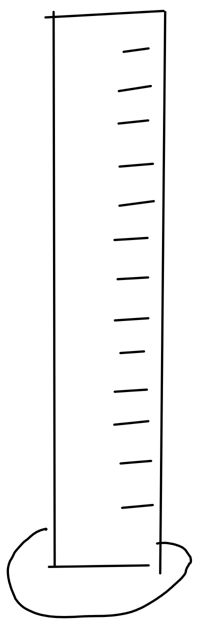
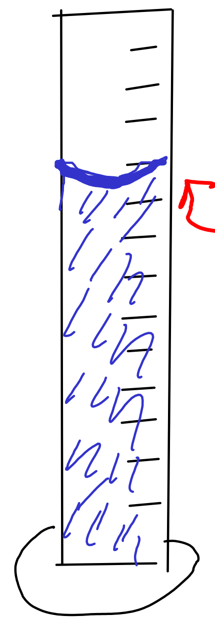
Measuring density

... 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

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

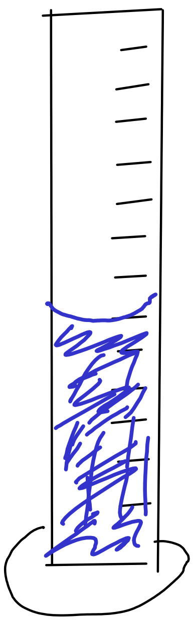
5) Density = mass liquid / volume liquid

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

...of an object

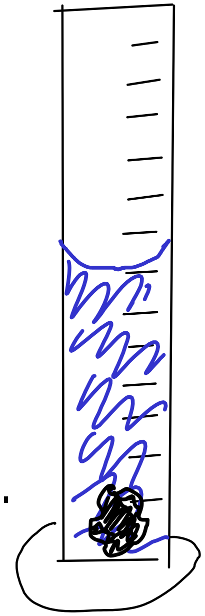
1) Measure mass of object

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

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

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

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

$$km = 10^3 m$$

$$kg = 10^3 g$$

$$ks = 10^3 s$$

$$kL = 10^3 L$$

Just apply the prefix to the base unit!

How do we actually USE a conversion factor?

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

DRAG AND DROP!

Convert 15.75 m to cm

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

Put what you want to cancel on the bottom, then ...

... put what it equals on the top!

Convert 0.01893 kg to g

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

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

Convert 14500 mg to kg

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

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

Convert 0.147 mm to µm

↖ micro-

(mc- also means "micro")

$mm = 10^{-3}\,m \qquad \mu m = 10^{-6}\,m$

$$0.147\,\text{mm} \times \frac{10^{-3}\,\text{m}}{\text{mm}} \times \frac{\mu\text{m}}{10^{-6}\,\text{m}} = 147\,\mu\text{m}$$

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

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

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

Even though English units are involved, we can solve this problem the same way we solved the previous problem where only metric units were used!

20 Even if you're unfamiliar with the metric units involved in a problem, you can still do conversions easily.

88100 kHz to MHz

$Hz = 1/s$ (frequency)

$kHz = 10^3\,Hz \quad MHz = 10^6\,Hz$

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

0.004184 kJ to J

$kJ = 10^3\,J \quad J = \text{Joule (energy)}$

$$0.004184\,kJ \times \frac{10^3\,J}{kJ} = 4.184\,J$$

A sample application of dimensional analysis: Drug calculations in the healthcare field...

Example: A patient is ordered 40 mg of codeine phosphate by subcutaneous injection. 50 mg in 1 mL liquid is available. How much of this liquid should be adminstered?

This is a CONVERSION FACTOR. Many statements with "in" or "per" connecting two numbers can be used as conversion factors!

$$50 \text{ mg drug} = 1 \text{ mL}$$

$$40 \text{ mg drug} \times \frac{1 \text{ mL}}{50 \text{ mg drug}} = \boxed{0.8 \text{ mL}}$$