Units and the Metric System

Unit I

Section 1.1: Metric System

Unfortunately, US students must learn two systems of measurement: English & Metric

**English System**:
- Length = feet
- Weight = pounds
- Mass = slugs
- Time = Seconds

**Metric System**:
- mks (meters, kilogram, second)
- cgs (centimeter, gram, second)

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<th>mks</th>
<th>cgs</th>
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<tbody>
<tr>
<td>Length</td>
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<td>Weight</td>
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<td>Mass</td>
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<td>Time</td>
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In this course we will use the Metric mks system of units.
The metric system is based on multiples of 10 with a prefix notation specifying that multiple.

1 Billion = giga \( \Rightarrow G \) \{ upper case \}
1 Million = mega \( \Rightarrow M \)
1 Thousand = kilo \( \Rightarrow K \)
1 Hundred = centi \( \Rightarrow c \) \{ Lower case \}
1 Thousandth = milli \( \Rightarrow m \)
1 Milliath = micro \( \Rightarrow \mu \) \{ Greek letter “mu” for micro \}
1 Billionth = nano \( \Rightarrow n \)

Prefix by abbreviation

The base unit for length = meter \( \Rightarrow m \)

1 Gigameter = 1 Gm = 1,000,000,000 m = 10^9 m
1 Megameter = 1 Mm = 1,000,000 m = 10^6 m
1 Kilometer = 1 Km = 1,000 m = 10^3 m
1 centimeter = 1 cm = \( \frac{1}{100} \) m = 0.01 m = 10^-2 m
1 millimeter = 1 mm = \( \frac{1}{1000} \) m = 0.001 m = 10^-3 m
1 micrometer = 1 \( \mu \)m = \( \frac{1}{1,000,000} \) m = 0.000001 m = 10^-6 m
1 nanometer = 1 nm = \( \frac{1}{1,000,000,000} \) m = 0.000000001 m = 10^-9 m
Notice that the conversion factor ratios are just the number 1. Then

\[
6 \text{ miles} \times 1 \times 1 = 6 \text{ miles} \times \frac{5280 \text{ feet}}{1 \text{ mile}} \times \frac{1 \text{ yard}}{3 \text{ feet}} = 10560 \text{ yards}
\]

Notice how the units cancel out algebraically.

Example: How many centimeters are in 8 kilometers?

\[
\text{Conversion Factors:} \quad 100 \text{ cm} = 1 \text{ m} \\
\quad 1 \text{ Km} = 1000 \text{ m}
\]

\[
8 \text{ km} \times \frac{1000 \text{ m}}{1 \text{ km}} \times \frac{100 \text{ cm}}{1 \text{ m}} = 8 \times 10^3 \times 10^2 \text{ cm} \\
= 8 \times 10^5 \text{ cm} \\
= 800,000 \text{ cm}
\]

Notice that we did not have to use a calculator for the metric conversion, but we needed a calculator for the English conversion.

This is why the metric system of units was developed.
Section 1.2: Conversion Factors

Conversion factors allow one to go from one set of units to another. For example, if I want to find out how many yards are in 6 miles, I would use the following conversion factors:

\[
\text{Conversion factors:} \quad 1 \text{ mile} = 5280 \text{ feet} \\
\quad 3 \text{ feet} = 1 \text{ yard}
\]

For the top equation, \(1 \text{ mile} = 5280 \text{ feet}\), I can divide (algebraically) \(1 \text{ mile}\) on both sides:

\[
\frac{1 \text{ mile}}{1 \text{ mile}} = \frac{5280 \text{ feet}}{1 \text{ mile}}
\]

but \(\frac{1 \text{ mile}}{1 \text{ mile}} = 1 = \frac{5280 \text{ feet}}{1 \text{ mile}}\)

Similarly, I can do the same for the bottom equation:

\[
\frac{3 \text{ feet}}{3 \text{ feet}} = 1 = \frac{1 \text{ yard}}{3 \text{ feet}}
\]

If I multiply 6 miles by the number 1, I just get 6 miles:

\[6 \text{ miles} \times 1 \times 1 = 6 \text{ miles}\]