Things that I should check before turning in my Formal Lab Report
PS315 Modern Physics
Spring 2023

updated: March 14, 2023

Grammar:

1. Use: data "are" … and … datum "is" Data (plural) Datum (singular)
   For example, "The data are shown in Fig. 2 along with the fitted parameters in the legend."

2. Read through your document to check for grammatical errors.

3. Have someone else read your document to check for grammatical errors.

Aesthetics (esp. Physics Journals)

1. When typesetting in LaTeX, **use a LaTeX editor**. For example, use Overlook, or use a spell checker in LED, or other LaTeX editors. Check your spelling.

3. **Do not use Excel Histograms.** These pictures stick out and don't present themselves well in a formal paper. The fonts are different, and the graphs don't have a clean appearance. The Excel graphs serve a useful purpose in your lab book by giving you a quick look at your data; however, you should switch to Matlab, Python, or Mathematica to generate a clean plot or histogram for a formal lab report.

4. Try to **avoid using first person singular** in your writing.

5. **Don't start sentences with**:
   Figure 1 shows . . . .
   Table 1 shows . . . .
   Equation 3 shows the dependence . . . . .

6. When referring to **Figures** and **Equations,** use these accepted abbreviations, "Fig. 1" **and** **"**Eq. 4" . There is no accepted abbreviation for Table in scientific journals.
   Don't start a sentence with a numerical value (e.g., 100 measurements were taken of . . .)
   Don't start a section or subsection with a Figure or Diagram or Table.

7. At the minimum, **put a paragraph at the beginning of your section before inserting a table, figure or an equation.**
   And "Yes." A paragraph should have more than one sentence in it.

8. **When opening and closing quotation marks,** it is easy to do in MS Word. However, in LaTeX, you must open the double quote with two left -rising apostrophes (upper-left part of your keyboard), and close the double quote with two right-descending apostrophes (far-right, the unshifted double quote).

9. Write your results as $(6.475 \pm 0.154) \times 10^{-7}$ m, **showing the mean value the uncertainty, and the units**. Please do not use this form, not 6.48*E-7.
   $(6.475 \pm 0.154) \times 10^{-7} m$ is written like `$(6.475 \pm 0.154) \times 10^{-7} m $`

10. If you're quoting an accepted value from the NIST tables of physical constants, you can use the concise form → $h = 6.626\ 070\ 040(81) \times 10^{-34}$ J·s when quoting the quantity. The number in parentheses "81" represents the standard deviation. In this case, you would add/subtract "81" from "40" to determine the ± one σ value of h.

    The precision of Planck's constant from this source would be:

$$\frac{\delta h}{h} = \frac{0.000000081}{6.626070040}$$

11. Avoid using equal signs in the text. For example, do not write "The voltage was set to $U_3 = 4.9$ volts." Instead, write "The voltage U_3 was set to 4.9 volts."

12. Make sure the numbers on your axes are big enough to read. What good is it to generate a plot nobody can read. Also, make sure that the legends in your plots are big enough to read.

13. Make sure that the axes are labeled with the correct units.

Bibliography: It is important to quote the sources you used in your formal lab paper. Dependable sources can lend credibility to your writing.

1. **Read from sources other than what I present in my lab leaflets.** Your primary source for citations should be from credible sources such as edited and peer-reviewed material. For example: (1) Your modern physics **lab textbook** by Melissinos and Napolitano, (2) Your **modern physics course textbook**, (3) **library books**, (4) **professors' textbooks** in their offices, and so on.

2. **Reduce the number of references to www.** You don't have to eliminate them; just reduce them. Many websites are transient, unedited, and not peer reviewed. If you are not familiar with the integrity of the source, you should look for more reliable sources to quote.

3. Assume that people need to read your reference 10 - 20 years from now. Your professionally written **lab report should stand the "test of time."** Typically, URLs do not stand the "test of time" criterion. Many of them come and go.

4. Citations: Don't list a reference in your bibliography **if you don't cite it**. References serve very little purpose if you don't connect them with the topic you are discussing in your text.

5. You should not cite a **paper you haven't read** (e.g., Millikan's paper from 1909). Did you <u>really read it</u> and understand what he did? Actually, you should be able to read Millikan's original paper and understand it. Again, do not cite a paper you haven't taken the time to read and understand.

Accepted Practices: When writing your article, you should assume that **your audience has some scientific literacy**. You should write your formal lab report as if you are going to submit it for publication (e.g., to a journal).

1. When describing how you went about taking the measurements, **don't present it as a list of items.** Don't write it in a recipe fashion. Do not use the imperative tense (like the sentences in this paragraph).

2 **Don't list the equipment** in any of the sections. You can describe the equipment as necessary, but do not list it/them. **Listing equipment is unacceptable** in a journal paper.

4. **Describe the physics quantities** when you present an equation, especially if it might be ambiguous:
"where θ = the angular displacement (radians or degrees), U = the potential (volts)," etc.

