Week 1 Physics Notes

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1 Units and Measurements

1.1 SI Units

- What is a unit?
  - A basic, arbitrary, widely accepted reference standard.
  - Used in conjunction with a number to express the measurement of a physical quantity
  - Types
    - Fundamental Units (g, kg, ft, lb)
    - Derived Units (Newton, Velocity, Joule)
  - Set of fundamental and derived units: system of units.
- Systems of units
  1. International System of Units
     - From French *Système international d'unités*. It was also formerly known as the meter-kilogram-second (MKS) system.
     - Developed and recommended by the General Conference on Weights and Measurement in 1971.
     - Expressed in multiple or fractional quantities in powers of 10 (SI Prefixes).
  2. Imperial System of Units
     - Also known as British System and foot-pound-second (FPS).
  3. centimeter-gram-second (CGS)
- Base SI Units

Table 1: List of base SI units

Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric Current	amprere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous Intensity	candela	cd

- SI prefixes and multipliers

Table 2: List of SI prefixes ($10^{n>1}$)

Prefix	Symbol	Base 10
quetta	Q	10^{30}
ronna	R	10^{27}
yotta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deca	da	10^{1}

Table 3: List of SI prefixes ($10^{n<1}$)

Prefix	Symbol	Base 10
deci	d	10^{-1}
centi	c	10^{-2}
mili	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}
ronto	r	10^{-27}
quecto	q	10^{-30}

1.2 Conversion Factors

- Distance
  - Imperial-Metric
    - inches-centimeters: $\frac{1in}{2.54cm}$
    - feet-meters: $\frac{1ft}{0.30m}$
    - miles-kilometers: $\frac{1mi}{1.61km}$
  - Imperial-Imperial
    - feet-inches: $\frac{1ft}{12in}$
    - yards-feet: $\frac{1yd}{3ft}$
    - miles-yards: $\frac{1mi}{1760yd}$
- Area
  - Non-SI Unit to Metric
    - acres-kilometers: $\frac{1ac}{4.046m^2}$
    - hectare-kilometer: $\frac{1ha}{10km^2}$
- Volume
  - Metric Units
    - liters-m^3: $\frac{1L}{1dm^3}$
    - mililiters-cc: $\frac{1mL}{1cc}$
  - Imperial Units
    - gallon-liters^3: $\frac{1gal}{4.55L}$
    - quart-gallon: $\frac{4qt}{1gal}$
    - pint-gallon: $\frac{8pt}{1gal}$
    - ounce-gallon (imperial): $\frac{160floz}{1gal}$
    - ton-ft^3: $\frac{1ton}{35ft^3}$
  - Kitchen Units
    - cup-gallon: $\frac{16c}{1gal}$

    - tablespoon-ounce (imperial):

$$\frac{8tbsp}{5floz}$$

    - teaspoon-ounce (imperial):

$$\frac{6tsp}{1floz}$$

- Mass
    - Imperial and Metric
        - kilograms-pounds:

$$\frac{1kg}{2.2lb}$$

        - ounce-pounds:

$$\frac{16oz}{1lb}$$

        - ton (metric):

$$\frac{1t}{1000kg}$$

- Time
- Temperature
    - Farenheit-Celsius:

$$F\deg = (\frac{9}{5}C\deg)+32$$

$$C\deg = \frac{5}{9}(F\deg -32)$$

1.3 Percent Error

- Percent Error Formula

$$\%\text{ error} = \frac{|\text{ actual value} - \text{theoretical value }|}{\text{theoretical value}}$$

- Definitions
    - Actual Value
        - Also known as the experimental value.
        - It is the value that came up from an experiment's results.
    - Theoretical Value
        - It is the calculated ideal value of the result if an experiment were to be conducted perfectly in an ideal environment.
    - Percent Error
        - Determines the margin of error of the actual value from the theoretical value.
        - This may tell if the experiment was conducted successfully.

