All laboratories will deal with some form of data taking, and the interpretation of that data. The following provides guidelines for discussing errors associated with your data.

Experimental errors can be generally classified as being of three types: personal, systematic, and random.

PERSONAL ERRORS

Personal errors arise from personal bias or carelessness in reading an instrument, in recording observations, or in mathematical calculations. Examples of personal errors include:

1. In performing a series of measurements, it is quite common for the observer to favor the first measurement and assume that it is correct. This can lead to attempts on the part of the experimenter to make other measurements agree with it.

2. Errors in reading a scale. Reading a value from a scale involves lining up an object with the marks on the scale. The value read depends on the position of the eye, and moving the eye can give an apparent change in the reading. This apparent change is called parallax.

3. Not observing significant figures in calculations. (discussed below)

SYSTEMATIC ERRORS

Systematic errors are errors associated with particular measuring instruments or techniques, such as an improperly calibrated instrument or bias on the part of the observer that is carried throughout the observations. Some contributory conditions for systematic errors include:

1. Improperly “zeroed” instruments.

2. An instrument that is faulty.

3. Personal bias of an observer.

Thus a personal error can also be a systematic error.

RANDOM ERRORS

Random or statistical errors result from unknown or unpredictable variations in experimental situations. These are sometimes beyond the control of the experimenter. Conditions resulting in random errors can include:

1. Unpredictable temperature or voltage fluctuations.

2. Mechanical vibrations of the apparatus.

3. Unbiased deviations in measurement by the observer.
Note how the reading appears to change as the eye position changes.

In the latter case, you may wish to associate an estimated error value with each data point based on how accurately you could read the measuring apparatus. For example, if you had a meter stick that you could only read to the nearest millimeter, then you might quote each particular measurement as being only accurate up to half a millimeter on either side. For example, if you measure something to be 0.953 m long, you might quote this as 0.9530 ± 0.0005 m.

**ACCURACY AND PRECISION**

The *accuracy* of an experiment is a measure of how close the experimental result comes to the “correct” value (which in principle may not be known – in practice however, we are often involved in measuring quantities that have been determined before). When shooting at a target with a gun, for example, accuracy would be determined by how well the scope is calibrated. If a scope is calibrated so that aiming at the bull’s eye results in hitting 10 cm below, the shot is not accurate, no matter how precise the gun is able to fire.

The *precision* of an experiment is an expression of its reliability, or how reproducible the result is. It is a measure of the magnitude of uncertainty of the result without reference to what the result means. Again with the example of a gun, the precision will determine the random scatter around which the bullets fall, assuming the scope is accurately calibrated. A less precise gun will result in a larger scatter around the bull’s eye than a more precise gun.

So the accuracy of an experiment depends in general on systematic errors, while the precision depends on random errors.