UNIT #2 - MEASUREMENTS AND CALCULATIONS

SECTION 3: CALCULATIONS

It is easy to get an answer on your calculator when you add, subtract, multiply or divide. Unfortunately the calculator does not understand significant figures. Human judgment is required when it comes to rounding off these answers.

There are two sets of rules for rounding - one for adding and subtracting, the other for multiplying and dividing.

Adding and Subtracting

After you add or subtract numbers, round the answer so that its precision matches that of the LEAST PRECISE input number.

Example #1: Add a column of numbers

```
13.32
56.1
 0.167
10.42
80.007  - unrounded answer
```

(what your calculator would show)

In the above example we have four input numbers: 13.32, 56.1, 0.167 and 10.42. Of the four, 56.1 is the least precise. It only goes as far as the 1^{st} decimal place.

We do not know if it is exactly 56.1. It might actually be 56.08 or 56.14. Therefore we have to be conservative and assume that it is just an estimate – an estimate that is only good to the 1^{st} decimal place.

The quality of 56.1 is not high. It is only good to the 1^{st} decimal place. If you use this number in a calculation, then it will limit the quality of our answer.

An army can never march faster than its slowest soldier. Likewise an answer can never be better than its worst input number.

Since 56.1 is only good to the 1^{st} decimal place, we are forced to round the answer to the first decimal place. Therefore the 80.007 shown on your calculator must be rounded to **80.0 .**

The same rules apply when we subtract numbers. The following example demonstrates this point.

Example #2 - Subtraction:

$$\begin{array}{r} 6{,}980 \\ -\ \underline{652.8} \\ 6{,}327.2 \end{array}$$ **unrounded answer**

6,980 is precise to the ten's place - the zero that follows the '8' is a trailing zero. 652.8 is precise to the 1st decimal place. Therefore 6,980 is the least precise input number.

Just like Example #1, we have to round the answer to match the least precise input number. 6,980 is only good to the ten's place. Therefore the answer (6,327.2) must be rounded to the nearest ten - **6,330** .

Example #3: Subtract two numbers that have stated uncertainties.

$$\begin{array}{rcl} 117.7 & \pm & 0.2 \\ -\ \underline{22.42} & \underline{\pm} & \underline{0.06} \\ 95.28 & \pm & 0.26 \end{array}$$ - ALWAYS ADD UNCERTAINIES

Every time new numbers are brought into an equation, the overall doubt INCREASES. It does not matter if you add or subtract. Each new number adds to the total uncertainty.

Next step - round the answer. Again it must match the least precise input number. 117.7 only goes to the 1st decimal place, so round accordingly.

Rounded Answer = 95.3 ± 0.3 .

In the above example, BOTH the main number (95.3) and the uncertainty (0.3) were rounded off to the 1st decimal place. The precision of the uncertainty ALWAYS matches that of the main number.