Formatting a Lab Report

In brief, when you write a report, you should be telling a story about this entire project, with the main goal that you can hand this report over to a PHY180 student next year, and they can exactly do (and improve upon) your experiment. The best way to tell this story is usually with the format:

Introduction

Theory

Procedure

Results and Analysis

Conclusion

References

Appendix (super optional)

You can combine or rename some of these sections, so long as it's clear to the reader what they can find in that section. In a bit more detail:

Introduction (tell the reader why your experiment isn't meaningless)
Why we want to run this lab and/or what we want to learn in this lab? What's the learning goal of this lab?

Theory (physics the next researcher needs to understand to do this experiment) Description of the underlying physics (with figures where appropriate), the statement and derivation of the necessary formulas, and some analysis of what is most important for obtaining good results in light of the physics behind the experiment.

Procedure
What was your experimental setup? Why did you set it up that way? Does this setup improve your results in any way?

From the rubric: There should be a clear explanation of what you did (enough that I could make the exact same setup in my lab). You should show and explain some creativity in

your lab setup (in order to control variables), as opposed to the bare bones outline in the manual.

Results (your data) and discussion (your data analysis)
What exactly has been done? Answer to the questions (from you and from the lab manual) and discuss.

The data tables, sketches, and calculations should go here.

From the rubric: Data are compact and readable. Trend lines are labeled. Figures are numbered, with clear captions, and they are referenced appropriately in the text. Results are clearly described and interpreted. Limitations and/or reasonableness of your results are described. Emphasize on how your uncertainties affect your interpretations.

Conclusion
Quick summary of the experiment and big results. What have you learned? Anything else besides your learning goal (in the introduction)? Do you have suggestions for future researchers that are replicating your experiment?

References
Cite something here anytime you reference something (your textbook, a research paper, a talk, etc.).

Appendix (super optional)
Extra figures, raw data, reference figures, etc. go here.

On the next page is a document that I used for my undergraduate lab reports. I hope it is some use to you if you have any additional questions.

As a final remark, **you aren't graded on how *closely* you follow this suggested format!** I just found this to be a great way to present a clear, cohesive, scientific story about an experiment.

Lab Report Guidelines

What follows is basically a reiteration and expansion of the Lab Report discussion in the Syllabus. The "deliverable" of each experiment is a formal written lab report. The report should be a thorough summary of the scientific work that you did in the lab. As with any written presentation, it should be well-organized and make good use of the language. It should be written at the level of a reader who has studied physics but is less familiar with the material than the author is. It could be similar to a report you would write as an employee in industry, or a paper submitted for publication in a technical journal. Indeed, the ideal lab report for this class is one that, if submitted to *The American Journal of Physics*, would sail through the refereeing process (prior to the publication of any earlier papers they have published on the topic at hand!)

Your report should clearly state the phenomena and basic physics (theory) you have explored, what you did in the laboratory, what your observations were, how you analyzed the data, and what conclusions you reached. The agreement with theoretical expectations should be discussed, especially if you observe something divergent. A critique of the experiment itself, with an analysis of its weaknesses and suggestions for improvements, would be welcome, and shows the sort of reflection and analysis needed to do better science in the future. One basic question you should always keep in mind as you are writing your report is: Can a person next year duplicate our work completely and exactly based on this report and the other instructions and references I have been given? If the answer to this question is "no," add more helpful detail!

Reports must be typed with a word processor, using only one side of the paper. They should be on standard 8-1/2 by 11 inch paper, with a cover sheet, which includes:

Your name
Name of lab partner
Title of experiment
Dates when work was done
Date of submission

Use 1" margins around. *Avoid like the plague the presence of big, blank spaces in the report's body!* While any text font (with the possible exception of Wing-Dings) is acceptable, Times New Roman or Palatino Linotype 11-point, single-spaced, are always good choices.

Although there may be considerable variation depending on the type of experiment, a typical lab report would probably include the following sections:

1) Introduction, with pertinent background information and motivation for doing the experiment. A bit of historical context for the physics and the experiment would be appropriate here.

