## Lesson 02 – Estimating, Precision , Unit Conversion - Student Notes:

### Estimating

Estimating means rounding all the numbers to one significant figure so you can try doing the math in your head. Multiply the numbers and then add up the exponents. Estimating is not usually something we attempt when addition or subtraction is involved, unless one part of the addition or subtraction is small enough to be ignored.

**Simple Examples**

$(8 \times 10^{3}) \times (2 \times 10^{-6}) = 16 \times 10^{+3-6} = 16 \times 10^{-3} = 1.6 \times 10^{-2} = \underline{2 \times 10^{-2}}$

$(8 \times 10^{3}) \div (2 \times 10^{-6}) = (8 \times 10^{3})/(2 \times 10^{-6}) = (8/2) \times 10^{+3-(-6)} = \underline{4 \times 10^{9}}$

**More Complex Examples**

Round to 1 sig fig, first, then do the math

$(8.033 \times 10^{3}) \times (1.8192 \times 10^{-6}) = (8 \times 10^{3}) \times (2 \times 10^{-6}) = 16 \times 10^{+3-6} = 16 \times 10^{-3} = 1.6 \times 10^{-2}$

$= \underline{2 \times 10^{-2}}$

$(7.93 \times 10^{3}) \div (2.441 \times 10^{-6}) = (8 \times 10^{3}) \div (2 \times 10^{-6}) = (8 \times 10^{3})/(2 \times 10^{-6}) = (8/2) \times 10^{+3-(-6)}$

$= \underline{4 \times 10^{9}}$

**Tough Example**

Estimate the number of cubic inches in 16 cubic miles

$16(5280)(5280)(5280)(12)(12)(12) \text{ in}^3 = 20(5000)(5000)(5000)(10)(10)(10) \text{ in}^3 =$

$2\text{x}5\text{x}5\text{x}5\text{x}1\text{x}1\text{x}1 \times 10^{+3+3+3+1+1+1} \text{ in}^3 = 250 \times 10^{+12} \text{ in}^3 = 2.50 \times 10^{+14} \text{ in}^3 = \underline{2 \times 10^{+14}} \text{ in}^3$

**Tougher Example**

$$\frac{(3728)(470{,}165 \times 10^{-14})}{(278{,}146)(0.000713 \times 10^{-5})} = \frac{(4\text{x}10^{3})(500{,}000\text{x}10^{-14})}{(300{,}000)(7.13\text{x}10^{-9})} = \frac{(4\text{x}10^{3})(\ 5\text{x}10^{-9})}{(3\text{x}10^{5})(\ 7\text{x}10^{-9})} =$$

$$\frac{(4)(5)}{(3)(7)} \times 10^{+3-9-5-(-9)} = \frac{20}{21} \times 10^{+3-5} = \underline{1 \times 10^{-2}}$$

Add the exponents in the numerator and subtract the exponents in the denominator.

**Precision**

Precision refers to the readability of the scale on a measuring device. When making measurements, unless using a digital display device, we are allowed to estimate to estimate one additional digit beyond the direct reading from the scale.

For example: The smallest marks on a standard meter stick are one millimeter apart. You might think that the precision of a meter stick is therefore 1 millimeter. However, we are allowed, in fact we are obligated, to estimate one additional digit by estimating to the nearest one-tenth of the distance between those marks. Therefore, the precision of the meter stick is 0.1 millimeters.

Measurements with a meter stick should look like this.

7.9 mm = 0.79 cm = 0.0079 m = $7.9\text{x}10^{-3}$ m = $7.9\text{x}10^{-6}$ km (2 SF)

3.47 cm = 0.0347 m (3 SF)

43.52 cm = 0.4352 m (4 SF)

92.19 cm = 0.9219 m (4 SF)

Notice that precision does not refer to the number of significant figures. In the examples, we can get 2, 3 or 4 significant figures. Precision refers to the smallest magnitude we can measure. Again, the precision of the meter stick is 0.1 millimeters. When making measurements with a meter stick you are obligated to report the distance to that level of precision, i.e. to the nearest one-tenth of a millimeter.

As you can see from the examples, the number of significant figures is determined by a combination of the precision of the device and the magnitude of the quantity being measured.