Unit 1 Reading: Discrepancies (a.k.a. errors)

When doing labs sometimes the results do not turn out as expected. Another way to say this is that there is a discrepancy between the theoretical prediction and the experimental results – this discrepancy is often called "error". The problem could be solely with the experiment or solely with the theory, but most likely it is a little of both. It must be recognized that there are uncertainties in experimental measurements and assumptions in theories. Any evaluation of laboratory "error" must take these two factors into account. For example, if the theory assumes a frictionless surface and it was impossible to achieve a frictionless surface for the experiment, how close of a match can you expect between the theoretical predictions and the experimental results? Is the resulting discrepancy the fault of the theory, which did not take into account the effects of friction, or the fault of the experiment, which failed to eliminate friction? Actually, it is not important to assign blame, but it is important to recognize and explain any discrepancies. Do not deem an experiment a failure just because it did not match theoretical predictions! You must evaluate *why* it did not match theoretical predictions (i.e. understand the details of the experiment you performed, and recognize the assumptions of the theory).

Possible Causes of Errors/Discrepancies

- **Human Error (experimental or theoretical blunders):** Examples include failing to connect a wire or making mistakes in calculations. Human error is NOT acceptable – these errors must be fixed!
- **Systematic Equipment Error:** This type of error will give results that are consistently too high or too low, in other words inaccurate. Often these types of errors are due to faulty apparatus, such as a meter that reads consistently low or an electrical connection that has extra resistance. For systematic errors, your graphs will generally have the expected shape with a difficult-to-explain vertical intercept.
- **Unmet Theoretical Assumptions**: For example, a theory may assume negligible friction or air resistance but the experiment may be unable to meet these idealized conditions. In this case, reasonable steps must be taken by the experimenter to minimize the discrepancy. If the overlooked factor (friction, air resistance, etc.) is consistent, you will have a systematic error – the graphs will have the expected shape but will be shifted vertically. If the overlooked factor does not have a consistent effect, your graph will have unexplained wiggles or even appear completely random.
- **Measurement Scale Limitations:** The experimenter can only be as precise as his/her measuring equipment. For example, if your ruler is only marked to the nearest centimeter then you will only be able to record significant figures to the nearest 10^{th} of a centimeter (when measuring you estimate one digit past the instrument markings). This means that if you plot a data point to be at 3.4 cm, it actually could be anywhere from 3.0 cm to 4.0 cm. This type of error will cause your graph to "wiggle" a bit from its expected shape.
- **Approximations in Measurement:** At times the experimenter may have to make approximations. For example, when measuring a pendulum's length it may be difficult to determine the location of the center of the bob, giving perhaps a 2 mm (0.2 cm) uncertainty. In this case, a meter stick marked to 0.01 m is not anymore useful than one marked to 0.1cm. The resulting uncertainty is essentially the same as a measurement scale limitation.
- **Random Errors:** Random errors are experimental uncertainties due to unpredictable changes in conditions. Repeated trials (doing the exact same thing more than once) help to minimize the effect of random errors. Random errors will cause your graph to "wiggle", sometimes wildly. Random errors are most severe when experimental constants have not been identified or are allowed to vary.
- **Systematic Drift:** This may be caused by conditions such as a battery dying, or a string stretching with use. In the case of systematic drift the graph will not be the correct shape.

These are meant to give you a starting place for thinking about errors. When explaining a discrepancy for your particular lab you must discuss the specifics of the lab. Simply stating "this lab has systematic equipment errors" is not sufficient.