Physics 4321/2: Notes on Lab Reports

May 27, 2011

General advice and reminders for lab reports based on what I've seen in the past. You should also reread the "Lab Reports" section of the syllabus.

1. The report should be written as a technical document that could have wide distribution (e.g. in a pedagogical scientific journal such as the American Journal of Physics). You are the expert. Write to inform the reader about the relevant physics and the experimental demonstration of the physics. Don't assume that your audience has read the lab handout or even has easy access to it. The lab handouts provide guides to the experiments and organization of the data. You should try to understand why each step of the experiment was done and why the questions raised in the handout are relevant. Integrate this understanding into your report.

2. Use sections, subsections, subsubsections, labeled paragraphs, etc. to organize your report. Divide it into bite-size chunks. It may be convenient to number the first 2-3 levels of these divisions for later reference (e.g. "see Sec. 2.1.").

3. The Introduction is important. It should motivate the experiment in terms of the scientific questions that it addresses and include some historical context. Introduce enough physics so that a reader understands the scientific motivation.

4. Use simple schematic diagrams where appropriate and show the origin of the most relevant equations to the extent that a fellow student could understand their derivation. Sometimes it's best to set up the physical problem, define terms, and describe the path to a solution without going through all the math (which could be put in an Appendix). As an example, in the Rutherford Scattering experiment, one could have a schematic of the scattering process, using it to define angles, impact parameter, differential cross-section, etc. The Rutherford scattering formula could then be given after explaining that it follows from conservation of energy and angular momentum (perhaps even setting up the equations to be solved). The entire derivation of the formula could be given in an Appendix. There may be a few equations in the labs for which the derivation is simply too involved; these can be assigned a book or journal reference.

5. Consider including a description of any modern uses or devices that rely on the same physics—for instance, Rutherford Backscattering (RBS) is now used to determine the positions and types of atoms in materials. This could be done either in the Introduction or in a later discussion of the implications of the experiment (i.e., in a discussion or Conclusion section).

6. All figures and tables should have a descriptive caption (typically below) and a sequential number (number figures and tables separately). The caption should begin with the figure/table label (e.g., "Figure 1." "FIG. 1." "Fig. 1:" "FIGURE 1:" ...). It must define symbols and state the experimental conditions, where appropriate (e.g. the temperature, magnetic field,...). Each figure or table should be referenced in the main text (though sometimes as a group, e.g. "Figs. 1–3 show..."). Keep first-references in order, e.g., don't refer to Fig. 3 before Fig. 2 has been referenced in the text (this is a requirement of scientific journals).

7. It's only a matter of style, but most journals don't like frame lines around figures and captions. Use space to set the figure and caption apart from the main text. You might also choose a slightly smaller font for the caption.

8. Keep diagrams clear, using them to define the geometry, concepts, and symbols that you use in the text. Diagrams that show *all* the wiring connections with a detailed depiction of knobs and sockets on the instruments may be useful for performing the experiment with our specific equipment, but they typically don't clarify the physics for a reader. Simple boxes with functional labels are more useful. For circuits and wiring, straight line segments should be used to denote wired connections unless the density of wires is very low. Connected wires should have a dot at the connection; by present-day convention crossing wires without a dot are understood to be unconnected (but try to minimize crossings for ultimate clarity).

9. Plot axes should have labels that include the units. The divisions on each axis should typically progress in uniform increments with convenient values (0.5, 1.0, 1.5 instead of 0.512, 1.012, 1.512). SI prefixes are useful for making neater axis labels. Instead of "0.0005 A" use "0.5 mA," for example (and always use a leading zero, as opposed to ".5 mA").

10. Put error bars on plotted data points, especially if there is a fitted model function shown on the graph. If the error bars are smaller than the data point symbols, then leave them off, but include a phrase like "error limits lie within the size of each data symbol."

11. Work on understanding uncertainties in your measurements; they should make sense! Use an appropriate number of significant digits. Discuss the uncertainty limits of your measurements in the text or in an Appendix. Tell how they were determined. Any derived quantity such as h/e, e/m, wavelengths of atomic lines, should have an uncertainty attached to the best value. The uncertainty in the slope of a line is most easily determined graphically by identifying the smallest and largest slopes that still appear consistent with the data. You are welcome to use more rigorous statistical methods, but a simple statement of the correlation coefficient is not the same as uncertainty limits.

12. Compare theory with experiment or accepted values with your measurements. Accepted values may not be in the lab handout, but they are available in reference books. Show that your data really fits the hypothesis or explain why it doesn't.

13. Use scientific notation instead of "e." "2.3e5" is unacceptable, "2.3E5" is barely acceptable, and "2.3×10^5" is best.

14. Use real superscripts and subscripts instead of a caret or underscore, i.e. "B^2" as opposed to "$B \wedge 2$" and "B_2" instead of "B_2."

15. In a table of values, column headings should be aligned over the data so that the presentation is clear to the reader.

16. Each Appendix should have text that describes what is presented there. Figures and tables that appear in Appendices still need captions, axis labels, etc.