United States Naval Academy
Mechanical and Nuclear Engineering Department

Format and Style Guide for Laboratory Reports

Technical writing consists of two necessary components: *content* and *style*. Content is the meat of the writing, while style is how the content is conveyed. All engineers need to be able to communicate effectively through technical writing. There are two main purposes for writing a lab report: 1) to provide enough information such that someone else could repeat the experiment under similar conditions and produce similar results, and 2) to provide a clear connection between experimental data, the trends in the data, and the knowledge gained from those trends.

This document provides content and style expectations for lab reports in all Mechanical and Nuclear Engineering Department courses. It is broken into two sections. The first reviews the components of a lab report. The second offers general formatting and writing style tips. Both sections provide examples and templates. It is suggested that you read this guide in its entirety prior to writing your first lab report. Once you've got a handle on things, use this guide for referencing specific topics, such as "How do I format a plot?" (page 7) or "How do I write my conclusions?" (page 9).

Keep in mind that the Writing Center can help with lab reports and technical writing. Students are encouraged to go to the Writing Center especially if style issues are their main concern. There are also many online resources for technical writing as well [1].

1 – The Components of a Lab Report

Lab reports typically include the following sections (in this order): ***Objectives***, ***Background***, ***Procedures***, ***Results***, ***Discussion***, ***Conclusions***, ***References***, and ***Appendices*** (if applicable). Below you will find guidance for each of these sections, including a description of expected content, suggested templates, formatting and style, and examples of common writing errors.

1.1 Objectives

The Objectives section contains a concise (one to three sentences) statement of the experimental objectives. Objectives will vary based on the lab exercise, but they typically fall under two categories: understanding the effect of an independent variable on a dependent variable or verifying the accuracy of a theoretical prediction.

- The main objective of this lab was to measure/analyze/determine the effects of __________ on __________.
- The objective of this lab was to determine if __________ accurately predicts __________ as obtained from __________ experiments.

The lab exercise may also have pedagogical objectives (e.g. teaching you how to collect experimental data or use software for data analysis). Do not include them in your lab report.

1.2 Background

The Background section provides the reader with relevant concepts needed to understand the experimental results and discussion presented later on in your report. This includes descriptions of engineering concepts, vocabulary definitions, the basics of an experimental method, and fundamental equations. These descriptions are written generally, similar to a textbook. Avoid the temptation to include specific experimental details (they belong in the Procedures section!).

- *Incorrect:* Each of the nine members in the truss used in this experiment will be loaded in either tension or compression during the 5 different loading conditions.
- *Correct:* Trusses consist of two-force members that are loaded in either tension or compression along their axis.

How do you know if you're not being general enough? Check for phrases like "in this experiment" and specific values like the ones underlined in the *Incorrect* example above. Instead, focus on the general concepts that this lab pulls from. Keep in mind that including figures like schematics and images can offer a lot of information in place of lengthy, descriptive sentences.

Formatting Figures – Schematics/Images/Models/etc

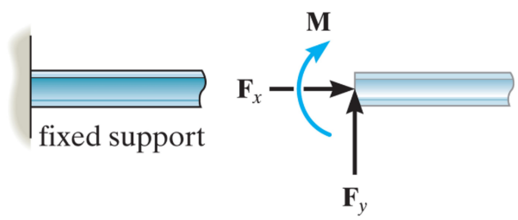

Figure 1: The reaction moment and force components for a fixed support [2].

Figure 1 highlights how to format a figure. Figures belong on their own line with center alignment. They should be large enough to read but take up no more than half a page. The corresponding figure caption is centered directly below the figure. It should be a concise, but complete sentence. If you didn't make the figure then your caption must include a reference. Figures are numbered sequentially as they appear in the text. This includes plots, which are also a type of figure (page 7).

