0.6: Measurement Accuracy and Uncertainty

Learning Objectives

- Students will be able to explain the meaning of measurement precision and sources of error

Another scientific skill you will be practicing in these modules is measurement; in many of the activities you will be using actual astronomical data. In any scientific experiment or observation, there are unavoidable sources of measurement imprecision. Each time you make a measurement and quote a value, you must also quote how accurately you measured the number.

The factors that influence the accuracy of the measurement, known technically as sources of error or uncertainty, can be due to equipment, measuring devices, the conditions under which the experiment was performed, etc. “The tick marks on the ruler are 1 mm apart. Therefore, we were able to measure the length of the glass rod to an accuracy of 0.5 mm, because I can read the ruler to an accuracy which is half as large as the distance between the tick marks.” “The graph was a straight line overall, with some slight variations of a few percent.” Mistakes and misconceptions do not count. Some examples of laboratory mistakes include things like: “We dropped the glass rod, and it broke into 100 pieces. Therefore, our measurement of its length is uncertain.” “I don’t know how to use my calculator; therefore, my calculations are in error.” Or, our personal favorite: “Human error.” If you make a mistake, you should start the activity over; astronomical data are very forgiving that way, as long as there is a copy of the original on the computer.

Finally, sometimes you will be asked to calculate other numbers from numbers that you measured. When doing this type of calculation, it is important to keep in mind that just because your calculator can give you 10 digits does not mean that you measured something that precisely! The key is to determine how accurate your measurements are and carry that through your calculations. For example, say you need to split up a room into three equal-length sections, and when you measure the total length of the room, you get 10.138 meters. But when you divide that number by three on your calculator, you get 3.3793333333 …. With a meter stick or measuring tape, there is no way you could be accurate down to the nanometer scale. Instead, you could accurately say that each section would be 3.379 ± 0.001 m. The ± symbol means “plus or minus” and indicates that you are certain each section of the room should be between 3.378 and 3.380 m long.