1.4 Accuracy vs. Precision

- Definitions
    - Accuracy
        - degree of conformity of a measure to a standard or a true value (*Merriam-Webster Dictionary*)
    - Precision
        - the quality of strictly conforming to a pattern, standard, or convention (*Merriam-Webster Dictionary*)

- Accuracy and precision are not mutually exclusive, one can change without the other changing.
- Accuracy and precision are not all black and white, it is more effective to think of them as percentages rather than absolutes.
- Graphical Explanation

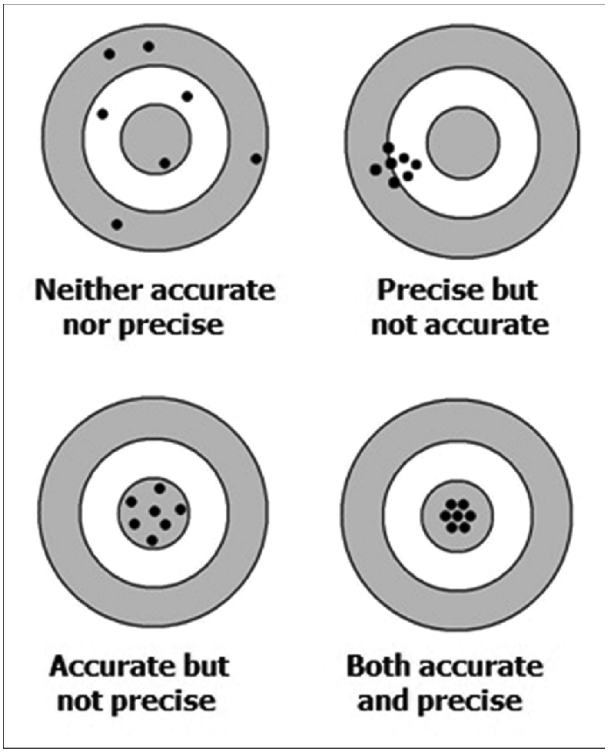

Figure 1: a diagram showing the permutations of accuracy and precision (Hazra, 2017)

1.5 Scientific Notation

- a succinct way of writing huge numbers by expressing them in powers of 10 (10^n).
  - if $n > 0$, then the coefficient will become larger.
  - if $n < 0$, then the coefficient will become smaller.
- Parts of Scientific Notation
  - $5.67 \cdot 10^{-4}$
    - $5.67 \rightarrow$ coefficient
    - $10 \rightarrow$ base
    - -4 $\rightarrow$ exponent
- Examples:
  - $1 \cdot 10^6 = 1000000$
  - $4.56 \cdot 10^{-3} = 0.00456$
  - $6.022 \cdot 10^23 = 602200000000000000000000$

1.6 Significant Figures

- Significant figures are the digits in a number that are important for determining its precision. They convey how accurately a measurement is known.
- Rules for Significant Figures
  1. All nonzero digits are significant
     ex. 11.73 has 4 significant figures.
  2. All zeros that are found between nonzero digits are significant.
     ex. 300.45 has 5 significant figures (including the zeros between 3 and 4).
  3. Leading zeros (to the left of the first nonzero digit) are not significant.
     ex. 0.0098 has 2 significant figures
  4. Trailing zeros for a whole number that ends with a decimal point are significant.
     ex. 4500.00 has 6 significant figures.
  5. Trailing zeros to the right of the decimal place are significant.
     ex. 0.00410 has 3 significant figures.
  6. Irrational numbers have an infinite amount of significant figures
     ex. π and e are irrational numbers and therefore have an infinite amount of significant figures.
  7. In scientific notation, like $A \cdot 10^n$, the number of significant figures comes from the value A only. The exponent n is treated as an exact number and doesn't affect the count of significant figures.
     ex. The value 5,200 can be written in scientific notation to reflect two, three, and four significant digits:
     $5.2 \cdot 10^3 \rightarrow$ two significant figures
     $5.20 \cdot 10^3 \rightarrow$ three significant figures
     $5.200 \cdot 10^3 \rightarrow$ four significant figures