}{100\,cm}\right)}_{1}\cdot\underbrace{\left(\frac{1\,\cancel{m}}{100\,cm}\right)}_{1}$$

$$= \frac{(3)(1000)\,g}{1000000\,cm^3} = \boxed{0.003\,\frac{g}{cm^3}}$$

Dimensional analysis

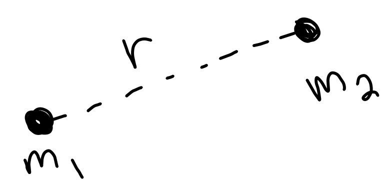
Units/dimensions must make sense.

- How many inches in an hour?
  - Doesn't make sense!

- e.g. we will see later that

$$[\text{Force}] = \frac{kg\cdot m}{s^2}$$

if $F_g = G\frac{m_1 m_2}{r^2}$



What is $[G]$?

Solution —

$$F_g = G\frac{m_1 m_2}{r^2}$$

$$[F_g] = \left[G\frac{m_1 m_2}{r^2}\right]$$

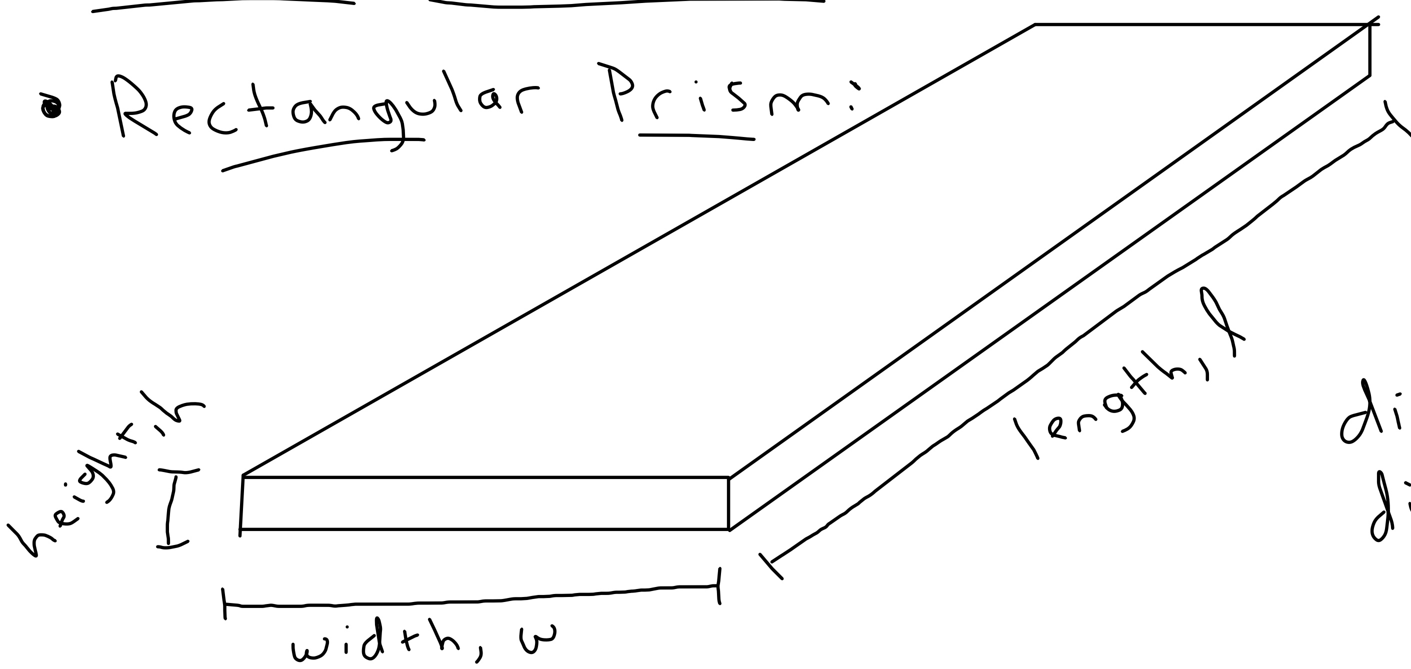
$$\frac{\cancel{kg}\cdot m}{s^2} = [G]\frac{kg^{\cancel{2}}}{m^2}$$

