Chapter 1 – Measurement and Units

Fundamental Quantities

Length [L]

Mass [M]

Time [T]

Other physical quantities can be constructed from these three.

Units

To communicate the result of a measurement for a quantity, a *unit* must be defined.

Defining units allows everyone to relate to the same fundamental amount.

Systems of Measurement

SI -- Systéme International

-- agreed to in 1960 by an international committee

-- main system used in the text

-- also called mks for the first letters in the units of the fundamental quantities (meter, kilogram, second)

Systems of Measurement

cgs – Gaussian system

-- named for the first letters of the units it uses for fundamental quantities (centimeter, gram, second)

Systems of Measurement

US Customary (fps)

-- everyday units (foot, pound, second)

-- often uses *weight*, in pounds, instead of *mass* (in slugs) as a fundamental quantity

Standard SI Units

as defined by the
General Conference on Weights and Measures

(CGPM)
Conférence Générale des Poids et Mesures

Standard SI Units

The *meter* is the length of the path traveled by light in vacuum during a time interval of

1/299 792 458 of a second.

This fixes the speed of light in vacuum at exactly 299 792 458 m/s.

Standard SI Units

The ***kilogram*** **is the unit of mass. It is equal to the mass of the international prototype of the kilogram (pictured here) kept at the International Bureau of Weights and Measures under conditions specified by the 1st CGPM in 1889.**

(Defined by the 3d CGPM in 1901.)

Standard SI Units

The *second* is the unit of time.

It is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom at a temperature of 0 K.

(Defined in 1967 by the 13th CGPM, affirmed in 1997 by the CIPM – International Committee for Weights and Measures.)

Significant Figures

A *significant figure* is one that is *reliably known*.

All non-zero digits are significant.

Zeros are significant when

- **between other non-zero digits**
- **after the decimal point and another significant figure.**
- **(E.g., in 0.106 the zero between 1 and 6 is significant.)**
- **Use scientific notation to clarify.**
- **E.g., write 0.106 as 1.06×10^{-1}.**

Significant Figures

More examples:

200 → 1 significant figure
200.→ 3 significant figures
.0160 → 2 significant figures
1.60×10^{-2} → 3 significant figures

Operations with Significant Figures

The number of significant figures is a measure of *accuracy*.

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Accurate **means "capable of providing a correct reading or measurement." In physical science it means 'correct'. A measurement is accurate if it correctly reflects the size of the thing being measured.**

Operations with Significant Figures

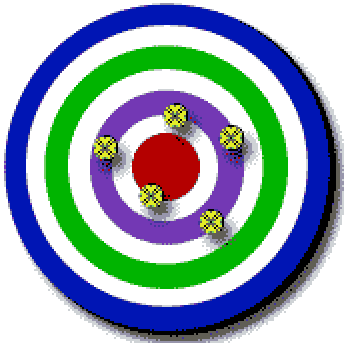
The number of significant figures is a measure of *accuracy*. This is not the same as *precision*.

Precise means "exact, as in performance, execution, or amount." In physical science it means "repeatable, reliable, getting the same measurement each time."

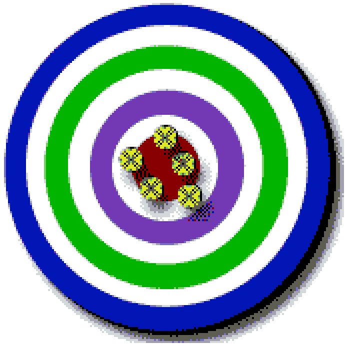
Operations with Significant Figures

Example: Throw five darts at a target.

Low accuracy, high precision



High accuracy, low precision



High accuracy, high precision

Operations with Significant Figures

Multiplication and Division

The number of significant figures in the final result is the same as the number of significant figures in the least accurate of the factors being combined.

$$3.701 \times .0056 = .021 \text{ or } 2.1 \times 10^{-2} \quad (\text{not } .0207256)$$

$$\frac{35.4}{2.54906} = 13.9 \quad (\text{not } 13.88747224)$$

Operations with Significant Figures

Addition and Subtraction

Round the result to the smallest number of decimal places of any term in the sum.

$6.124 + 2.78 - .3309 = 8.57$ not 8.5731