This handout is for CHM 090 students to read to themselves week one of the course. There is nothing to turn in, it is just for your benefit to read and understand. Cheers!

The Factor-Label Method

For many years, science teachers complained that students could not solve "word problems". They tried many methods to help, and finally settled on one method that seems to be most useful to students: the factor-label method (sometimes called the unit-conversion method, or dimensional analysis). The factor-label method tells us that units (such as pounds, miles, quarts, or millimeters) can be multiplied, divided, and cross-cancelled just like numbers. A unit can be cross-cancelled only with the identical unit, and one must be in a **numerato**r, and the other in the **denominator**. In the calculation below, the unit "foot" has been cancelled out to calculate the number of inches in a student's step that was measured in to be 2.7 feet.

$$2.7 \text{ ft} \left(\frac{12 \text{ in}}{1 \text{ ft}} \right) = 32 \text{ inches}$$

If you wrote the conversion fraction upside down, you would divide by 12 rather than multiply by 12. If you did make this mistake, your fractions would be:

$$2.7 \text{ ft} \left(\frac{1 \text{ ft}}{12 \text{ in}} \right) = \frac{2.7 \text{ ft} \times \text{ft}}{12 \text{ in}}$$

and you would realize that you have a meaningless set of units in your answer. **If the units are not right, the answer to the problem will not be right!!**

A **conversion factor** is a statement that two things are **equal,** but are expressed in different units. For example, **12 inches = 1 foot.** Conversion factors are most useful in fractional form, and one conversion factor can be written in two fraction forms, right side up and upside down:

$$\left(\frac{12 \text{ in}}{1 \text{ ft}} \right) \text{ or } \left(\frac{1 \text{ ft}}{12 \text{ in}} \right)$$

Only one of the fractions will work in any particular problem, because only one of them will "cancel out" the units properly.

1. Write the two fractional forms of the conversion factors listed below:

   a. 4 quarts = 1 gallon

   b. 100 centimeters = 1 meter

Answer: a. $\left(\frac{4 \text{ qts}}{1 \text{ gal}} \right)$ or $\left(\frac{1 \text{ gal}}{4 \text{ qts}} \right)$

b. $\left(\frac{100 \text{ cm}}{1 \text{ m}} \right)$ or $\left(\frac{1 \text{ m}}{100 \text{ cm}} \right)$

2. Refer to your conversions factors above and write in the correct one needed to "cross-cancel" units.

a. 148 qts (?) = gal

b. 15 m (?) = cm

Answer: a. $\left(\frac{1 \text{ gal}}{4 \text{ qts}} \right)$ is used so that qts cancel out

b. $\left(\frac{100 \text{ cm}}{1 \text{ m}} \right)$ is used so that meters cancel out

You are now on your way to easier and more accurate problem-solving!

Steps in solving problems with the "Factor-Label" method. Read through the steps first, and then see how they are applied to the problem below.

1. Read the problem carefully to find the "given" and the "wanted".
2. Set up the problem. Always start with the "given." Write (-------) next to the given to fill in with the proper conversion factor. Write the units of the "wanted" next to the space for the answer.
3. Decide on the conversion factor. Look up or remember the "connection" between the units in the "given" and the units in the "wanted". Example: 12 inches = 1 foot. Decide which form of the conversion factor will "cross-cancel" the "given" unit and leave the "wanted" unit. Write this form of the conversion factor in the (----------).
4. Solve the problem, "cross-cancel" the units, and "multiply / divide out" the numbers in the final fraction with a calculator.
5. Make sure the answer is reasonable. "Round off" the number on the calculator. Does the answer make sense?

Example 1: A jar of Skippy peanut butter contains 510 grams. How many ounces is this? (There are 28.4 grams in one ounce).

1. Given: 510 grams. Wanted: ounces
2. 510 g $\left(\quad\right)$ = _____ oz
3. 28.4 grams = 1 oz, in fractional form, either $\left(\frac{28.4\text{ g}}{1\text{ oz}}\right)$ or $\left(\frac{1\text{ oz}}{28.4\text{ g}}\right)$

   Looking at the "setup" in step 2, we see that "510 g" must be cancelled out---thus we use the second form of the conversion factor, the one with the "g" in the denominator so that the cross-cancellation will work.

   510 g $\left(\frac{1\text{ oz}}{28.4\text{ g}}\right)$ = _____ oz Note that 510 g $\left(\frac{28.4\text{ g}}{1\text{ oz}}\right)$ **won't work!!**
4. 510 times 1 divided by 28.4 = 17.957746
5. The answer should be "rounded off": 18 oz is close enough. (There are exact rules for rounding off--and you will probably learn them later. For now, just use 2 or 3 numbers in your answer. Placeholder zeros, such as **0.00**525 or 51,**000** aren't counted as numbers) **A 510-gram jar of peanut butter contains 18 oz**. Does this make sense? Yes!

Example 2: A piece of notebook paper is 8.50 inches wide. What is its width in cm? (There are 2.54 cm in one inch)

1. Given: 8.50 inches. Wanted: ? cm
2. 8.50 in $\left(\quad\right)$ = _____ cm
3. 2.54 cm = 1 inch. in fractional form, either $\left(\frac{2.54\text{ cm}}{1\text{ inch}}\right)$ or $\left(\frac{1\text{ inch}}{2.54\text{ cm}}\right)$
4. 8.50 in $\left(\frac{2.54\text{ cm}}{1\text{ inch}}\right)$ = 21.59 cm
5. The answer can be rounded off a bit to 21.6 cm. **A piece of notebook paper 8.50 inches wide is 21.6 cm wide.**

Comments: Sometimes students have difficulty figuring out the "Given" and the "Wanted". Practice helps, but here are a couple of hints. The **"wanted"** can usually be found if you look for the question mark, or key words such as "calculate", "determine", etc. The **"given"** is often the amount of something that is unique to the problem at hand. The **"conversion factor"** is often a more universal relationship, such as "100 cm in a meter", or "2.54 cm in one inch". It always has two units in the statement or math expression. Note that it is **never** a good idea to begin a problem with the conversion factor. You have a 50% chance of using it upside down!