

How to ACE your 2CL lab reports!

1. Record your data carefully.
 - a. Don't just write numbers. Say what the numbers are and include units (e.g. ohms) and the associated uncertainty.
2. Make clear diagrams.

- a. Make a clear diagram showing the overall experimental set-up.

 - b. Make clear diagrams of all relevant electrical circuits.
3. Use graphs to display experimental results, but don't just draw axes and plot points.
4.

a. Justify the choice of plot.

 A sentence like "We expect the voltage V to decay exponentially with time so plot $\log(V)$ vs. t (time) to obtain a straight line" is all you need.
 - b. Give the graph a title.
 - c. Label your axes and put the units (e.g. sec) in parentheses next to the axis name.
 - d. Put error bars on the experimental points.
 - e. If you are fitting (comparing) experimental points to some mathematical expression (the fitting function), then include the fitting function on the graph. Include also any fitting parameters with their uncertainties (errors). Finally, graph the fitting function through your experimental points and include in your report a succinct comment on the agreement between fitting function and experimental points, i.e., the goodness of the fit.
5. When you use measured values (say x and y) to calculate a result q , e.g. $q = x/y$, slow down and correctly use the errors (uncertainties) associated with x and y to find the uncertainty in the calculated value q . This is sometimes called "propagating the errors" and we'll spend a lot of lecture time discussing how uncertainties propagate through a calculation to produce an uncertainty in the final result. Have no fear, you'll be an expert before you know it.
6. If your report requires a comparison between an experimental result with some expected result, then make a quantitative comparison. Simply writing two results (numbers and their uncertainties) next to each other and making a remark like "they're almost the same" is not sufficient. Instead, do the following:
 - a. Compute the absolute value d of the difference between the measured value x_m and the expected value x_e . That is,

$$d = |x_m - x_e|$$

- b. Use the uncertainty Δ_m in the measured value x_m and the uncertainty Δ_e in the expected value x_e to calculate the uncertainty Δ_d in d . That is,

$$\Delta_d = \sqrt{\Delta_m^2 + \Delta_e^2}$$

- c. Then compute the ratio t of d to its uncertainty Δ_d . That is,

$$t = \frac{d}{\Delta_d}$$

- d. If $t < 2$, then we will judge that the agreement between x_m and x_e to be satisfactory. If it is not (hopefully this will not happen to you) then say some succinct words about what you think went wrong; or better, perhaps you have made a fundamental discovery.
- e. Why steps a-d? Very briefly, in an experiment which is dominated by random errors, the values of the difference d will lie symmetrically about the value zero. This will occur because a random measurement error is equally likely to underestimate or overestimate x_m compared to x_e . The distribution of the differences d will have a width, or standard deviation, Δ . That is, most (but not all) values of d will have values which satisfy $-\Delta < d < \Delta$.

In (b) above, we calculated Δ_d , which is an estimate of the width Δ . In (c) we established how many standard deviations away from the mean (of zero) our value d lies. In (d) we commented on whether this value in the distribution of possible d values supports the hypothesis that d 's expected value is zero.

More about this later, in case you don't already know this stuff. For now just do it, it'll make your TA happy, i.e., he/she will stay off your case. So good luck and good experimenting.

The following guidelines are intended to supplement the discussion in the laboratory manual concerning the lab notebook.

1. All data and notes should be entered into the lab notebook in ink!! It is OK to cross out mistakes and replace them with the corrections. NO erasing or use of white-out will be allowed. No loose pages will be accepted. Any additions should be permanently attached to the pages of the notebook (staple or tape). It is OK to photocopy a master data set and attach it to your notebook after you leave the lab.
2. Data which is tabulated should include units and uncertainties. It is much easier to grade your notebook if you also present an analysis table. For example: Suppose you measured a voltage V (with error) and a distance r (with error) and tabulated them into your data table. Next, you decide to plot V^2 versus $1/r^2$. It is a very good idea to make a new table containing V , V^2 , r and $1/r^2$ (all with the propagated uncertainties) before actually making the plot. Also, a sample calculation is requested to demonstrate how you obtained the table entries (one is sufficient).

In most cases, graphs and preliminary analysis can be completed while "in the lab" using the computers and software (Origin) that are available at lab stations. You may also find it convenient to make graphs by hand; appropriate graph paper and diligence should be used.

3. If you are making a least-squares analysis, you should start by showing the predicted functional relation and identifying the various coefficients which are determined by your "fit". The output of a least-squares analysis should contain both coefficients and their uncertainties. Remember that it may be necessary to propagate the errors in the coefficients to obtain the errors in the final results. Finally, show the "fit" on the graph with your data for comparison.
4. All results should be compared with the accepted (or theoretical) values whenever possible, and any discrepancies should be noted and discussed in your concluding remarks.