Notes 2: The international system of units, or *System Internationale* (SI)

Objective 1: Know and state the fundamental units in the SI system.

1. The SI or *Metric System* is used by scientists around the world to insure all measurements and data can be shared without conversions.

2. Accidents (and tragedies) can occur if scientists and engineers fail to pay attention to units. For example, a 1998 NASA mission to Mars crashed when the orbiter flew too close to the planet's surface. Investigators discovered that one team working on the Orbiter used English units (pounds) while another used metric units (kilograms) for a key part of navigation module.

3. A fundamental unit is the simplest and/or most convenient form of measurement.

   a. kilogram (kg) ... mass

   b. meter (m) ... length or displacement

   c. second (s) ... time

   d. ampere (A) ... electric current

   e. mole (mol) ... amount of substance

   f. kelvin (K) ... temperature

   g. candela (cd) ... luminous intensity

Objective 2: Distinguish between, and give examples of, fundamental and derived units.

4. A derived unit involves the combination of two or more fundamental units. Some derived units include:

   a. ***Velocity***

      Velocity is found by dividing the ***displacement*** (in *meters*) by ***time*** (in *seconds*) to give *meters per second* (or *m/s*)

   b. ***Acceleration***

      Acceleration is found by dividing the ***velocity*** (in *m/s*) by ***time*** (in *seconds*) to give *meters per second per second* (or *m/s/s* or m/s^2 or ms^{-1})

   c. ***Force***

      Force is found by multiplying ***mass*** (in *kilograms*) by ***acceleration*** (in m/s^2) to give ***Newtons*** (*N* or $kg\left(\frac{m}{s^2}\right)$)

Objective 3: ***Know and be able to state values in multiples of units using the appropriate prefixes.***

5. Common Prefixes for SI units. The Systeme Internationale uses prefixes to denote powers of ten without numbers. The following prefixes and their associated powers of ten are to be memorized.

   a. ***Giga (G)*** – 1,000,000,000 units; 1 Gigahertz (GHz) = 1 x $\mathbf{10^9}$ Hertz (Hz)

   b. ***Mega (M)*** – 1,000,000 units; 1 Mega meter (Mm) = 1 x $\mathbf{10^6}$ meters (m)

   c. ***kilo (k)*** – 1000 units; 1 kilogram (kg) = 1000 grams (g) = 1 x $\mathbf{10^3}$ g

   d. ***centi (c)*** – 1/100 of a unit; 1 centimeter (cm) = 0.01 m = 1 x $\mathbf{10^{-2}}$ m

   e. ***milli (m)*** – 1/1000 of a unit; 1 millimeter (mm) = 0.001 m = 1 x $\mathbf{10^{-3}}$ m

   f. ***micro (μ)*** – 0.000001 of a unit; 1 micrometer (μm) = 1 x $\mathbf{10^{-6}}$ m

   g. ***nano (n)*** – 0.000000001 of a unit; 1 nanometer (nm) = 1 x $\mathbf{10^{-9}}$ m

6. SI Conversion Stair Chart (we'll discuss this in class...leave space below for chart)

7. Sample Problem: To use the chart to solve the problem: 5.66 m = ___ mm

   a. Locate starting unit on chart

   b. Count "steps" to ending unit

   c. Move decimal left if up

   d. Move decimal right if down

   e. Write new number with "relocated" decimal.

      Eg., 5.66 m = 5660 mm

Objective 3: *Be able to convert units*.

8. You will often be required to convert units, say from kilometers (km) or miles (mi) to meters (m). To do so, you will need a ***conversion factor***.

   a. All conversion factors have a value of 1 and are used to convert a quantity expressed in one unit into its equivalent in another unit.

   b. For example, since 12 inches = 1 foot, then $\frac{12\text{ in}}{1\text{ ft}} = 1$

   c. By writing out the units explicitly and canceling them, we need not think about whether we multiply or divide by a number because the units tell us whether we have chosen the correct factor.

9. Reasoning strategy for onverting between units.

   a. Always write down the units explicitly.

   b. Treat all units as algebraic quantities. In particular, when identical units are divided, they are eliminated algebraically.

   c. Use the conversion factor for the desired units.

   d. Check by verifying that the units combine algebraically to give the desired unit for the answer.

10. For example, if you drive 90 km/h, how fast are you going in meters per second and in miles per hour?

   a. We use the knowledge that 1000 m = 1 km and 60 s = 1 min and 60 min = 1 h to convert to m/s

$$\frac{90\ \cancel{\text{km}}}{\cancel{\text{h}}} \times \frac{1000\text{ m}}{\cancel{\text{km}}} \times \frac{1\ \cancel{\text{h}}}{60\ \cancel{\text{min}}} \times \frac{1\ \cancel{\text{min}}}{60\text{ s}} = 25\text{ m/s}$$

   b. To convert to mph, we use the conversion factor $\frac{1\text{ mi}}{1.61\text{ km}} = 1$

$$\frac{90\ \cancel{\text{km}}}{\text{h}} \times \frac{1\text{ mi}}{1.61\ \cancel{\text{km}}} = 55.9\text{ mi/h (or mph)}$$

11. In any conversion, if the units do not combine algebraically to give the desired result, the conversion has not been carried out properly.