Generic Deliverables for this lab

Learning Goals: The learning goal for sharing this document with you is to both standardize our expectations between labs and help communicate the professional norms around physics writing. Lab reports have a very specific format that is based off of journal scientific practices. Our goal is to help you communicate and connect the physics, experimentation and data analysis that we ask you to do in lab.

Overall expectations: We expect all communication within these lab reports to be professional, polite and clear. Therefore, before your next lab please submit a lab report with the following sections// components:

1. **A descriptive title**
    a. Descriptive titles often start with a noun such as “Examination of…“ or “Investigation of …”
    b. Then for strong titles you include the main goal of your experiment in the second part of your title. For example, “Investigation of the damped driving motion with springs”. Specificity is good in lab titles!
    c. Below your title should be your name as the author, and your lab partner's name as collaborator.
2. **Introduction**
    a. A good introduction will introduce the historical context of what you are testing, and the theory behind it
        i. Often your lab guide will include ‘warm up questions’ in it. Those can be useful to put here, but warm up questions are not required to be included in your lab report, they are merely meant to help you get started with the lab.
    b. A good introduction needs to have at least **2 citations**. In this class, we are fine with reputable websites
        i. You should include one reference that is either a scientific paper or your textbook. We follow the following citation style, and there is an example at the bottom of this document:
            1. American Physics Society, who follows the Chicago Manual of Style. https://cdn.journals.aps.orga/files/styleguide-pr.pdf

2. (this is the clearer resource) https://journals.aps.org/authors/references-physical-review-physical-review-letters

c. A good theory section which includes:
    i. A description of the theory necessary for this experiment and analysis with equations.
    ii. Labeled equations (so it is easier for you to cite them later on)
    iii. Ex. F=ma (Eq. 1) or F = ma (1)
    iv. Later this can be cited as equation 1.
    v. Equations should be typed in the word processor used.
d. Include why they are important, as well as provide a motivation for this experiment.
    i. An example might be: “In this experiment we will attempt to show the relationship between velocity and frequency, as theoretically explained in equation 1”. Or “We propose to explore the effect of viscosity on T1 and T2 numbers, in an attempt to better understand nuclear magnetic resonance”.
    ii. In our experience that last point, clearly explaining the motivation behind an experiment, is the most difficult for students. Please consider sending your lab instructors (or Dana ldana@wpi.edu) your motivating paragraph to see if it matches what we expect.

3. Method

a. Please do not write this out as a list, please write this out as a paragraph procedure of what you did. You should include pictures or diagrams of your setups here.
b. The description of what you did should be detailed enough that another student reading it could understand what you did.
c. Make sure to include the equipment used in this section. It does not need to be a list, but it is important to note as you use each item. If you made choices about certain equipment over other equipment say why.
d. Every method requires a picture of your experimental setup.
    i. Annotating that picture is above and beyond but is very helpful.
    ii. Every figure needs to be Labeled and captioned. The captions should be 1-2 complete sentences and include details to help orient readers to what you are looking at.
    iii. The figures should be placed near where you refer to them.

4. Results // Analysis

a. This is for the barebones data you collect. All your graphs, data tables, and trial results should be here.
    i. If you test several variables you should plot them all.
    ii. Do not forget to label your graphs and tables. You should have axis labels with units on the graph, and captions on both graphs and tables. Include a title on your graphs.

iii. Significant figures should be correct (i.e., Not one million decimal values). Our general rule is that your significant figures should have the same accuracy as your statistical uncertainty.
iv. Units on all non-unitless values.

b. This is where you calculate and explain how you did those calculations.
    i. Show the equations, not necessarily the math. You can do one example calculation out if that makes things clearer to you and the reader, but otherwise just the equation.
c. Calculate the uncertainty associated with your data and display it here. We want you to discuss both the systematic and statistical uncertainty for this lab. You need to apply numbers in both cases.
    i. For more information about systematic and statistical uncertainty please see some of the resources in the Appendix.

5. **Discussion // Conclusion**
    a. Compare your theoretical results (what results would you have had if the equation worked perfectly) with your experimental results. This is where you discuss if the theoretical model you were using was accurate, or off.
    b. This is where you do the final summing up.
        a. Some questions that are often answered here are, how well did my experiment match the theory? Why did it or did not match your theory?
        b. Conclusion for your lab.
        c. Would I do anything differently in the future? Potential follow up experiments.
    c. If there are any additional questions in your lab guide, please answer them here.

General notes

- You do not have to use passive voice in your paper. We understand it is the convention in some scientific fields to never use 'I' or 'We', but in physics we talk about what we did all the time, and it would interrupt our ability to communicate effectively and clearly to speak passively.
    - To quote the paper for which Einstein won his Nobel prize, "While we consider the state of a body to be completely determined by the position and velocities of a very large, yet finite, number of atoms and electrons, we make use of continuous spatial functions to describe the electromagnetic state of a given volume, and a finite number of parameters cannot be regarded as sufficient for the complete determination of such a state."
- All writing should be professional. That means
    - Full Sentences

- Proofread
- Spellchecked
- All figures and tables need captions

Appendix

Useful resources about statistical and systematic error

- **Introduction to Statistical and Systematic Uncertainty** -- Brokk Toggerson and Aidan Philbin, University of Massachusetts Amherst, "Physics 132 Lab Manual": https://openbooks.library.umass.edu/p132-lab-manual/chapter/introduction-to-statistical-vs-systematic-uncertainty/
- **Systematic Uncertainty --** Scott Oser, University of British Columbia, "Physics 509C --- Theory of Measurement": https://phas.ubc.ca/~oser/p509/Lec_11.pdf
- **Error Propagation --** Scott Oser, University of British Columbia, "Physics 509C --- Theory of Measurement": https://phas.ubc.ca/~oser/p509/Lec_10.pdf

Citation examples

Book for footnote or endnote

1. Zadie Smith, Swing Time (New York: Penguin Press, 2016), 315–16.

Book for corresponding bibliography reference

Smith, Zadie. Swing Time. New York: Penguin Press, 2016.

Scientific article for footnote or endnote

1. Susan Satterfield, "Livy and the Pax Deum," Classical Philology 111, no. 2 (April 2016): 170.
2. Shao-Hsun Keng, Chun-Hung Lin, and Peter F. Orazem, "Expanding College Access in Taiwan, 1978–2014: Effects on Graduate Quality and Income Inequality," Journal of Human Capital 11, no. 1 (Spring 2017): 9–10, https://doi.org/10.1086/690235.
3. Peter LaSalle, "Conundrum: A Story about Reading," New England Review 38, no. 1 (2017): 95, Project MUSE.

Scientific article for corresponding bibliography reference

Keng, Shao-Hsun, Chun-Hung Lin, and Peter F. Orazem. "Expanding College Access in Taiwan, 1978–2014: Effects on Graduate Quality and Income Inequality." Journal of Human Capital 11, no. 1 (Spring 2017): 1–34. https://doi.org/10.1086/690235.

LaSalle, Peter. "Conundrum: A Story about Reading." New England Review 38, no. 1 (2017): 95–109. Project MUSE.

Satterfield, Susan. "Livy and the Pax Deum." Classical Philology 111, no. 2 (April 2016): 165–76.

Website for footnote or endnote

1. Firstname Lastname, "Title of Web Page," Name of Website, Publishing Organization, publication or revision date if available, access date if no other date is available, URL.

Websites for corresponding bibliography reference

- Lastname, Firstname. "Title of Web Page." Name of Website. Publishing organization, publication or revision date if available. Access date if no other date is available. URL.