Uncertainty in Measurement

Metric Measure, Significant Figures & Dimensional Analysis

Metric facts

- First developed in France in the late 18th century
- Used by most countries throughout the world
- Based on the decimal system
- Divide or multiply units by 10

SI Units

- Seven base units
- Uses prefixes to indicate decimal fraction or multiples of various units
- Ex. milli- 10^{-3} fraction of a unit
  - milligram (mg) is 10^{-3} gram (g)

Prefix

SI Base Units

Physical Quantity	Name of Unit	Abbreviation
Mass	Kilogram	kg
Length	Meter (re)	m
Volume	Liter (re)	l
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

Selected Prefixes Used in the SI System

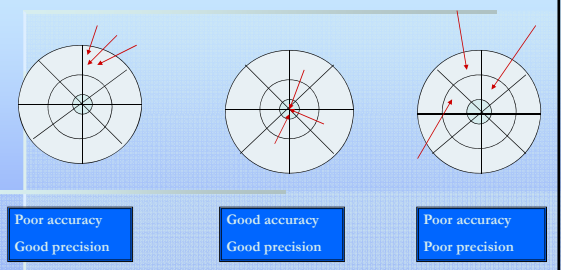
Prefix	Abbr.	Meaning	Example
Mega-	M	10^{6}	1 megameter(Mm) = $1x10^{6}$ m
Kilo-	k	10^{3}	1 kilometer (km) = $1x10^{3}$ m
Deci-	d	10^{-1}	1 decimeter (dm) = 0.1 m
Centi-	c	10^{-2}	1 centimeter (cm) = 0.01 m
Milli-	m	10^{-3}	1 millimeter (mm) = 0.001 m

Precision and Accuracy

- Two kinds of numbers
  - **Exact**
    - Those whose values are known exactly
      - 12 eggs in a dozen
      - 1000 g in a kilogram
      - 2.54 cm in an inch
  - **Inexact**
    - Those obtained by measurements
      - Equipment errors
      - Human errors
- Remember: Uncertainties always exist in measured quantities

- Precision
  - Measure of how closely individual measurement agree with one another
- Accuracy
  - Refers to how closely individual measurements agree with the correct, or "true" value
- The more precise the measurement, the more accurate it will be.

Bull's Eye



Significant Figures

- All nonzero digits are significant
  - 457 cm (three significant figures)
  - 2.5 g (two significant figures)
- Zeros **between** nonzero digits are significant
  - 1005 kg (four significant figures)
  - 1.03 cm (three significant figures)
- Zeros to the **left** of the first nonzero digit are **not** significant (they indicate the position of the decimal point
  - 0.02 g (one significant figure)
  - 0.0026 cm (two significant figure)

- Zeros that fall both at the **end** of a number and to the right of the decimal point **are** significant
  - 0.0200 g (three significant figures)
  - 3.0 cm (two significant figures)

- Numbers ending in zeros but contains no decimal point, the zeros may or may not be significant
  - 130 cm (two or three significant figures)
  - 10,300 g (three, four or five significant figures)

    1.03×10^4 g (three significant figures)

    1.030×10^4 g (four significant figures)

    1.0300×10^4 g (five significant figures)

Now let's try…

- How many significant figures are in each of the following numbers
  - 4.003
  - 6.023×10^{23}
  - 5000
  - 3.549 g
  - 2.3×10^4 cm
  - 0.00134 m^3

Significant Figures in Calculations

- Multiplication and Division
  - Answer follows the number of significant figures in the number with the fewest significant figures.
  - Round off the numbers if it contains more than the correct number of significant figures.

Area = (6.21 cm)(5.2 cm) = 32.3492 cm^2

Round off to 32 cm^2

- Addition and Subtraction
  - Result should follow the same number of decimal places as that of the term with the least number of decimal places.

This number limits the number of significant figures in the result

20.4 ← One decimal place

1.322 ← Three decimal places

83 ← Zero decimal places

104.722 → Round off to 105

Dimensional Analysis

Conversion factor

- A fraction whose numerator and denominator are the same quantity expressed in different units
- Ex. 2.54 cm and 1 in. are the same length
  - 2.54 cm. = 1 in.
- Two conversion factors
  - $\frac{2.54\ cm.}{1\ in.}$ $\frac{1\ in.}{2.54\ cm.}$

Convert 8.50 in. to cm.

Desired unit

$$\text{No. of cm.} = (8.50\ \text{in.}) \frac{2.54\ \text{cm.}}{1\ \text{in.}} = 21.6\ \text{cm}$$

Given unit

Note this!

$$\text{Given unit} \times \frac{\text{Desired unit}}{\text{Given unit}} = \text{Desired unit}$$

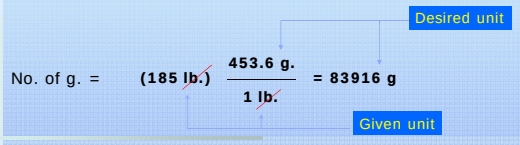
Therefore:

- What data are you given in the problem?
- What quantity do you wish to obtain in the problem?
- What conversion factors do you have available to take you from the given quantity to the desired one?

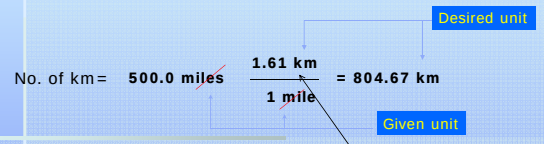
Now let's try this:

- A man weighs 185 lb. What is his mass in grams?
  - Conversion factor = 1 lb = 453.6 g
- Determine the length in kilometers of a 500.0-mi automobile race
  - Conversion factor = use your table of conversion factors

Convert 185 lbs to grams



Convert 500.0 miles to km



- Sig figs… 804.67km = 805km
- Remember, fewest amount of sf in problem are reflected in answer