

2DL Lab Report Tips

May 13, 2010

COMMON ERROR ANALYSIS MISTAKES

Here is a list of common errors in lab reports and tips on how to avoid them.

Error: Not Stating Meaningful Uncertainties of Experimental Quantities

Uncertainty in measurements is a part of experimentation. Therefore, you must include in your lab notebook and lab report the experimental uncertainty of all your experimental quantities.

Explain where the uncertainty comes from and why it was chosen. Experimental uncertainties can arise because of the limits of a measuring tool or because of the experimental apparatus. The experimental uncertainty you record for each quantity should be the larger of these two possibilities. For example, in experiment six, you will use calipers that are accurate to at least tenths of millimeters. However, the diffraction rings you will measure are very broad—much broader than tenths of millimeters. Therefore, your measurement uncertainty in the ring diameter is determined by the error in locating diffraction maxima, not the accuracy of the calipers.

The textbook suggests that if no information is given in an instrument's manual about the uncertainty of a quantity it displays, that you should assume ± 1 in the last digit if the instrument's output is digital. However, if you find your data spread is large, this may not be a reasonable assumption.

Error: Using a Paired t-Test With One Set of Data

For the labs in this class, you will compare the results from your experiments with the well-known experimental results given in the lab manual. In general, the results given in the lab manual are known to a high degree of accuracy. Therefore, you should not assume an experimental uncertainty for these well-known experimental quantities and use a paired t test to compare your data and uncertainty with the well-known value. Instead, if you would like to use a t test to interpret your results, use the single sample t test described in chapter 5. This test compares a single set of data with an expected value.

The only time it makes sense to use a paired t test is if you were comparing two sets of data taken, say by two different partners. However, although this paired t test analysis could tell you useful information, is not required for your lab reports.

Error: Doing a Statistical Analysis of an Independent Variable

Some of the labs allow you to chose values of one variable x and measure the value of another variable y as you change the value of x . Since you are *choosing* the values of x , and probably

choosing them rather arbitrarily, calculating the mean and standard deviation of x will not help you discover underlying physics. Instead, you should do statistical analysis on a quantity that is expected to have the same value for all of your trials. For example, suppose you wanted to measure the value of g by timing a ball dropped from different heights to the ground. It would not help you much to find the average height you used for all of your trials. However, combining the height and time for each trial by using kinematics should result in the same value of g . Therefore, measuring the average and standard deviation of g from all of your trials of different heights can be a measure of your experimental error.

Error: Not Including Explanations

One of the most important scientific skills is being able to clearly explain your reasoning and results. You should, at least briefly, justify all the calculations and equations you include in your lab report. Not only will practicing this make you a better scientist, but it may also help you catch mistakes.

The same idea holds in showing how you obtained the results in your lab manual. It should be very clear what experimental numbers you used to calculate each result and what equation you used to obtain the result.

Error: Using an Inaccurate Number of Significant Figures

You should use the appropriate number of significant figures for your measurements, calculated quantities, and uncertainties. With a few exceptions (see chapter 2 of the text), your uncertainty should only be one significant figure, and it should be the same order as the last decimal place of the corresponding quantity.

Error: Not Including Error Bars or Best-Fit Lines in Plots

The size of your error bars should be determined by your error analysis calculations; you will need to enter them into the plotting software manually. Make sure to show the equation of your best-fit line near the plot itself. Also, the data you are plotting should take up the majority of the plotting area; do not include the origin in your plot unless your data is all very close to the origin.

HOW TO MAKE PLOTS USING COMMON SOFTWARE

As a UCSD student, you have access to Matlab and Microsoft Excel in the ACS computer labs. Alternatively, you can download Open Office by Sun Microsystems for free to use on your own computer. It is available for most operating systems. At this time, Google Docs does not have the ability to add error bars or best fit lines to plots, so the other programs will be more useful.

Remember that if you are having trouble figuring out how to do something with your plotting program, you can probably get the information you need with a google search.

Making Basic Plots in Excel/Open Office

- Highlight the cells containing the data you want to plot
- From the menu bar, select Insert → Chart

- Select X Y Scatter (without lines, because you will want to make a best fit line separately)
- To change the axis scale, select the axis and then double click on it. From there you can find a menu to set the minimum and maximum for the axis
- In Excel, to add error bars, click the series to select it and then double click on the series. Under the error bars section of the menu that appears, select the type of error bar you want (both sides). Under error amount, select custom and then click on 'Specify Value'. Starting with your first data point, enter the amount above each point that each error bar should go. Separate these values with commas. Do the same for the negative span of each error bar. You may need to adjust the size of your plotting area and/or data point markers so that you can see the error bars clearly
- In Open Office, to add error bars, right click on the series and select the option to add error bars. You need to have the error bar sizes in two separate columns in your spreadsheet, one corresponding to the length of the error bar on the positive side for each value and one corresponding to the length of the error bar on the negative side. To insert these error bars once you have right clicked on your data, select the 'Cell Range' option and enter the cell ranges for the positive and negative error bar lengths
- The best fit line is called a trendline in these programs. Right click on the data series and select the option to add a trendline. Make sure to select the option to display the equation of the trend line on your chart. This will show the equation of your best fit line
- Remember to include a title and labels (including units) for all of your axes, and adjust the length of both of your axes so that the data takes up the plotting area