Chapter 1
Measurement

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Scientific Method

- Observation
- Hypothesis
- **Experimentation**
- Theory
- Law

Measurement

Any number is useless without any units. Units are used to signify what quantity has been measured.

Physical Quality	Non SI	SI
Length	Miles, feet	Meters (m)
Weight	Pounds, ounces	Grams (g)
Time	Seconds	Seconds (s)
Temperature	Degree Fahrenheit, Celsius	Kelvin (K)
Electric current	Ampere	Ampere (A)
Volume	Gallons, quarts	Liters (L)
Pressure	Atm, torr, Pascal	Newtons (N)

Instruments Used for Measurement

- Length: meter stick or measuring tape
- Time: stop watch or watch
- Solid Volume: meter stick
- Liquid Volume: measuring cylinder, beakers
- Temperature: mercury or digital thermometer
- Weight: electronic balance, analytical balance
- Pressure: barometer

Non SI Units

What unit is larger?

Pint or gallon?

Gallon: 1 gallon = 4 pints

Inch or foot

Foot: 1 ft = 12 inches

Score or decade?

Which means there are issues with non SI units.

SI Units

BaseUnit:

Liter (L)
Meter (m)
Seconds (s)

Prefix	Symbol	Meaning	Example
Tera-	T	1×10^{12} (1,000,000,000,000)	1 teragram (Tg) = 1×10^{12} g
Giga-	G	1×10^{9} (1,000,000,000)	1 gigawatt (GW) = 1×10^{9} W
Mega-	M	1×10^{6} (1,000,000)	1 megahertz (MHz) = 1×10^{6} Hz
Kilo-	k	1×10^{3} (1,000)	1 kilometer (km) = 1×10^{3} m
Deci-	d	1×10^{-1} (0.1)	1 deciliter (dL) = 1×10^{-1} L
Centi-	c	1×10^{-2} (0.01)	1 centimeter (cm) = 1×10^{-2} m
Milli-	m	1×10^{-3} (0.001)	1 millimeter (mm) = 1×10^{-3} m
Micro-	μ	1×10^{-6} (0.000001)	1 microliter (μL) = 1×10^{-6} L
Nano-	n	1×10^{-9} (0.000000001)	1 nanosecond (ns) = 1×10^{-9} s
Pico-	p	1×10^{-12} (0.000000000001)	1 picogram (pg) = 1×10^{-12} g

Scientific Notation

- The representation of a number in the form $A \times 10^n$.
  Where A should be >1 and < 10 and n is an integer
- Every digit included in A is significant.

Example: Write the following numbers in scientific notation:

0.000653
350,000
0.02700

Answer:

6.53×10^{-4}

3.5×10^{5}

2.700×10^{-2}

Using Units with Scientific Notations

Example: Write the following measurements without scientific notation using the appropriate SI prefix:

4.851×10^{-9} g = 4.851 ng

3.16×10^{-2} m = 3.16 cm

8.93×10^{-12} s = 8.93 ps

Make the following conversions using scientific notation:

6.20 km to m = 6.20×10^{3} m

2.54 cm to m = 2.54×10^{-2} m

1.98 ns to s = 1.98×10^{-9} s

5.23 μg to g = 5.23×10^{-6} g

Measurement

Measurements can be Precise or Accurate

Precision: measured values close to each other

Accuracy: measured value close to actual value

both accurate and precise

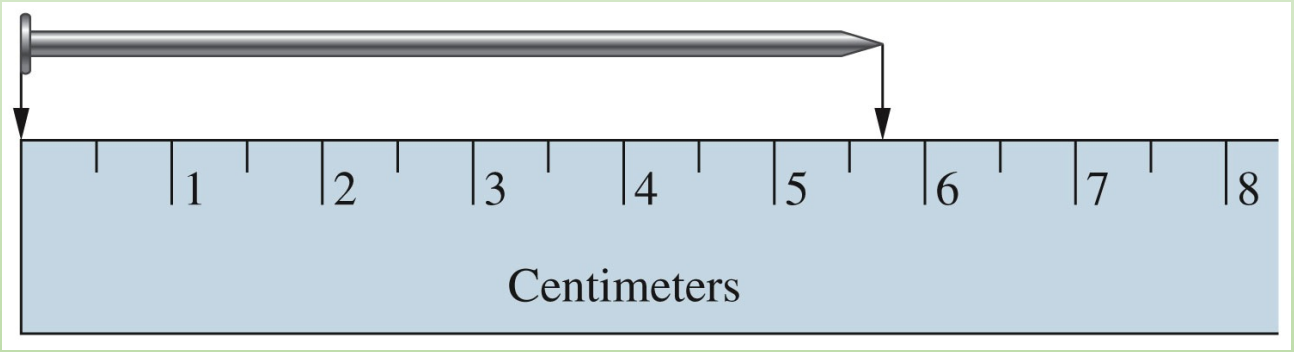
not accurate but precise

neither accurate nor precise

Significant Figures

5.12 g or 5.124 g

Those digits in a measured number (or in the result of a calculation with measured numbers) that include all certain digits plus a final digit having some uncertainty.



5.7 cm

(The tenths place is estimated)

Guidelines for Significant Figures

We need some guideline because in calculations you can have different data of different sig figs;

e.g. in calculation of an area: 1.2356 m x 1.95 m = answer in how many sig figs?

First you need to find how many sig figs you have for each measurement and then do the calculation.

1. Any non-zero digit is significant (1-9)
2. Zeros between non-zero digits are significant (101)
3. Zeros to the left of the first non-zero digit are not significant (010)
4. Zeros to the right of the last non-zero digit are significant if decimal is present (100.00)
5. Zeros to the right of the last non-zero digit are not significant if decimal is not present (100)

Solved Problem:

How many significant figures are in each of the following measurements?

a. 310.0 kg = 4 sig figs
b. 0.224800 m = 6 sig figs
c. 0.05930 kg = 4 sig figs
d. 4.380×10^{-8} m = 4 sig figs
e. 3.100 s = 4 sig figs
f. 91,000 = 2 sig figs

Calculations and Significant Figures

- **Multiplication and Division**: find the lowest sig fig and round off to that number.

  E.g. $$\frac{6.8914}{1289 \times 7.28} = 0.734383925 = 0.734$$

- **Addition and Subtraction**: find the lowest decimal number and round off to that number.

  E.g $0.453 - 1.59 = -1.13700000 = -1.14$

- **Rounding off**: Find out the correct sig figs you need then, count from the left to that number, look at the number on the immediate right of the last number and if it is 5 or more than 5 then round off the previous number to +1; if lower than 5 then drop that number and all the numbers that follow.

Key Words/Concepts

- Units of Measurement
- SI and non SI units
- Accuracy and Precision
- Significant figures