All science requires mathematics. The knowledge of mathematical things is almost innate in us. . . [Mathematics] is the easiest of sciences, a fact which is obvious in that no one's brain rejects it…

Roger Bacon (c. 1214-c. 1294)

Stand firm in your refusal to remain conscious during algebra. In real life, I assure you, there is no such thing as algebra.

Fran Lebowitz (b. 1951)
• **Step 1:** State your question in an expression that sets the unknown unit equal to the value given.

  - Start with the same number of units as you want.
    - If you want a single unit, start with a value that has a single unit.
    - If you want a ratio of two units, start with a value that has a ratio of two units, or start with a ratio of two values, each of which have one unit.

• Put the correct type of unit in the correct position.
Unit Analysis

Step 2

- **Step 2:** Multiply the expression to the right of the equals sign by one or more conversion factors that cancel the unwanted units and generate the desired unit.

  - If you are not certain which conversion factor to use, ask yourself, "What is the fundamental conversion and what conversion factor do I use for that type of conversion?"
Step 3: Check to be sure you used correct conversion factors and that your units cancel to yield the desired unit.

Step 4: Do the calculation, rounding your answer to the correct number of significant figures and combining it with the correct unit.
# English-Metric Conversion Factors

<table>
<thead>
<tr>
<th>Type of Measurement</th>
<th>Probably Most Useful to Know</th>
<th>Others Useful to Know</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>$\frac{2.54 \text{ cm}}{1 \text{ in.}}$</td>
<td>$\frac{1.609 \text{ km}}{1 \text{ mi}}$, $\frac{39.37 \text{ in.}}{1 \text{ m}}$, $\frac{1.094 \text{ yd}}{1 \text{ m}}$</td>
</tr>
<tr>
<td><strong>Mass</strong></td>
<td>$\frac{453.6 \text{ g}}{1 \text{ lb}}$</td>
<td>$\frac{2.205 \text{ lb}}{1 \text{ kg}}$</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td>$\frac{3.785 \text{ L}}{1 \text{ gal}}$</td>
<td>$\frac{1.057 \text{ qt}}{1 \text{ L}}$</td>
</tr>
</tbody>
</table>
Rounding Answers from Multiplication and Division

Step 1

• **Step 1:** Determine whether each value is exact, and ignore exact values.
  
  – Exact values
    
    • Numbers that come from definitions are exact.
    
    • Numbers derived from counting are exact.
  
  – Do Step 2 for values that are not exact.
    
    • Values that come from measurements are never exact.
    
    • We will assume that values derived from calculations are not exact unless otherwise indicated.
• **Step 2:** Determine the number of significant figures in each value that is not exact.

  • All non-zero digits are significant.
  • Zeros between nonzero digits are significant.
  • Zeros to the left of nonzero digits are not significant.
  • Zeros to the right of nonzero digits in numbers that include decimal points are significant.
  • Zeros to the right of nonzero digits in numbers without decimal points are ambiguous for significant figures.
• **Step 3:** When multiplying and dividing, round your answer off to the same number of significant figures as the value used with the fewest significant figures.

  • If the digit to the right of the final digit you want to retain is less than 5, round down (the last digit remains the same).

  • If the digit to the right of the final digit you want to retain is 5 or greater, round up (the last significant digit increases by 1).
Rounding Answers from Addition and Subtraction

• **Step 1:** Determine whether each value is exact, and ignore exact values.
  – Skip exact values.
  – Do Step 2 for values that are not exact.

• **Step 2:** Determine the number of decimal positions for each value that is not exact.

• **Step 3:** Round your answer to the same number of decimal positions as the inexact value with the fewest decimal places.
• *Mass density* is mass divided by volume. It is usually just called density.

\[
\text{Density} = \frac{\text{mass}}{\text{volume}}
\]

• It can be used as a unit analysis conversion factor that converts mass to volume or volume to mass.
• Mass percentages and volume percentage can be used as unit analysis conversion factors to convert between units of the part and units of the whole.

For X% by mass:
\[
\frac{X \text{ (any mass unit) part}}{100 \text{ (same mass unit) whole}}
\]

For X% by volume:
\[
\frac{X \text{ (any volume unit) part}}{100 \text{ (same volume unit) whole}}
\]
Conversion Types

Metric unit <-> Another metric unit

Conversion factors from prefixes on Table 1.2
(same type of measurement)

English length unit <-> Metric length unit

\frac{2.54 \text{ cm}}{1 \text{ in.}} \quad \text{or conversion factors in Table 8.1}

English mass unit <-> Metric mass unit

\frac{453.6 \text{ g}}{1 \text{ lb}} \quad \text{or conversion factors in Table 8.1}

English volume unit <-> Metric volume unit

\frac{3.785 \text{ L}}{1 \text{ gal}} \quad \text{or conversion factors in Table 8.1}

English unit <-> Another English unit

Conversion factors in Table A.5 Appendix A
(same type of measurement)

Mass <-> Volume

Density as a conversion factor

Mass of a part <-> Mass of a whole

For X\% by mass \quad \frac{X \text{ (any mass unit) part}}{100 \text{ (same mass unit) whole}}

Volume of a part <-> Volume of a whole

For X\% by volume \quad \frac{X \text{ (any volume unit) part}}{100 \text{ (same volume unit) whole}}
Temperature Conversions

°F = \(-\frac{9}{5} \times °C + 32\)°F

°C = \(-\frac{5}{9} \times (°F - 32)\)°C

K = °C + 273.15

°C = K - 273.15