1 Morning class week 1 day 4: Estimation, numbers, and a little proportionality

1. The most important part of a number is its order of magnitude. The second most important part is its first significant figure.

   (a) Recall, from earlier work, the order of magnitude of the number of seconds corresponding to a lifetime of 100 years.

   (b) The current estimate is that the universe is ten billion years old. What is the order of magnitude of the age of the universe measured in seconds.

   (c) Avogadro's number is approximately 6×10^{23}. What is the order of magnitude of Avogadro's number?

   (d) Is the order of magnitude of Avogadro's number bigger or smaller than the age of the universe measured in seconds?

2. The following questions introduce the concepts of momentum and kinetic energy. Note 2 miles/hr, or a bit more exactly 2.2 miles/hr $\approx$ 1 m/s. One pound is around 500 (or a bit more exactly 450) grams. One ounce is around 30 grams.

   (a) Momentum is the mass times the velocity of a moving object. (The equations in this section do *not* apply to objects moving at the speed of light), $p = mv$ where momentum is p, mass m, and velocity v.

   (b) Estimate to one significant figure, in kg, the mass in grams of an adult male, a baseball, and a bullet.

   (c) Estimate to one significant figure, in kg m/s, the momentum of a person walking at 3 miles/hr, a baseball thrown at 50 miles/hr and a bullet travelling at 1000 m/s.

   (d) The kinetic energy is $E = \frac{1}{2}mv^2$. Estimate to one significant figure the kinetic energy of the person walking, the baseball thrown and a bullet travelling.

   (e) Consider that a person walking bumps into you, a baseball hits you, and a bullet strikes you. Consider how much you are knocked by the three blows and how much you are damaged by the three blows. Is momentum or energy a better measure of how much you are knocked? Is momentum or energy a better measure of how much you are damaged?

   (f) One joule is the kinetic energy of two kg travelling at 1 m/s. How fast does half a kg have to travel in order to have one joule of energy?

   (g) Estimate the mass of your arm. Based on this estimate, calculate how fast your arm has to travel to achieve five joules of kinetic energy. Strike your chest with your fist/arm with five joules of energy.

   (h) Estimate the mass of Mohammed Ali's arm. Estimate how fast Mohammed Ali's arm travelled, in his prime, when he gave a quick punch. Estimate the number of joules in one of Ali's blows.

   (i) One ounce of oxygen gas reacting with hydrogen gas produces around 300 kJ of energy. How does that compare to Mohammed Ali's punches?

(j) Review what you have learned in solving these problems.

3. Without using a calculator, express as a single simplified fraction, the following quantities:

   (a) $\frac{1}{2} + \frac{4}{3}$
   (b) $\frac{1}{2} - \frac{4}{3}$
   (c) $\frac{49}{14} + \frac{27}{3}$
   (d) $\frac{49}{14} \times \frac{27}{3}$
   (e) $\frac{49}{3} \times \frac{27}{14}$
   (f) Please also decide if $\frac{49}{14} + \frac{27}{3}$ equal to $\frac{49}{3} + \frac{27}{14}$?
   (g) Please also decide if $\frac{49}{14} \times \frac{27}{3}$ equal to $\frac{49}{3} \times \frac{27}{14}$?

4. Some proportionality questions:

   (a) The mass of a cone obeys the formula $m = (1/3)\pi\rho r^2 h$, where h is the height of the cone and r is the radius of the base of the cone. What is the proportionality relation in the above equation? What is the constant?
   (b) The area of a trapezoid is $\frac{1}{2}(base + top) \times height$. What is the area of a trapezoid proportional to? What is the proportionality constant?
   (c) In the movie *Titanic*, the movie producers built a ship which was of the right shape but of 5/6 the length of the original *Titanic*. What is the ratio in weight of this smaller Titanic and the weight of a Titanic which the movie producers would have produced had they made a full-scale model?
   (d) Assume human babies have exactly the same shape and density as human adults. Assume a human baby boy typically weighs nine pounds, while an adult human male weighs 180 pounds. Based on these numbers, if an adult human male is six feet tall, how tall is a typical human baby boy?

5. Estimating the volume of the Earth:

   (a) Estimate how long it takes to drive from Chicago to NYC in hours.
   (b) Estimate the speed at which you are travelling in miles/hr.
   (c) Estimate the distance from Chicago to NYC in miles.
   (d) What is the time difference between Chicago and NYC?
   (e) What fraction of the globe has one travelled in going from NYC to Chicago?
   (f) Estimate the circumference of the globe in miles.
   (g) Estimate the circumference of the globe in kms (5 km $\approx$ 3 miles).
   (h) Estimate the radius of the globe in kms.
   (i) Estimate the volume of the Earth.