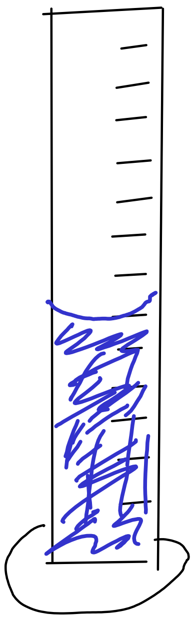
...of an object

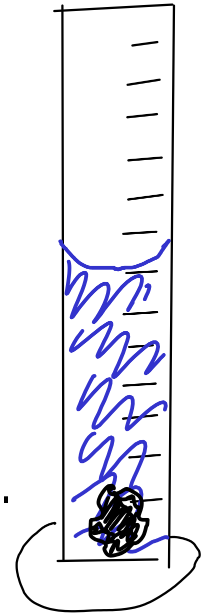
1) Measure mass of object

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

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

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

Converting from one unit to another

We will use the method of dimensional analysis, sometimes called the factor-label method.
... or, the "drag and drop" method!

Dimensional analysis uses conversion factors to change between one unit and another

What's a conversion factor? A simple equality.

Example

12 in = 1 ft

Conversion factors in metric

In the metric system, conversion factors between units may always be made from the metric prefixes!

For example, "kilo-" means 10^3

$$k = 10^3$$

so

$$km = 10^3 m$$

$$kg = 10^3 g$$

$$kL = 10^3 L$$

$$ks = 10^3 s$$

Just apply the prefix to the base unit!

How do we actually USE a conversion factor?

Convert 15.75 m to cm

$cm = 10^{-2}\,m$

$$15.75\,m \times \frac{cm}{10^{-2}\,m} = 1575\,cm$$

* This fraction equals one, so multiplying by it does not change the VALUE of the number, only its UNITS!

* Similar to...

If X = 2, then

$$\frac{X}{2} = 1$$

15.75 / EE −2 .. on TI-83

Convert 0.01893 kg to g

$kg = 10^{3}\,g$

$$0.01893\,kg \times \frac{10^{3}\,g}{kg} = 18.93\,g$$

DRAG AND DROP

- Drag the part of the factor that contains the unit you want to get rid of (cancel out) to the BOTTOM.

- Then, drag the other half of the factor to the TOP

Convert 14500 mg to kg $mg = 10^{-3} g$ $kg = 10^{3} g$

$$14500\, mg \times \frac{10^{-3}\, g}{mg} \times \frac{kg}{10^{3}\, g} = \boxed{0.0145\, kg}$$

Convert 0.147 cm^2 to m^2 $cm = 10^{-2} m$

$$0.147\, cm^2 \times \frac{10^{-2}\, m}{cm} \times \frac{10^{-2}\, m}{cm} = \boxed{1.47 \times 10^{-5}\, m^2}$$

$0.000147\, m^2$

For squared and cubed units, use each conversion factor two (squared) or three (cubed) times. Remember ...

$$cm^2 = cm \times cm$$

$$cm^3 = cm \times cm \times cm$$

8.45 kg to μg

$kg = 10^{3}\,g \qquad \mu g = 10^{-6}\,g$

$$8.45\,\text{kg} \times \frac{10^{3}\,g}{kg} \times \frac{\mu g}{10^{-6}\,g} = 8450000000\,\mu g$$

$8.45 \times 10^{9}\,\mu g$

88100 kHz to MHz

$kHz = 10^{3}\,Hz$

$MHz = 10^{6}\,Hz$

$Hz = s^{-1}$ (frequency)

$$88100\,kHz \times \frac{10^{3}\,Hz}{kHz} \times \frac{MHz}{10^{6}\,Hz} = 88.1\,MHz$$

Convert 38.47 in to m, assuming 2.54 cm = 1 in

$2.54\ cm = in \qquad cm = 10^{-2}\ m$

$$38.47\ in \times \frac{2.54\ cm}{in} \times \frac{10^{-2}\ m}{cm} = \boxed{0.9771\ m}$$

Convert 12.48 km to in

$2.54\ cm = in \qquad cm = 10^{-2}\ m \qquad km = 10^{3}\ m$

$$12.48\ km \times \frac{10^{3}\ m}{km} \times \frac{cm}{10^{-2}\ m} \times \frac{in}{2.54\ cm} = \boxed{491300\ in}$$

Accuracy and Precision

- two related concepts that you must understand when working with measured numbers!