- divide both sides by kg
- multiply both sides by m^2

$$\Rightarrow \boxed{[G] = \frac{m^3}{kg\cdot s^2}}$$

Surface Area/Volume

- Rectangular Prism:



l, w, h have dimensions of distance.

6 rectangular faces: $h \times w$ (2 of them)

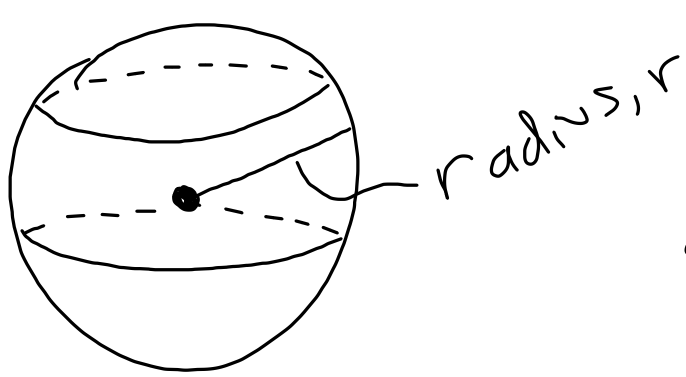
$h \times l$ (2 of them)

$l \times w$ (2 of them)

$$SA = 2\left((h \times w) + (h \times l) + (l \times w)\right)$$ dimensions: dist.^{2}

$$V = l \times w \times h$$ dimensions: distance^3

Sphere:

