UNIT #2 - MEASUREMENTS AND CALCULATIONS

SECTION 2: UNCERTAINTY AND SIGNIFICANT FIGURES

Here are two very important definitions:

Precision = How fine your measurement is. If a number has a lot of decimal points then it is considered to be very precise.
e.g. 5.728 mm is more precise than 5.7 mm.

Accuracy = How close the measurement is to the TRUE value

e.g. A book is actually 31.2 cm long. Two students measure it.
Student #1 - 29.482 cm.
Student #2 - 31.1 cm.

In the above example, student #1 got a very precise measurement. However student #2 was more accurate.

Student #1 had a precise measuring instrument, but errors occurred during its use. This gave him an inaccurate result.

Therefore the terms 'Precision' and 'Accuracy' have very different meanings.

Due to concerns about precision and accuracy, we have doubts (uncertainty) about our measurements. Even if we are careful, there are still limits to the quality of our measurements. Experience in using measuring instruments allows one to come up with reasonable ranges of doubt.

<u>The Standard Uncertainties For This Class</u>

Ruler: ± 1 mm (same as ± 0.1 cm) - Measure to the nearest whole mm.

Thermometer: ± 1°C - In other words, measure to the nearest whole degree.

e.g. 17.5 °C - INCORRECT
17.0 °C - INCORRECT
17 °C - CORRECT (looks like it was measured to nearest whole degree)
17.2 °C - NOT CORRECT

Centigram Balance: ± 0.01 gram - In other words, measure to 2nd decimal place.
e.g. 20.20 g - CORRECT
20.2 g - NOT CORRECT

Buret : ± 0.1 mL - Always measure to the 1st decimal place.

(You will learn more about burets later in this unit.)

Outside of our class the uncertainties could be different, because there is different equipment.

How do we determine the uncertainty of a measuring instrument ?

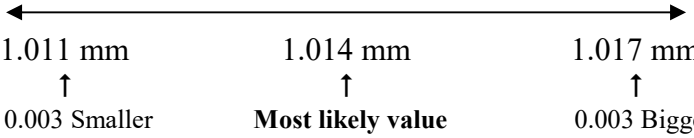
Answer - through experience. By frequently repeating our measurements we can determine the reliability of the equipment.

For example a technician uses a micrometer to measure the thickness of a copper sheet. He gets a reading of 1.014 mm.

However from his past experience with this micrometer, he knows that the actual thickness could be 0.003 mm bigger or smaller than the reading – even if he has been skillful.

Therefore he has a range of reasonable doubt:

REASONABLE RANGE OF POSSIBLE VALUES



He can state this range of doubt by writing it down like this: 1.014 ± 0.003 mm .

This plus/minus factor is his stated uncertainty.

****Important point - The precision of the uncertainty always matches that of the main number. In this example, both 1.014 and 0.003 are precise to the third decimal place.**

Another example –

The length of a stick is somewhere within the range of 138 cm to 144 cm. We can rewrite this estimate into the form of a stated uncertainty:

141 ± 3 cm .

141 cm is the mid-point of the range (138 – 144). The ± 3 means that the top end of the range is 3 cm greater than 141 cm, while the bottom end is 3 cm less than 141 cm.

You should now be ready to try the practice exercises.