Anatomy of a Formal Scientific Report

Megan Smith, Viva Horowitz, Brian Collett

Lab reports are the avenue by which you ***communicate your lab results and the physics behind them***. They include conclusions, synthesis and summaries of the work you've done in lab.

Writing Style

Formal scientific writing is impersonal. Tell us about the objective truth that you observed. Do not include how it made you feel nor what you learned. (Example to avoid: "This lab was awesome! I learned all about quantum erasers!") There is no value judgement in a formal scientific report. Everything should be objectively true and a general fact of the experiment. Write very literally and avoid idiomatic English. (Example of an idiom to avoid: "Doing this lab was a piece of cake.")

Order is everything. Always define all non-standard terms before you use them.

Focus on the essential physics. Here's an example from a Physics 390 lab:

- **Unacceptable**: "I moved a switch."
  In formal reports, we do not identify one of the authors as "I". (When necessary, individual authors are identified by their initials.)
- **Needs improvement:** "We moved a switch."
  This is not very useful for the reader.
- **Much better:** "We reversed the voltage on the plates."
- **Even better:** "Reversing the voltage on the plates causes ..."

Keep it formal and literal:

- **Needs improvement**: "The electron wanted to approach the positive charge."
- **Better**: "The electron is attracted to the positive charge." Passive voice is normal and often a good choice.
- **At least as good**: "The positive charge attracts the electron." Active voice, but still impersonal.

Sections to include:

- **Title of Lab** (Something informative, not "Lab 8")
- **Date**
- **Authors (everyone in lab group)**

  1. Abstract

  An abstract is a summary of the goals and questions of your experiments, the experimental methods used, and the results and conclusions of the lab. It should stand alone and not reference any of the body of the notebook (so avoid symbols and acronyms that are defined elsewhere). *Abstracts should be between 50 and 200 words*. Professional abstracts almost always have length limits. Though written at the end of the lab, they belong just below the title and lab group names, and should tell the reader the major points of the report. If there is a main result, give the measurement in standard form, as you learned in Physics 190/195. Generally, the abstract has a sentence or two summarizing the introduction, a sentence or two summarizing the methods, a sentence or two summarizing the results, a sentence or two summarizing the analysis, and a

sentence or two summarizing the conclusions. Abstracts can be dense. Professional scientists often put a lot of thought and care into making every word count. Avoid acronyms; they haven't been defined yet (and order is everything).

(For examples, *Physical Review Letters*: https://journals.aps.org/prl/, then pick one of the editor's suggestions, or *Science*: http://www.sciencemag.org/journals.)

2. Introduction

Order is everything. Tell us the purpose of the experiment before anything else. Summarize key science ideas. (We do not need historical context in Physics 290, so your introduction may be shorter than a professional report.)

3. Theory (optional)

This section is the most like a problem set write-up or a physics textbook derivation. You talk about the basic physics. You **do** need to have complete sentences. In formal writing, you don't need to show every step of a derivation (as you have seen in your textbooks!).

4. Methods Describe the essential parts of the apparatus. A **schematic** is required. (See note on formatting figures below.) A picture is not a schematic diagram. Think about what it needs to show. Eg. In Snell's Law (from 195), if we can't see angles then it is useless! Tell us what you *did*, including appropriate figures. Please write your methods as a narrative, not as a bullet-point list.

Additional details of the experimental set-up and any specific methods that you employed should also be included. This can go in Methods or Results. These details might include:

- Were there specific settings on the instrument that you used?
- Did you take a particular approach when measuring?
- Did you do something to reduce error?
- Was there something unique about your set-up?
- Any other notes that would be important to understand and reproduce your data

5. Results (sometimes called Data) Tell us what you found. This section should include figures (diagrams and graphs) and tables, if applicable. Tables should be carefully formatted. Think about how you communicate the data. All numeric values must include units and all graphs should be properly labeled with axes and titles/captions. Include error bars on graphs as appropriate. Include any observations you've made during the experiment.

A piece of a spreadsheet is NOT an acceptable substitute for a table. A table is designed to present data clearly, with proper column headings (and row if appropriate), units, and attention paid to issues of significant digits. This is a non-negotiable requirement and gets a lot of students into trouble.

6. Analysis (sometimes called Calculations) You may combine results and analysis into one section if you so choose. Provide equations you used to analyze your data. Calculations go in here, unless they are very extensive, in which case they go in an appendix. If there are multiple identical calculations, please give one as an example. (This might elucidate what is happening in a table.) Uncertainties are calculated as you go, not left to a chunk at the end. Unless you do something unusual, you do not need to include the details of how the error was propagated, although, of course, you *must* have discussed the origin and magnitude of all the uncertainties.

7. Discussion

You may combine Discussion and Conclusions into one section if you so choose. (Some people combine Discussion with Analysis; that works too. You have some freedom in this.)

Talk about the tables and/or graphs. Assess your results and what they mean. What do the results show? Are they consistent with your hypotheses? With other data? Comment on sources of uncertainty and other approaches that might improve the measurements (if any).

8. Conclusion

What is the 'take home' message from this lab? If your results are a number, restate it here in standard form. (A professional would give an outlook, saying what the next research will be. You don't have to, so this section may be shorter.)

For this course, you do not need to include a statement of author contributions or data availability, but you may see these in published reports.

9. References

You will have citations throughout your document. You may pick any style for references: footnotes, endnotes, or a reference section, but you must be self-consistent and use one style for the whole document.

10. Appendix (optional)

If you wrote a python script, you would copy it here.

Formatting figures and tables

Figures are labeled, "Figure 1", "Figure 2". Tables are also labeled, "Table 1", "Table 2". Each of these should have a caption and should be introduced in the main text.

Again, EVERY figure

1. MUST have a figure number
2. MUST be discussed or described in the text.
3. ANY time you show us a figure you need to tell us what you want us to see in that figure.
4. Graphs need error bars, if possible.

Grammar

Again, passive voice is normal, especially in the description of the apparatus.

Don't shift tenses for no reason. Most of a report should normally be in the perfect tense ("We have observed") or past tense ("We observed"). The present tense ("We observe") is usually not accurate for experimental work.

Citing

Usually, you will not copy-paste anything from the lab handout or textbook into a formal report, but you may paraphrase or re-draw diagrams. If you paraphrase or re-draw diagrams from a scientific article, the lab handout, textbook, or another source, cite it where you use it. If you do actually reprint a figure or portion of a figure, then your caption should say "Reprinted from …" so that it's clear that it's not your own drawing.)

The same logic applies to your codes – if you borrow code from a classmate or find snippets on the internet, cite them!