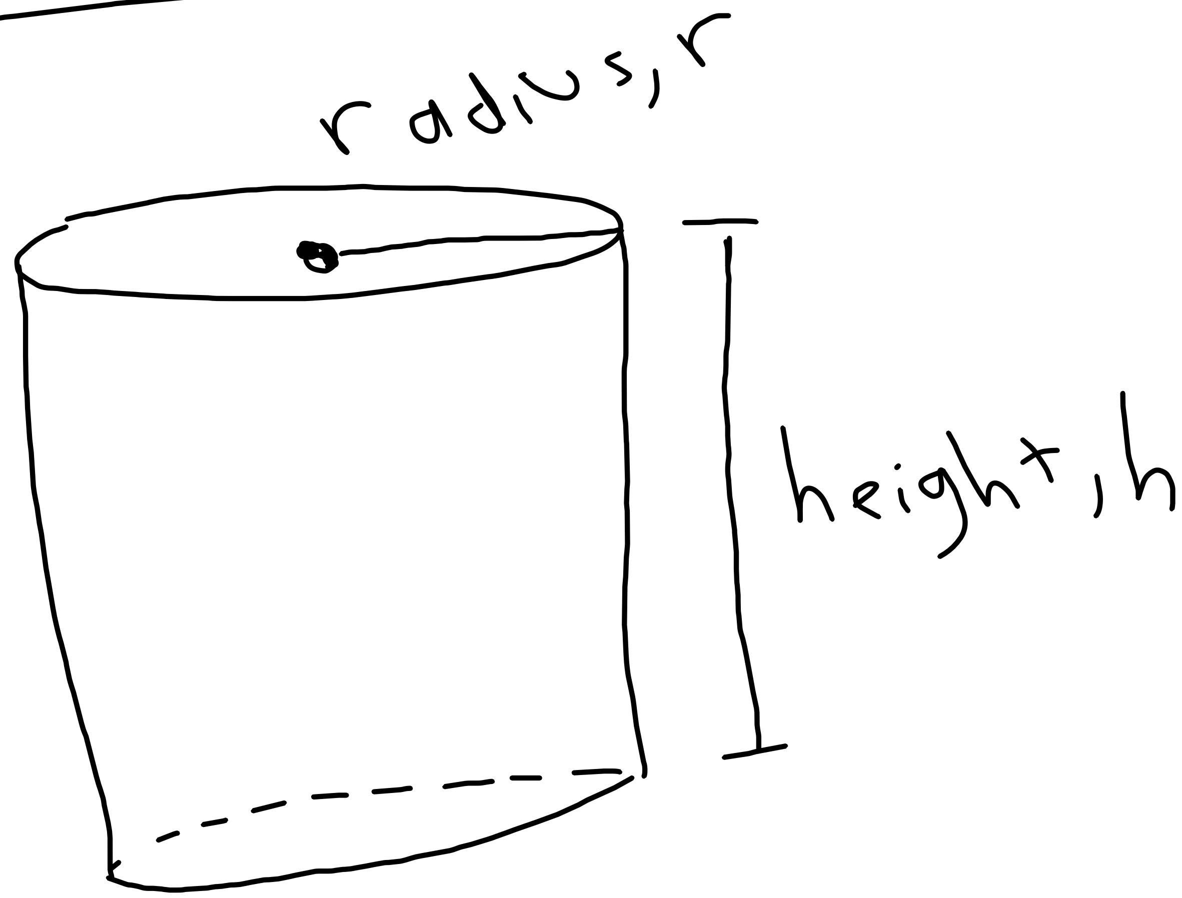


dimensions: distance

$$SA = 4\pi r^2$$ dimensions: distance^2

$$V = \frac{4}{3}\pi r^3$$ dimensions: distance^3

<u>Cylinder</u>

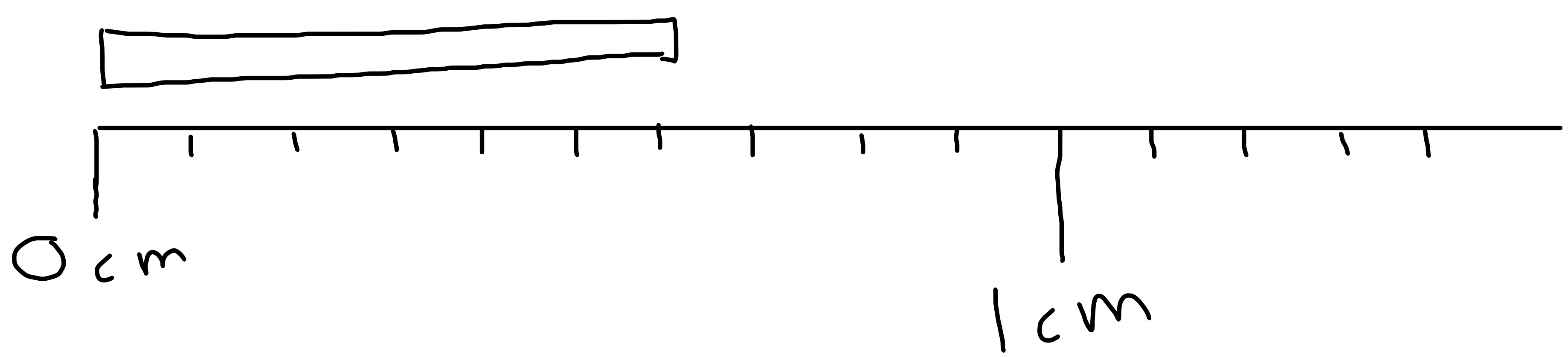


$$SA = 2\pi r^2 + 2\pi r h$$

$$V = \pi r^2 h$$

Error and error propagation (uncertainty)

When making a measurement, error is typically assigned as half of the smallest reading. e.g. ruler:



mm is smallest reading (0.1 cm)

$\Rightarrow \delta L = 0.05$ cm

$$\text{Length} = 0.62 \pm 0.05 \text{ cm}$$