Unit Conversion--The Factor Label Method

All measured values have a unit name which is every bit as important as the numerical part. A football field is 100 yards long, not just 100 long. A soft drink costs 75 cents, not just 75, and so on. Therefore units must be included in measurements and for all derived quantities. In many calculations units "cancel," so the final answer has fewer units than went into the computation. Some examples are given below:

1) If one drink costs $.75, how much will 3 drinks cost?

\[
\frac{3 \text{ drinks}}{1 \text{ drink}} \times \frac{\$0.75}{1 \text{ drink}} = \$2.25
\]

2) If you travel at 50 miles per hour, how far will you go in 1.5 hours?

\[
\frac{1.5 \text{ hours}}{1 \text{ hour}} \times \frac{50 \text{ miles}}{1 \text{ hour}} = 75 \text{ miles}
\]

In example 1) the number of drinks was changed to $ by a conversion factor, $0.75/drink. In example 2) the number of hours was changed to miles using the conversion factor 50 mi/hour. Conversion factors relate one quantity to another. They allow you to cancel units so that the unit you start with can be changed to the unit you desire in the answer. Notice that the starting number was expressed in fraction form. Any number that has only one unit, can be expressed with the number one in the denominator.

### Part I Metric Conversions

Study the chart at right. It gives you conversion factors for metric units. For instance, there are a 1000 meters in a kilometer, while only 0.001 g in one milligram. Use the conversion factors to convert the following metric units from one to another below:

1) 35 grams to kilograms

2) 35 grams to milligrams

3) 35 mg to g

4) 2 meters to centimeters

5) 3.57 centimeters to millimeters

6) 0.035 km to m

7) 24.6 mm to m

8) 24.6 mm to km
Use the volume conversion factors below to answer questions 9) - 14).

\[ 1 \text{ dm}^3 = 1 \text{ Liter} = 1000 \text{ mL} = 1000 \text{ cm}^3 \]

9) 20 mL to cm  
10) 0.010 L to dm$^3$

11) 90.4 mL to L  
12) 11 dm$^3$ to cm$^3$

13) .004 cm$^3$ to L  
14) 13.1 dm$^3$ to mL

Part II Multi-Step Conversions

Problems 5 and 9 were the most difficult in part I. In problem 5, centimeters do not have to be changed directly to millimeters. It is possible to first change centimeters to meters and then change meters to millimeters:

\[ \frac{3.57 \text{ cm}}{1} \times \frac{1 \text{ m}}{100 \text{ cm}} \times \frac{1000 \text{ mm}}{1 \text{ m}} = 35.7 \text{ mm} \]

You could even use the values in given table to achieve the same answer:

\[ \frac{3.57 \text{ cm}}{1} \times \frac{0.01 \text{ m}}{1 \text{ cm}} \times \frac{1 \text{ mm}}{0.001 \text{ m}} = 35.7 \text{ mm} \]

The work to problem 8 could be shown as:

\[ \frac{24.6 \text{ mm}}{1} \times \frac{1 \text{ m}}{1000 \text{ mm}} \times \frac{1 \text{ km}}{1000 \text{ m}} = 0.0000246 \text{ km} \text{ or } 2.46 \times 10^{-5} \text{ km} \]

When converting between English and metric units it is often necessary to use more than one step:

\[ \frac{5 \text{ ft}}{1} \times \frac{12 \text{ in}}{1 \text{ ft}} \times \frac{2.54 \text{ cm}}{1 \text{ in}} \times \frac{10 \text{ mm}}{1 \text{ cm}} = 2000 \text{ mm} \]

<table>
<thead>
<tr>
<th>Length</th>
<th>Volume</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.54 centimeter = 1 inch</td>
<td>1 quart = 0.9463 L</td>
<td>1 ounce = 28.35 gram</td>
</tr>
<tr>
<td>5280 ft = 1 mile</td>
<td>4 quarts = 1 gallon</td>
<td>1 pound = 0.454 Kg</td>
</tr>
<tr>
<td>1 yard = 36 in = 3 ft</td>
<td>32 ounces = 1 quart</td>
<td>16 ounces = 1 pound</td>
</tr>
</tbody>
</table>

Use the Metric-English Unit identities given below to perform the following conversions. You will probably have to use more than one step. Show all your work indicating the cancellation of all units.
1) 250 grams to pounds

2) .75 quarts to milliliters

3) 4.88 liters to gallons

4) 6 tons to grams (1 ton = ??? – Look it up!)

5) .0034 centimeters to yards

6) 1000 centigrams to ounces

7) 6.2 feet to kilometers

8) 500 milliliters to inches

9) 10,000 meters to miles

10) 12 ounces to liters

**Part 3  Volume Conversions**

In volume conversions, set up units to cancel like any other problem. Do not concern yourself with the units until linear units are arranged to cancel. The last step should be to cube each linear fraction.

Example: $2 \text{ m}^3$ to $\text{cm}^3$

**Step 1:**

$$\frac{2 \text{ m}^3 \times 100 \text{ cm}}{1 \text{ m}}$$

**Step 2:**

$$\frac{2 \text{ m}^3 \times (100 \text{ cm})^3}{1 \text{ (m)}^3}$$

**Step 3:**

$$\frac{2 \text{ m}^3 \times 1000000 \text{ cm}^3}{1 \text{ m}^3} = 2000000 \text{ cm}^3 \text{ or } 2 \times 10^6 \text{ cm}^3$$

Show unit cancellation in converting the following units:

1) 25 centimeters$^3$ to meter$^3$

2) .0211 to decimeter$^3$

3) 2 yard$^3$ to feet$^3$

4) 52 feet$^3$ to meter$^3$
Answers to Part 1

1) 0.035 kg  
3) 0.035 g  
5) 35.7  
7) 0.0246 m  
9) 20  
11) 0.094 L  
13) 0.000004 or 4 \times 10^{-6} \text{ L}

Answers to Part 2

1) 0.55 lb  
3) 1.29 gal  
5) 0.000037 yd or 3.7 \times 10^{-5} \text{ yd}  
7) 0.0019 km  
9) 6.21 mi

Answers to Part 3

1) 0.00002 m$^3$ or 2 \times 10^{-5} m$^3$  
3) 54 ft$^3$