2) Theory behind the experiment described. Make the physical principles clear, and use them to derive formulas and expressions that will be useful in your data analysis and that would not be immediately obvious to your target audience.

3) Description of apparatus and experimental procedures. Describe the apparatus used and outline how the taking of data was accomplished. A reader should be able to set up the experiment (perhaps after consulting references) and duplicate your results. This is a good place to discuss what aspects of the apparatus and procedures could limit the precision of your results. Anything you did to study or determine possible sources of systematic error should be described. Apparatus schematics and photos go well here.

4) Results. This is where you present your data and the analysis thereof. Indicate clearly how calculations using the original data were made. Make it clear which numbers were used, but do not include the details of the arithmetic. Whenever possible, indicate the precision of your measurements (*i.e.* uncertainties) and of quantities derived from those measurements. Whenever possible, the results of an experiment should be shown by means of graphs or tables. Graphs and tables should have titles and captions describing what they are. The axes of the graphs and the columns of the tables should be labeled to indicate what data are given, and their units. Visual presentation of data is important; be careful in choosing axis scales and symbols. You will almost certainly want to use graphing computer programs; consider the use of Origin, which is loaded on computers in the Advanced Lab.

5) Discussion. Compare your results with what is expected theoretically or with results obtained by other workers. Be sure to cite the references and the values. On the basis of your measurement precision, do the results agree as well as could be expected, worse, or too well? Why? Discuss anything unusual or unexpected about the experiment or the results. Discuss, if appropriate, the precision of your measurements, and what limits the precision. Discuss, if appropriate, how the experiment could be improved (not as a lab exercise, but as a measurement).

6) References. A note on references: *Web sources, such as Wikipedia, are in general not trustworthy*. Printed materials, such as textbooks, reference volumes, or published papers, are always preferred as references over Internet sources.

Grading Scheme

The lab report grading scheme is based on these guidelines. Reports will be graded on the basis of the quality and completeness of the lab work as indicated by the results given, the analysis of the recorded data (especially including the treatment of uncertainties), the presentation of the experiment (both in written and graphical form), and the organization and quality of the writing in the report. Somewhat more quantitatively, scores will be based on a rubric specific to each lab. These will be made available at the beginning of the year. Grading will also take into account:

1) Introduction – clarity of the description of the context of the measurement (i.e. why are we doing this?), and of the expectations of the outcomes based on the physics and the design of the experiment.

2) Theory – the description of the underlying physics (with figures where appropriate), the statement and derivation of the necessary formulas, and some analysis of what is most important for obtaining good results in light of the physics behind the experiment.

3) Description – the explanation of the apparatus (including its expected precision and accuracy) and procedures, which should be thorough (including necessary diagrams) and good enough for someone to reproduce your work. There should also be some analysis of the apparatus and procedure, describing the parts most important for obtaining precise measurements and minimizing uncertainty.

4) Results – the most important part here is the quality of the treatment of the data. Were the proper results derived? Were equations stated earlier used properly? Was there a correct treatment of uncertainties? Other factors in this category are the quality of the recorded data themselves, and the presentation of the data (graphs, figures, etc.). It's better to do a good analysis of poor data than vice-versa. If the goal of your lab exercise was to measure a fundamental constant, such as G or e, you will lose points if your answer and the accepted value are very different, and you have no explanation for the discrepancy. If the lab you were doing had numerous options for sub-experiments, the more of these you have completed thoroughly and well, the better. Note: all of the equipment in PHY 44X is

sufficiently good that you should be able to get with a factor of two of the accepted value for the quantity you're measuring.

5) Discussion – the most important part here is an analysis of the results. Do they agree with your expectations? What is the precision of your results, and what in the experiment limited that? This analysis should include quantitative evaluation of your results with comparison to expectations and checks for internal consistency. There should also be some discussion of how to improve the limiting factors through changes to some aspect of the experiment, especially if your result was significantly different than what you expected. If the goal of your lab exercise was to measure a fundamental constant, such as G or e, it is crucial that you decide, based on your error analysis, whether your answer agrees with the accepted value or not.

6) Writing – good grammar, spelling, word choice, syntax, etc. are expected