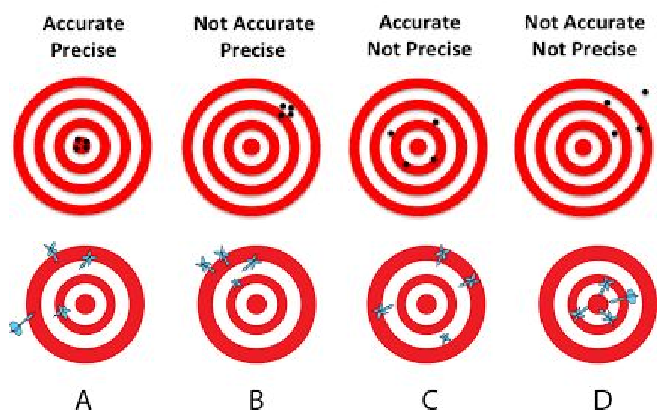
MEASUREMENT AND UNITS

"LORD, make me to know my end, And what is the measure of my days,
That I may know how frail I am." Psalm 39:4

- mathematics: science of quantity; language of science
- equation: set of symbols summarizing mathematical relationship between quantities [V=lwh]; most important part of equation is the **equal** sign; equation may be rearranged to get desired information [h=V/lw]
- *Fibonacci numbers*: begins with 0 and 1; every other number in the sequence is found by adding the two numbers before it:
  0+1=1 → 1+1=2 → 1+2=3 → 2+3=5 → 3+5=8 → 5+8=13 → 8+13=21 -> 13+21=34
  examples in nature: daisy head has 21 clockwise spirals, 34 counterclockwise spirals
  pineapples have 8 curves one way, 13 curves the other way
- Accuracy: how closely a measurement reflects the actual value (dart hitting a target)
  Precision: repeatability of a measurement, or how close several measurements are to each other (ability to consistently hit the bullseye of the target)



Significant figures

- used to record only measured values or calculated values (not speculated or hypothetical values)
- all nonzero digits are significant (1,2,3,4,5,6,7,8,9)
- Zeroes before/to the left of first nonzero digit are never significant: 0.0917 = three significant figures
- Zeroes between nonzero digits are always significant: 30.005 = five significant figures
- Zeroes after/to the right of last nonzero digit are significant only if there is a decimal point in the number: 40.0 = three significant figures; 40 = one significant figure

- Calculating with significant figures:
  -multiplication and division: answer rounded to same# of significant figures as least significant factor
  Ex: 3.24 x 0.08 = 0.2592 → 0.3
  -addition and subtraction: results are rounded to the last place value that is significant in the least accurate measurement
  Ex: 5.20 + 6 = 11.20→ 11
  Round answers to significant figures only at the end of all calculations to avoid multiple rounding errors
  [Application p. 15]

Scientific notation
- shortcut to writing extremely large or small numbers
- based on fact that every number (except 0) can be expressed as a number between 1 and 10 multiplied by a power of 10
  Ex: 6,020,000 = 6.02 x 10^6 (positive exponent → decimal moved from right/large number)
  0.00092 = 9.2 x 10^{-4} (negative exponent → decimal moved from left/small number)
  [Application p.17]

Units
- Measured data must include units for universal understanding; need for developing system of measurement
- Cubit: length of person's arm from elbow to tip of middle finger; based on the individual
  need for developing a standard of measure: specific measure to which other measures are compared to ensure uniformity
- F.P.S. system: system of measurement used in the United States; foot-pound-second system
  Unciae: "inches" / *mille passus*: "thousand double paces" / *libra*: "weighing balance"
- Metric system:

measurement	unit
length	meter (m)
weight	gram (g) / kilogram (kg)
volume	liter (L) / cubic meter (m^3)
time	second (s)
temperature	celsius (℃)

- Prefix attached to name of each basic unit to make it larger or smaller based on powers of 10:

Prefix	Symbol	Meaning	Power of 10
kilo-	k	1000 x	10^3
deca-	da	10 x	10^1
deci-	d	1/10 x	10^{-1}
centi-	c	1/100 x	10^{-2}
milli-	m	1/1000 x	10^{-3}

- SI: *Système Internationale d'Unités*; universally accepted as standard system of measurement for scientific and technical purposes
  [Metric system conversion illustrations p.20]
  [Measuring mass illustrations p. 21]
- Temperature conversions between Fahrenheit (F), Celsius (C) and Kelvin (K)
  F = 9/5 x ℃ + 32
  C = 5/9 (℉ -32)
- The coldest possible temperature is absolute zero: the temperature at which molecular vibrations ceases = 0 K (zero Kelvin)
  K = ℃ + 273.15
  ℃ = K - 273.15
- *memorize boiling point/freezing point of water in K/℉/℃
  [Application p. 24]

VOLUME AND DENSITY

- mass/weight/volume/density are several physical properties of matter commonly used in physical science

Volume

- Amount of space that matter takes up; describes how large or small an object is
- Geometric formulas can be used to find the volumes of simple shapes
  [Table p.26]
  1 cm^3=1mL

[Application p.26]

- The volume of an irregularly shaped solid can be measured using the technique of fluid displacement [demonstration]
  -subtracting the initial volume (water only) from the final volume (water+object) gives the volume of the object:

$V_{(object)} = V_{(final)} - V_{(initial)}$

- Direct measurement method uses a container with volume markings
  -only works with liquid or if the solid is in small pieces that fit together almost perfectly

<u>Density</u>

- Density: amount of matter in a certain volume; how much there is in a certain amount of space
- Density of water = 1 g/cm³
- found by dividing mass by volume:

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \text{OR} \quad \varrho = \frac{m}{V}$$

Ex: What is the density of a cork cylinder that has a mass of 400.g and takes up a volume of 1700cm³? Is cork more or less dense than water?

- Density can be used to identify substances (gold v. "fools gold")
- The relative densities of two substances will determine whether one will float in the other → in general, a solid will float in a liquid if the solid has a lower density than the liquid

<u>Specific gravity</u>

- Ratio of density of a substance to the density of a standard
- For solids and liquids, the standard is water, which has a density of 1.00 g/cm³
- Found by dividing the density of the substance by the density of water:

$$\text{Specific gravity} = \frac{\varrho \text{ substance}}{\varrho \text{ water}}$$

Ex: What is the specific gravity of iron if its density is 7.87g/cm³?

- Note: specific gravity is just a number with NO UNITS