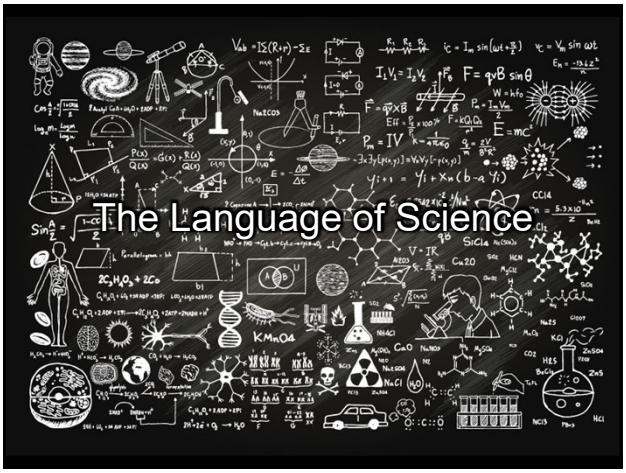
What is science?

- Science is a process by which we try to understand how the natural world works and how it came to be that way.

- Scientists investigate and observe phenomena in the natural world to gather evidence.
- This evidence is analyzed to try to make sense of what is happening.
- The scientist then provides an explanation or theory as to why or how the phenomena occurs.
- This explanation is always considered tentative as there are limitations of what we know and what we can observe.

- All explanations are not equally valid. Explanations that best fit the data are more valid than others.
- It must be possible to disprove an explanation.
- Scientific explanations cannot be based merely upon personal opinion, popular vote, belief, or judgment.
- Science is a human endeavor. Therefore, bias, opinion, ego, and other human factors will come into play. The task is to try to remove those factors from a scientific explanation.



Units

- The measurements of physical quantities are expressed in terms of units.

Physical Quantity	Units
time	second (s)
mass	kilogram (kg)
distance	meter (m)
volume	liter (L)
speed	meters/second (m/s)
temperature	Celsius (°C)

SI Prefixes

Small

centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}

Large

kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
terra	T	10^{12}

Converting Units

- Calculations are done using base units.
- To convert to base units, multiply the value by the appropriate multiplier.

$$2\ \text{nm} = ?\ \text{m}$$

The multiplier for nano is 10^{-9}.

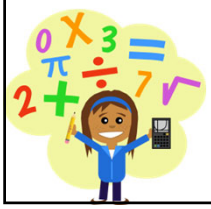
$$2\ \text{nm} = 2 \times 10^{-9}\ \text{m}$$

- To convert from base units to a prefixed value, divide by the appropriate multiplier.

$$5000\ \text{m} = ?\ \text{km}$$

The multiplier for kilo is 10^{3}.

$$\frac{5000\ \text{m}}{10^{3}} = 5\ \text{km}$$



Examples

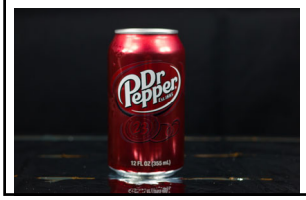
$50\ \mu m =$ 50×10^{-6} m

$250\ g =$ 0.25 kg

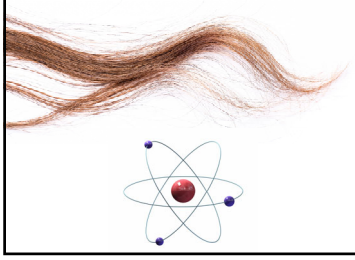
$\frac{250}{10^3}$

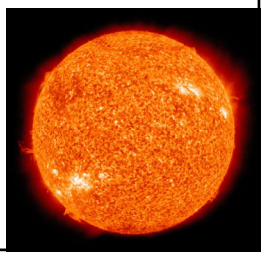
Scientific Notion

- Many measurements we encounter are values that are easily understood and manipulated.
  - Volume of a soda can = 355 mL
  - Distance from Winnipeg to Toronto = 2000 km



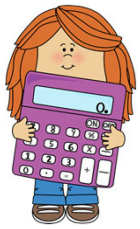
- But there also are extreme values.
  - Width of a human hair = 0.00005 m
  - Electron radius = 0.00000000000047 m
  - Mass of the sun = 2000000000000000000000000000000 kg





- A shorthand method of writing very small and very large numbers is called scientific notation, in which we express numbers in terms of exponents of 10.
- Scientific notation follows the general format $a \times 10^n$. Where a is a decimal number and n is an integer.
  - 1.67×10^{-27}
  - 5.97×10^{24}

- To write a number in scientific notation, move the decimal point to the right of the first digit in the number.
- Count the number of places that you moved the decimal point.
- The number of places moves is the exponent.



- For large numbers, the decimal moves to the left and the exponent will be positive.

$$123.000.000.000.$$

$$1.23 \times 10^{11}$$

- For small numbers, the decimal moves to the right and exponent will be negative.

$$0.000.000.001.23$$

$$1.23 \times 10^{-9}$$

Examples

$250\ 000\ 000\ \text{m} =$ $2.5 \times 10^8\ \text{m}$

$0.000\ 006\ 8\ \text{kg} =$ $6.8 \times 10^{-6}\ \text{kg}$

Uncertainty

- There is an inherent uncertainty in any measurement. It is caused by random fluctuations within a system.
- This uncertainty cannot be eliminated but it can be measured and reduced by conducting repeated observations of a specific event.

- The amount of uncertainty in a measurement is expressed by +/- notation.

1.23 ± 0.05

measurement value

uncertainty

The value of the measurement is between $1.18\ (1.23 - 0.05)$ and $1.28\ (1.23 + 0.05)$.