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Writing Lab Reports

A Guide on Content and Format

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1. Introduction

Laboratory experiments and reports are a core academic tool in STEM education. Experiments make the course content hands-on and exciting, allow students to verify the material firsthand, and teach the fundamental properties of the scientific method. Further, reports are practice for technical communication, and are an introduction to doing real scientific research. This document is designed to serve as a guide on how to write proper lab reports throughout your academic career and beyond. It will focus on both the content of a report and its format.

2. Content

Lab reports have a relative standard set of sections and corresponding content. Although different courses may combine or omit some of these sections, the following will cover most of what students will encounter.

2.1 Sections

2.1.1 Cover page

The cover page should be simple, and should only show what needs to be shown:

- Title of lab
- Subtitle of lab
- Your name
- The date
- Class title
- Instructor's name

Fancy graphics should generally be avoided, but things like the school's logo or seal are generally acceptable.

2.1.2 Abstract

The abstract is a very brief summary of the report. It contains the report's results and what they mean. It should read like a movie trailer to the full report, except it reveals the spoilers.

2.1.3 Introduction

The introduction is where the report should truly begin, introducing the reader to what the experiment and report is about:

- Context and background of topic
- Why the topic is significant
- Goals of the lab, hypothesis, or an expected outcome

2.1.4 Theory

This is where the theoretical model of the topic and experiment is introduced and explained. It should show:

- Introduction and derivation of equations or other key relationships, mathematical or not
- Diagram of model
- Variable list (may be moved to appendix)

2.1.5 Method

This is the cookbook recipe to the experiment. It contains a list of instruments and tools used, and a procedure for how the experiment was performed. The procedure should be detailed enough that a peer would be able to recreate the experiment.

2.1.6 Data

Here, simply list the raw data collected. No calculations should be done yet except for simple conversions like Celsius to Fahrenheit. The data should be listed in a table or plot.

2.1.7 Analysis

Now, perform calculations on the data with the equations given in the Theory section. Calculations should be written out with the variable equation, then with the input values plugged in, and finally the output value, as shown below.

> Plugging into equation (5),
>
> $$\begin{aligned} E &= hf \\ &= (6.62607 \times 10^{-34}\ \text{J s})(512.75\ \text{THz}) \\ &= 321.02\ \text{zJ} \end{aligned}$$

If there are multiple of the same type of calculation, it only needs to be written out once. Similarly, the multiple outputs should be listed in a table or plot. Avoid discussing the results until the discussion section.

2.1.8 Discussion

This is where the outputs from the analysis are interpreted for further meaning. It should explain the following:

- What the output values or plots mean
- Whether or not they support the stated goals, hypothesis or expected outcome
- Possible sources of error

2.1.9 Conclusion

The conclusion is a bit like the abstract, introduction, and discussion sections squeezed together. It is a brief summary of the report covering what was found, what it means, and why it is important. It should confirm if the original goals, hypothesis, or expected outcomes were realized or supported.

2.1.10 References

Any and all resources used to perform the lab or write the report should be listed here. The format (e.g. APA, MLA, IEEE, etc.) will depend upon the instructor.

2.1.11 Appendix

The appendix contains information that is important, but would be distracting to the reader if it were in the main body of the report. Common examples are:

- Large tables, plots, or figures
- Definitions of abbreviations
- Precise specifications of equipment
- List of variables, what they represent, and their units
- Expanding upon simplified statements

Each entry in the appendix should have its own subsection.

2.2 Composition

2.2.1 Percent difference vs. percent error

Some labs require a comparison between values in their analysis to estimate experimental error; this is normally done using percent difference or percent error. Percent error compares two an experimental value against a theoretical value to see how far off the experimental is.

$$\%\mathrm{Error} = \left|\frac{\mathrm{theoretical} - \mathrm{experimental}}{\mathrm{theoretical}}\right| \times 100\%$$

Percent difference compares two experimental values (ideally obtained through two different methods) against one another. The closer the values are to each other, the more likely it is that there is low experimental error.

$$\%\mathrm{Difference} = \left|\frac{\mathrm{experimental}_1 - \mathrm{experimental}_2}{\frac{1}{2}(\mathrm{experimental}_1 + \mathrm{experimental}_2)}\right| \times 100\%$$

2.2.2 Present vs. past tense

Use past tense for what was true at the time of the experiment, but is no longer true.

> The speed of the projectile was $343\ \frac{\mathrm{m}}{\mathrm{s}}$

Use present tense for things that are still true, especially natural phenomena.

> The speed of light is $2.99792 \times 10^8\ \frac{\mathrm{m}}{\mathrm{s}}$

3. Format

Half of the report is in its format. The ultimate goal is to maintain clarity and understanding for the ready. So even if the words themselves make sense, if the format of the report makes it difficult to follow your reasoning, the goal has been failed.

3.1 Math

Lab reports being technical in nature, mathematical typesetting is often necessary, and often done incorrectly. There are some general rules in how mathematics should be typeset, some followed more or less closely than others. These standards can be read further in [1] and [2].

Variables must be italic, normal text is roman.

> The horizontal displacement x increased over time.

Units are roman. Do not make the common mistake of italicizing the ‘µ’ in the ‘micro-’ prefix.

> Grade 2 filter paper has a pore size of $8\ \mathrm{\mu m}$

Special functions are roman.

