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

observation/experiment: Flip switch, but nothing happens. Lights are not turning on!

hypothesis: ~~Explanation: Circuit breaker has tripped, since there was some bad weather last night.~~

Explanation: Bad bulb?

prediction: ~~Resetting the circuit breaker will restore the light!~~

Changing the bulb should restore the light.

experiment: ~~Reset circuit breaker, and try the switch. Result: The light is still off.~~

Change the bulb. Result: light comes on!

Measurements

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

A properly-reported measurement has TWO PARTS:
(1) a measured NUMBER
(2) a UNIT

English/US Units:

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

5280 ft = mi

So what's the problem?

English system is messy - units don't relate to each other in logical ways.

Different kinds of English units have different conversions ... means you have to memorize lots of essentially random numbers to use the system.

English units are nonstandard and difficult to use. Solution?

THE METRIC SYSTEM

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

Metric Base Units:

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

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

Comparing to the English system:

- 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 mm = 10^{-3} m ($\frac{1}{1000}$ 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?

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

107 km

By "best suited", we mean a metric unit that would represent the number without many beginning or end zeros. These kinds of numbers are easier for us to remember!

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

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

8.0 cm

Derived Units

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

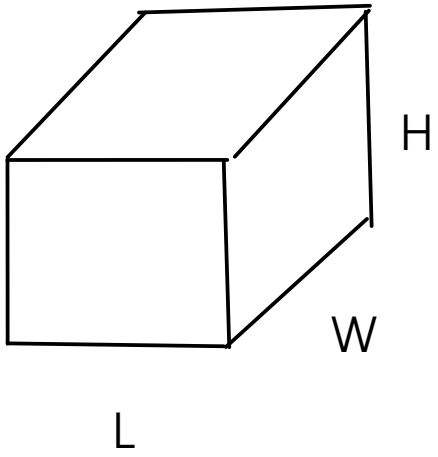
Example: speed $\frac{\text{miles}}{\text{hr}}$, $\frac{\text{km}}{\text{hr}}$ $\left(\frac{\text{length}}{\text{time}}\right)$, $\frac{\text{m}}{\text{s}}$

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?

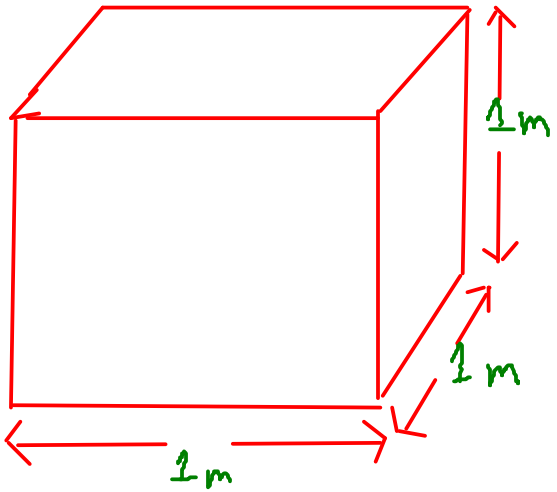
L = LENGTH. = meter

W = WIDTH. = meter

H = HEIGHT. = meter

VOLUME UNIT = (meter) x (meter) x (meter)

= m^3 "cubic meter"



Problem: A cubic meter is too large of a unit to use for routine laboratory measurements.

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 : Kilogram

volume : m^3

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

We don't usually measure masses in kilograms OR volumes in cubic meters in the lab. So we'll use a different density unit!

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

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

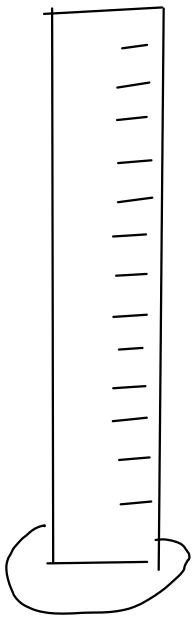
same as $\frac{g}{cm^3}$

A useful density to remember:

WATER at room temp: Density = 1 g/mL

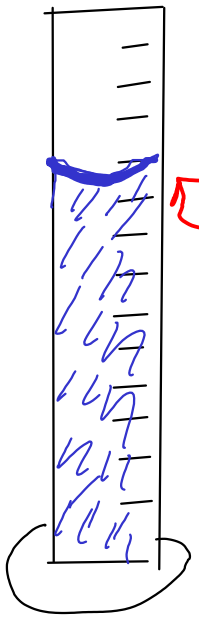
Measuring density

... 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

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

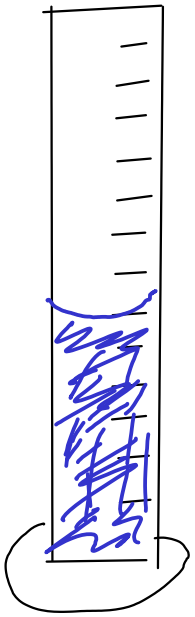
5) Density = mass liquid / volume liquid

$$\text{Density} = \frac{33.20\ \text{g}}{25.3\ \text{mL}} = 1.31\ \text{g/mL}$$

...of an object

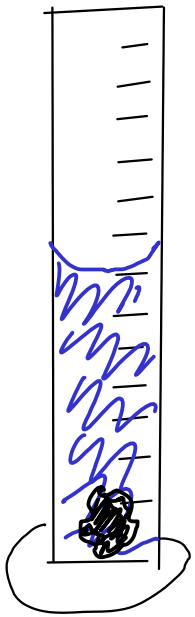
1) Measure mass of object

mass = 9.78 g



2) Partially fill cylinder with liquid, record volume.

volume = 25.0 mL



3) Put object into cylinder, record new volume

volume = 26.6 mL

4) Subtract to find volume of object

$$\begin{array}{r} 26.6\ \text{mL} \\ -\ 25.0\ \text{mL} \\ \hline 1.6\ \text{mL} \end{array}$$

5) Density = mass object / volume object

$$\text{Density} = \frac{9.78\ \text{g}}{1.6\ \text{mL}}$$

$$= 6.1\ \text{g/mL}$$