

## 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!  $\text{dm}^3$

(decimeter =  $\frac{1}{10}$  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)

$\text{mL}$   
cubic centimeter  
=  
milliliter

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

-or-

$$1000 \text{ mL} = 1 \text{ L}$$

## 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?

$$\text{DENSITY} = \frac{\text{kg} \leftarrow \text{Base unit of mass}}{\text{m}^3 \leftarrow \text{Simplest volume unit}}$$

But we don't use cubic meters in lab, since they're too large.

Also, we don't measure mass in kilograms. Our scales have a maximum capacity of 200g, and this is typical for a laboratory.

9  
In the lab, we typically measure masses as grams and volumes as milliliters, so the density unit we will use most often is:

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

$$\left( \frac{g}{cm^3} \right)$$

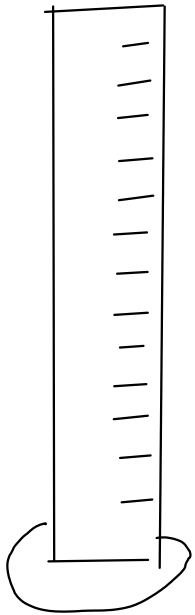
$$\left( \frac{g}{cc} \right)$$

A useful density to remember:

WATER at room temp: Density =  $1 \frac{g}{mL}$

## Measuring density

... of a liquid



1) Measure mass of empty cylinder

$$\text{mass} = 97.35 \text{ g}$$



2) Fill cylinder and measure volume of liquid

$$\text{volume} = 25.3 \text{ mL}$$

3) Measure mass of filled cylinder

$$\text{mass} = 130.55 \text{ g}$$

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

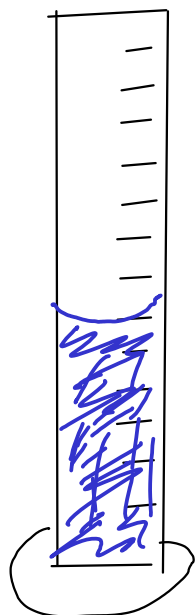
$$\text{Density} = \frac{33.20 \text{ g}}{25.3 \text{ mL}} = 1.31 \text{ g/mL}$$

...of an object



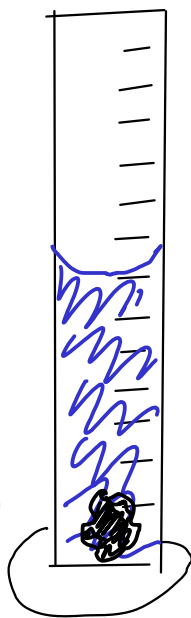
1) Measure mass  
of object

$$\text{mass} = 9.78 \text{ g}$$



2) Partially fill cylinder  
with liquid, record volume.

$$\text{volume} = 25.0 \text{ mL}$$



3) Put object into cylinder, record new  
volume

$$\text{volume} = 26.6 \text{ mL}$$

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

$$12 \text{ in} = 1 \text{ ft}$$

## 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

$$kg = 10^3 g$$

$$km = 10^3 m$$

$$ks = 10^3 s$$

$$kL = 10^3 L$$

Just apply the prefix to the base unit!

## How do we actually USE a conversion factor?

Convert 15.75 m to cm

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

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

\* Similar to...

If  $X = 2$ , then

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

15.75 / [EE]-2 .. on TI-83

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

Convert 0.01893 kg to g

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

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

## 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

$$\text{mg} = 10^{-3} \text{g}$$

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

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

Convert 0.147  $\text{cm}^2$  to  $\text{m}^2$

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

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

$0.0000147 \text{ m}^2$

For squared and cubed units, use each conversion factor two (squared) or three (cubed) times for cancelling. If you think of squared units as ...

$$\text{cm}^2 = \text{cm} \times \text{cm}$$

... then this makes sense.

8.45 kg to  $\mu\text{g}$ 

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

$$\mu\text{g} = 10^{-6} \text{g}$$

$$8.45 \cancel{\text{kg}} \times \frac{10^3 \cancel{\text{g}}}{\cancel{\text{kg}}} \times \frac{\mu\text{g}}{10^{-6} \cancel{\text{g}}} = \boxed{\begin{array}{l} 8450000000 \mu\text{g} \\ 8.45 \times 10^9 \mu\text{g} \end{array}}$$

88100 kHz to MHz

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

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

$$\text{Hz} = 1/\text{s} \text{ (Frequency)}$$

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