Unit I Reading: Uncertainty in Measurement

Laboratory investigations usually involve the taking of and interpretation of measurements. All physical measurements obtained by means of instruments (meter sticks, thermometers, electrical meters, clocks, etc.)are to some extent uncertain. If, for example, the mass of an object is determined by means of a Dial-O-Gram balance, the measured mass will be uncertain by at least + 0.01 gram. If the object were now weighed on progressively more accurate scales, the uncertainty in the mass of the object would get progressively less, but regardless of the precision of the measuring device, any instrumental measurement is to some extent uncertain. The degree of uncertainty in physical measurements can be indicated by means of significant figures.

Consider, for example, a measurement of the length of the object as indicated below, with three differently calibrated meter sticks.



**Figure 1**

Observe that when measuring the length of the object with the uncalibrated meter stick (top) the actual length of the object in Figure 1 can only be estimated, and then only to the nearest tenth of a meter, or as 0.3 meter (one significant figure).

Measuring the length of the object, however, with a meter stick calibrated in tenths of a meter (center stick in Figure 1) it is obvious that the length of the object is greater than 0.2 m but less than 0.3 m. Once again, it would seem to be reasonable to estimate the length of the object to the nearest tenth of the smallest calibration or to the nearest hundredth of a meter; thus 0.27 m. It might actually be as short as 0.26 m or as long as 0.28 m, so 0.27 m (to the nearest hundredth of a meter) seems to be the most reasonable estimate of the object's length. This measurement has two significant figures indicating less uncertainty in the second measurement than in the first.

Measuring the length of the object with a meter stick calibrated in hundredths of a meter (lower stick in figure 1), the length of the object could be estimated to tenths of the smallest calibrations (centimeters) or the measured length could be estimated to the nearest millimeter; nearer to 0.270 m than to 0.269 m or 0.271 m. Note that this measurement has three significant figures indicating less uncertainty in this measurement than in either of the other two preceding measurements. Thus, the number of significant figures in a measurement indicates the precision of the measurement and not the absolute length of the object.

Once the logic of significant figures is accepted, some simple rules are useful for their implementation.