Conversion between units

Scientists often need to convert measurements from one set of units to another. The **factor-label** method (or dimensional analysis) is a standard technique for performing these conversions. In addition, these ideas also help in understanding (and in some cases deriving) equations.

The basic premise behind this method is that multiplying 'anything' by one does not change the value of 'anything'. To find a convenient fraction for 'one' (called a 'conversion factor'), we note that any number (except zero) divided by itself is one. For example, $\frac{5}{5} = 1$, or $\frac{-0.1572}{-0.1572} = 1$. In the factor-label method, we use an equality to get this fraction. For example,

12 inches = 1 foot $\qquad \therefore \frac{12\,inches}{12\,inches} = 1 = \frac{1\,foot}{12\,inches} \quad or \quad \frac{12\,inches}{1\,foot} = 1 = \frac{1\,foot}{1\,foot}$

If a value is multiplied by $\frac{1\,foot}{12\,inches}$, this is equivalent to multiplying by one. For example, to answer the question, "How many feet are there in 36 inches?", the following calculation should be performed:

$$36 \text{ inches x } \frac{1\,foot}{12\,inches} = 3 \text{ feet}$$

The only problem with this approach is the potential confusion over which conversion factor to use. For example, 36 inches x $\frac{12\,inches}{1\,foot}$ is 'correct' in the sense that we have simply multiplied 36 inches by 'one'. However, it is 'wrong' in the sense that the value obtained is meaningless: the units don't make any sense. In this example, the answer of 432 $\frac{inches^2}{foot}$ doesn't answer the question because the answer is not in the proper units of 'feet'.

Rules for using the Factor-Label method

1. Write down the known quantity, including any units that are given. *(36 inches)*
2. Select an equality (don't memorize, these will be given to you) that contains both the units of the known quantity and the desired units. *(12 inches ≡ 1 foot)*
3. Create a conversion factor by writing: $\frac{Desired\,Units}{Known\,Units}$ ($\frac{1\,foot}{12\,inches}$)
4. Multiply the known quantity by the conversion factor. *(36 inches x $\frac{1\,foot}{12\,inches}$ = 3 feet)*

Example

As an example, given that 2.54 cm ≡ 1 inch, how many cm are in 12 inches?
[Step 1] 12 inches [Step 2] 2.54 cm ≡ 1 inch [Step 3] $\frac{2.54\,cm}{1\,inch}$
[Step 4] 12 inches x $\frac{2.54\,cm}{1\,inch}$ = 30.48 cm.

Additional Problems (Answers on web site)

2.54 cm ≡ 1 inch (in)	1 quart ≈ 0.946 litter (L)	1 kg ≈ 2.20 lb	1 calorie = 4.184 joules
5280 ft ≡ 1 mile	12 in ≡ 1 foot (ft)	3 feet ≡ 1 yard	100 cm = 1 meter (m)

1. How many inches are present in 12 cm?
2. How many quarts are present in a 2.0 liter bottle?
3. If a person weighs 150 pounds (lb), how many kilograms (kg) is this?
4. If a car travels 65 $\frac{miles}{hour}$, how far can this car go in 3.5 hours? (Hint: $\frac{65\,miles}{1\,hour}$ is the conversion factor)
5. [Harder] How many yards are present in 400 meters? (Hint: m → cm → inches →feet → yards)