Accuracy

- how close a measured number is to the CORRECT (or "true") value of what you are measuring

- "Is it right?"

- checked by comparing measurements against a STANDARD (a substance or object with known properties)

Precision

- how close a SET of measured numbers are to EACH OTHER

- "Can I reproduce this?"

- checked by repeated measurements

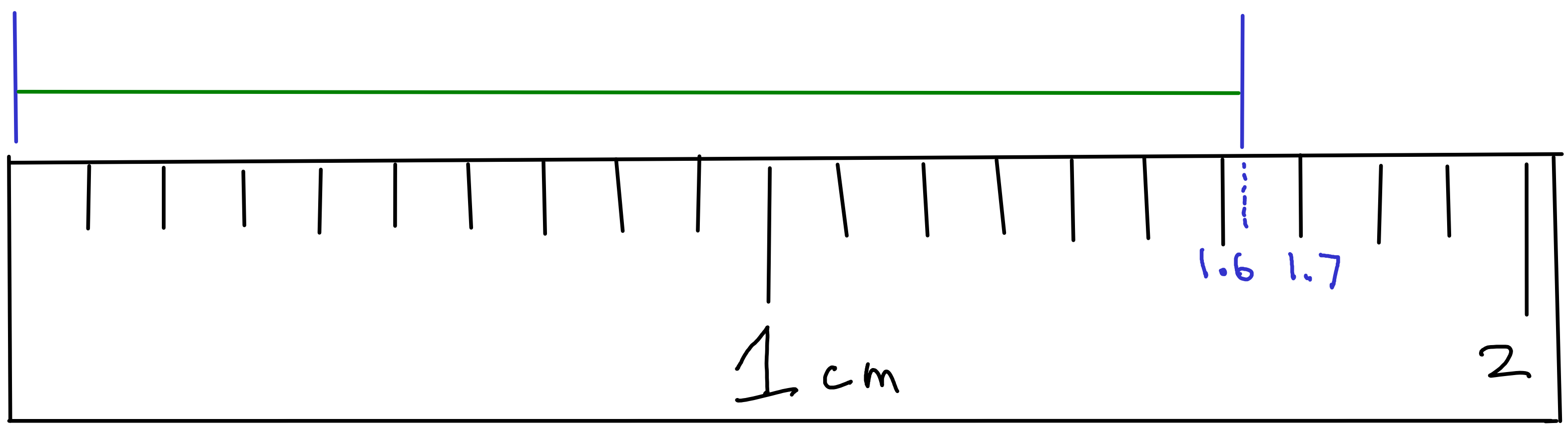
More on precison

Every measurement contains some amount of ERROR, or some amount of deviation from the true value of what is being measured.

RANDOM ERROR is the variability in a measurement that cannot be traced back to a single cause. Random errors cause measurements to fluctuate around the true value, but can be averaged out given enough measurements.

When reporting measurements, we want to indicate how much random error we think is present. How?

Form: X.XX cm



How long is the green line?

Write your answer on the card, then pass the card up to the front!

Our classroom experiment: Results

After throwing away obvious mistakes in reading the scale, we had:

Value	# students
1.61	1
1.62	6
1.63	6

13 measurements

Overall average

$\bar{x} = 1.62384615 4$ cm (unrounded)

$= 1.62$ cm ($\pm$ 0.01 cm)

CERTAIN DIGITS: Appear in nearly all repeats of the measurement

UNCERTAIN DIGITS: Vary.. Variation caused by estimation or other sources of random error.

When reading measurements from a scale, record all CERTAIN digits and one UNCERTAIN (or estimated) digit.

When using a digital device, record all the displayed digits.

Significant figures

SIGNIFICANT FIGURES are a way to indicate the amount of uncertainty in a measurement.

The significant figures in a measurement are all of the CERTAIN DIGITS plus one and only one UNCERTAIN (or estimated) DIGIT

Example:

From our classroom experiment,

1.62 cm

We estimated the last digit, It's uncertain

These digits were obtained in all measurements. They are certain

THIS MEASUREMENT HAS "THREE SIGNIFICANT FIGURES"!