> $$f(t) = \sin(\omega t)$$

Numerical (not physical) constants are roman, including e, the imaginary unit i, and the differential operator d. This rule is sometimes ignored even in major academic publications.

> The most beautiful equation in mathematics is
>
> $$\mathrm{e}^{\mathrm{i}\pi} + 1 = 0$$

Multiletter variables are roman. This prevents it looking like the individual letters are being multiplied. Similarly, subscript symbols are also roman unless they are referring to a specific, single letter variable.

$$\mathrm{SQNR} = \frac{P_{\mathrm{signal}}}{P_{\mathrm{noise}}} = \frac{E[x_s^2]}{E[x_p^2]}$$

Vectors are lowercase and matrices are uppercase, but both are bolded. Vectors may be written with an arrow hat instead, but be consistent within the same document.

The horizontal rows of matrix $\boldsymbol{X}$ are composed of the vectors $\boldsymbol{x}_n$.

The roll, pitch, and yaw of the aircraft are stored as

$$\vec{p} = [\phi,\ \theta,\ \psi]$$

Important equations that are referred to again later in the document should be numbered at the right of the column or margin.

Thus, we obtain the ideal gas law

$$PV = nRT \tag{1}$$

Using (1), we can find the pressure within the cylinder.

Equations should be centered, and have aligned equals signs where applicable.

The energy of a photon can equivalently be written in terms of its frequency or its wavelength,

$$\begin{aligned} E &= hf \\ &= \frac{h}{\lambda} \end{aligned}$$

Values should be in scientific notation. Engineers may opt to use engineering (base 1000) notation where applicable.

The most beautiful physical constant is Planck's constant,

$$h = 6.62607 \times 10^{-34}\ \mathrm{J\ s}$$

The wavelength of the laser was $\lambda = 700$ nm

3.2 Embedding tables and figures

Tables and figures are important ways to deliver quick information to your reader. They are the first places the reader's eyes go if reading quickly, so clarity and modularity are critical. It should be possible to read and comprehend the table or figure by itself without having to refer back to the report.

Accordingly, tables and figures must adhere to the following:

- Enumerated title
- Descriptive caption providing context beyond just what is shown
- Headers and axes should describe values, their units, and their corresponding variables, if applicable
- Values should be aligned by decimal value so that numbers in the same column can be easily compared
- The title should explicitly be referred to in the body of the text

Examples displaying these features are shown below in Table 1 and Figure 1, respectively.

Table 1. Displacement of water level when capsized vessel is fully submerged. (example)

Water displacement, h [m]	**Time**, t [s]
0.00	0.00
0.74	1.00
1.81	2.00
3.29	3.00
4.17	4.00
5.05	5.00

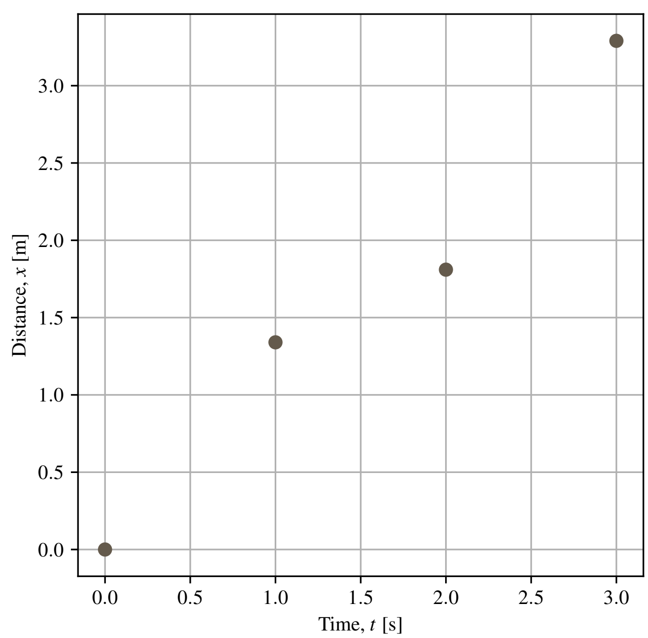

Figure 1. Horizontal distance vs. time plot of thrown paper airplane. (example)

If a figure is not a plot or chart, then the rules regarding values and axes do not apply, but the caption should be more descriptive in the information the reader is meant to glean from the figure. An example of this is shown in Figure 2.

Figure 2. The Boreal Owl (*Aegolius funereus*) is nocturnal, but it may hunt during the day due to the short summer nights in the upper latitudes of its range. Photograph courtesy of Bart "Rex" Slingerland from [3]. (example)

References

[1] C. Beccari, "Typesetting mathemetics for science and technology according to iso 31/xi," *TUGboat*, vol. 18, no. 1, pp. 39–47, 1997.

[2] I. Mills and W. Metanomski, *On the use of italic and roman fonts for symbols in scientific text*, Online PDF, Interdivisional Committee on Nomenclature and Symbols, IUPAC, December 1999.

[3] B. R. Slingerland. (2019) Aegolius funereus. [Online]. Available: https://commons.wikimedia.org/wiki/File:Aegolius-funereus-001.jpg

Appendix

A list of abbreviations used in this document is shown below in Table 2 with their corresponding meanings.

Table 2. Definitions of abbreviations

Abbreviation	Meaning
STEM	Science, technology, mathematics, and engineering
APA	American Psychological Association; a popular document format
MLA	Modern Language Association; a popular document format
IEEE	Institute of Electrical and Electronics Engineers; a popular document format