You flip the light switch in your den, but nothing happens. What is wrong?

observation/experiment: Flip light switch, no light!

hypothesis: ~~Explanation: Bulb is burned out.~~
Explanation: No power to bulb - check the breaker box?

prediction: ~~Changing the bulb will bring back the light.~~
Resetting the breaker may restore the light.

experiment: Result of changing the bulb: Still no light.
Result of resetting the breaker: Light comes on.

Measurements

Measurements are comparisons of properties against accepted standards, called units.

English / US units:

1 foot = 12 inches 1 yard = 3 feet 1 mile = 1760 yards

5280 feet = 1 mile

So what's the problem? English units are not very consistent - they don't relate to each other in easy ways. This makes the English system hard to learn and hard to use. Also, the relationships between the units must be memorized separately for each kind of unit.

English units are nonstandard and difficult to use. Solution?

THE METRIC SYSTEM

Metric Base Units:

Length	meter	m
Mass	kilogram*	kg
Temperature	Kelvin	K
Time	second	s

All metric units are made up of COMBINATIONS of BASE UNITS!

*we usually treat the gram as if it's the base unit for mass!

- One meter is approximately 3.3 feet.
- One kilogram is approximately 2.2 pounds.

What about SIZE?

Metric units may be made larger or smaller by adding PREFIXES.

Metric Prefixes:

mega-	10^{6}	M
kilo-	10^{3}	k
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	μ

Bigger units

smaller units

Memorize these prefixes!

Applying prefixes

1 _____ m = _____ m

1 km = 10^{3} m (1000 m)

1 cm = 10^{-2} m ($\frac{1}{100}$ m)

Scaling units with metric prefixes ... examples

The distance between here and Columbia, SC is about 107,000 meters. What metric unit would be best suited for a distance like this?

$k = 10^3$ $km = 10^3 m$ (1000m)

107 km

A piece of chalk is 0.080 meters long. What metric unit would be best suited for this length?

$c = 10^{-2}$ $cm = 10^{-2} m$ $\left(\frac{1}{100} m\right)$

8.0 cm

Derived Units

- are units that are made up of combinations of metric base units with each other and/or with prefixes

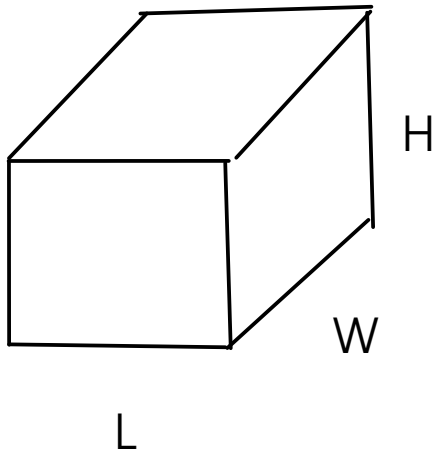
Example: speed $\frac{\text{miles}}{\text{hr}}$, $\frac{\text{km}}{\text{hr}}$ $\left(\frac{\text{length}}{\text{time}}\right)$ $\frac{\text{m}}{\text{s}}$

Two derived units are particularly important in introductory chemistry:

1) VOLUME

2) DENSITY

VOLUME



VOLUME = L × W × H

What are the units of volume in the metric system?

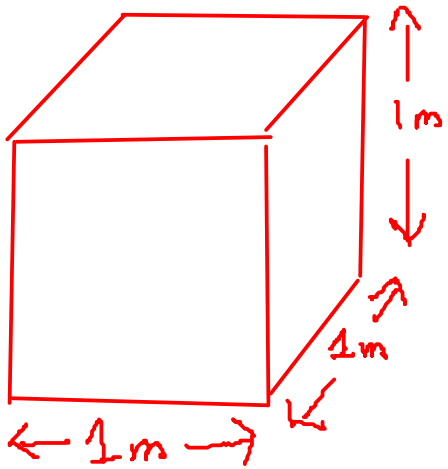
L = LENGTH. Metric unit of length is the METER (m)

W = WIDTH. Also in meters

H = HEIGHT. Also in meters

VOLUME = (m) × (m) × (m) = m^3 "CUBIC METERS"

L W H



... but the cubic meter is a large unit. It's too large for typical lab and medical work.

We need a more lab-friendly unit!

Practical issues for volume units

- Cubic meters are too large! A meter is very similar in length to a yard, so a cubic meter is a cube that is approximately a yard long on each side!

A smaller unit For volume?

Cubic decimeters! dm^3

(decimeter = 1/10 meter)

Cubic decimeters are given the name "liters", abbreviation "L"

In the lab, we typically need an even smaller unit than the liter, so we use milliliters (mL)

"cc"
cubic centimeter
=
milliliter

$1\ mL = 10^{-3} L$

-or-

$1000\ mL = 1\ L$

DENSITY

- Density is a measure of the concentration of matter; of how much matter is present in a given space

- Density is defined as the MASS per unit VOLUME, or ...

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

What are the metric units of DENSITY?

mass : Kg

volume : m^3

So, density unit = $\boxed{\frac{Kg}{m^3}}$

We don't usually use either cubic meters or kilograms to measure volume and mass in a laboratory setting.

In the lab, we typically measure masses as grams and volumes as milliliters, so the density unit we will use most often is:

$$\frac{g}{mL}$$

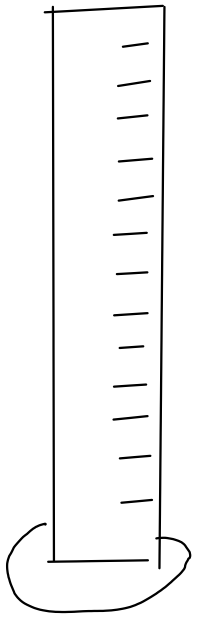
same as $\frac{g}{cm^3}$

A useful density to remember:

WATER at room temp: Density = 1 g/mL

Measuring density

... of a liquid



1) Measure mass of empty cylinder

mass = 97.35 g

2) Fill cylinder and measure volume of liquid

Volume = 25.3 mL

3) Measure mass of filled cylinder

mass = 130.55 g

4) Subtract to find mass of liquid

$$\begin{array}{r} 130.55\ \text{g} \\ -\ 97.35\ \text{g} \\ \hline 33.20\ \text{g} \end{array}$$

5) Density = mass liquid / volume liquid

$$\text{Density} = \frac{33.20\ \text{g}}{25.3\ \text{mL}}$$

$$= 1.31\ \text{g/mL}$$