5. Using fitting packages from Mathematica 13.0 and Python are great! However, you need to make sure you **understand what the fitting packages are doing.** Do not fall in the trap of citing these fitting packages and their results without examining the credibility of the results. If the results are unreasonable, the reader (me) gets the impression that you relegated all your "scientific skill" to a computer program. If you use a Python or Mathematica fitting package, you can say so "once or twice" as appropriate in the text and cite it after that. Mathematica and Python are tools generally accepted by the scientific community, but it is still up to you to know how to use them and interpret their results correctly.

6. You may spend a lot of time using fitting packages and trying to interpret their results. This is especially true at the beginning of your career. Do not equate "time spent" with how much text and how many figures you should devote to this exercise in your formal report.

7. <u>Don't quote a measurement without an uncertainty</u>. Without the uncertainty, the reader has no idea whether or not your measurement is meaningful. The savvy reader will always calculate $\delta x/x$ in their mind in order to determine how precise your measurement is. If you do not quote the uncertainty, the reader has no choice but to conclude that the experimenter doesn't care about the quality of their measurements. At this point, the reader will be left with the following question, "Why should I continue reading this paper if the experimenter does not care about the quality of their own measurements?" However, if the experimenter does a good job of describing their error analysis, the astute reader can suggest ways to improve the measurements or the analysis. This kind of dialogue is a *rite of passage* to becoming part of the scientific community. Providing a clear error analysis also brings credibility to what you're doing.

Common Sense results: Make sure that the numbers and units make sense.

1. **Consistency/Quality checks:** $Q = \_\_\_\_ \pm \delta Q$ where δQ was as big as Q. Really?

2. **Reality check** on physical quantities: "where the gap size between the parallel plates d = 0.3μm." Are you sure the separation is that small—a tiny faction of the diameter of a

human hair? How does this size compare with something else of known dimensions? Does it make sense?

3. Labs are a great place to do a **reality check** of what you learn in physics class, or what you read in books. Do the sizes, speeds, and distances make sense?
   Radius of an oil drop = ($1.44\times10^{-11} \pm 5\times10^{-14}$) meters. Really ?? Does that measurement make sense with the laboratory equipment you have on hand? Does having an oil drop smaller than the size of an atom make sense? A different question: "Is your measurement really that good?" $\delta r/r = 5\text{x}10^{-14} / 1.44\text{x}10^{-11} = 3.47 \times 10^{-3}$, or 0.347 %. (??)

3. "My measurements were prone to error." That's a pretty vague statement. **What kind of errors? Be specific.** What did you do to improve the precision of your measurement? It takes great care to make a good measurement. ref: NIST.gov

   If you think something signifiant could have contributed to the uncertainty, estimate the magnitude. Determine whether the error is "systematic" or "random." Try to reduce the error in your measurement if you can.

4. What is the significance of knowing *e*, the fundamental charge? Are you climbing a mountain just because it's there, or do your results have a significant impact in the physics field? **Why is knowing the fundamental charge so important?**

5. In the Millikan Oil Drop experiment, plot $Q = ne$. You're measuring the charge, not the integer n. Ultimately, you are going to identify the progression of $n = 1, 2, 3, \ldots$; however, you should **plot what you measure,** namely, Q. Do not presume charge is quantized. You should pretend that you're plotting this data (like Millikan did) without knowing *a priori* that $Q/e =$ 1, 2, 3, …

6. The Millikan Oil Drop is frequently repeated today. While it is becoming old technology (90+ years old), it is still very much in use today. Don't downplay that fact that this is old technology and that is why your measurements do not have the quality you expect. If you think your measurement is limited by the fact that you are using "old technology," then **describe a better way to improve the measuring technique.** However, in this case, the equipment is plenty good for making the observations you need to take. This is an experiment that requires a lot of patience, and also, collecting a lot of data can make the results more meaningful. Another example where we employ old technology for "cutting edge" physics experiments is interferometers (e.g., LIGO) even though the basic technology was developed a hundred years ago.

7. When measuring the terminal velocity (Millikan Oil Drop), did you determine the distance the *oil drop* should fall before reaching terminal velocity? To make a measurement of terminal velocity based on starting values $v_o=0$ at $t_o = 0$, doesn't make sense. **STOP, and think about what you are doing!** Tell the reader what matters when collecting the data and how it impacts the uncertainties..

8. Drop the same oil drop 10 times and measure $v\pm\delta v$. Plot the histogram of terminal velocities for one drop and show how you calculated δv for one oil drop.

9. **Do some preliminary calculations while you are doing the experiment.** This gives you enough time to repeat the measurements and improve the quality of the measurements. Don't just take one set of measurements and think that you've finished the task. Look at the preliminary results and think about how you can improve the measuring technique and go back and take another set of measurements if necessary. Analyze all your measurements. Describe how your improved measurement method hopefully improved your results.

10. Helmholtz Coils for the e/m measurement--**Do you know the region over which the magnetic field is homogeneous?** You should plot the magnetic field for a Helmholtz coil and show the region over which it is uniform. Sounds like a job for Mathematica. Is it consistent with your measurement technique? Check out: https://physicsx.erau.edu/HelmholtzCoils/

    What about the light bending as it passes through the spherical bulb? Is that of any significance?