Figures need to be introduced in the text so the reader understands what they are looking at. An introduction for Figure 1 might be:

> *A truss can be supported through a fixed support. The reactions at the support prevent both horizontal and vertical translation as well as rotation. Figure 1 illustrates a fixed support and its corresponding reaction forces and moments.*

This introduction should be in the text before the figure, unless formatting makes that impossible. The reader can and will go find the figure that you're referencing, even if it's on a different page. That being said, do not include directional phrases like "in the figure above" or "in the following figure".

Once a figure has been introduced you can reference it by its number later on in your report. This is why it's important to number your figures. Think of it like giving it a name. You might first introduce someone to your parents by saying "This is Angel, they are a friend of mine from the Academy". If you mention Angel again a week later, it's safe to assume your parents will know who you are talking about.

1.3 Procedures

The Procedures section describes what was tested, how it was tested, the raw data (direct measurements) collected during the test, and how that data was collected. Your goal is to provide enough detail such that someone could replicate what you did. When in doubt, more detail is better than less. As with the Background section, schematics and images (included as figures) can offer a lot of information in place of lengthy, descriptive sentences. The experimental procedures are written in the past tense ("what was done") not as step-by-step instructions ("what to do").

- *Incorrect:* Add one weight to the tray then measure the strain in each of the members. Next, add another weight and measure again. Repeat until the weight is five pounds.
- *Correct:* Weights were added to the tray in one pound increments up to five pounds. Strain gages were used to measure the strain in the nine members at each load.

How do you know if you're missing information? Check your tables. Have you explained how all of the raw data was collected? What equipment was used? How many trials/samples? Were there any special steps implemented to ensure the test was valid?

1.4 Results

The Results section is where you present your experimental data, discuss any calculations, and describe observed patterns or trends (or lack thereof!). This is not where you interpret those findings or address the 'why'. It's helpful to consider your results as "evidence" which will be used to support statements made later in your Discussion section.

It is reasonable, and for some MNE Department instructors preferred, to combine the Results and Discussion sections. A single section allows more flexibility in how to organize the content, however that can sometimes be challenging for inexperienced writers. This guide presents the sections separately to best emphasize their key components.

Regardless of if you combine sections or not, it is important to keep the reader in mind by organizing your tables, calculations, plots, and observed trends in a logical manner that makes it easy for them to understand. The following sub-sections walk through these components.

1.4.1 Tables

Tables are an ideal way to include data and additional relevant information (e.g. test conditions, specimen geometry, and simulation parameters) in your lab report. As with figures, tables can offer a lot of information in place of lengthy, descriptive sentences. Your Results section should pick up where the Procedures section left off by introducing the tables containing your experimental data. Remember, the reader needs to know what your data are before they can understand any calculations performed with that data or any plots made from that data.

Formatting Tables

Table 1: Experimental and predicted stresses in member 1.

Applied Load (lb)	Experimental Strain (in/in)	Experimental Stress (psi)	Predicted Stress (psi)
1	1.72×10^{-5}	570	500
2	3.45×10^{-5}	1203	1000
3	5.17×10^{-5}	1480	1500
4	6.90×10^{-5}	1945	2000
5	8.62×10^{-5}	2600	2500

Table 1 highlights how to format a table. Tables belong on their own line with center alignment. They should be large enough to read but do not split a table between two pages (it's ok to adjust the font size!). If your table can't fit on a single page then it should be put in an Appendix (page 10). All columns must be labeled with units (if applicable). The corresponding table caption is centered directly above the table. Tables are numbered sequentially as they appear in the text.

Tables need to be introduced in the text so the reader understands what they are looking at. An introduction for Table 1 might be:

> *Table 1 contains the experimental stress and strain in member 1 for all of the loading conditions tested. The predicted stress, calculated from Equation 1, is also included.*

This introduction should be in the text before the table, unless formatting makes that impossible. The reader can and will go find the table that you're referencing, even if it's on a different page. That being said, do not include directional phrases like "in the table above" or "in the following table".

Once a table has been introduced you can reference it by its number later on in your report. This is why it's important to number your tables. Think of it like giving it a name. You might first introduce someone to your roommate by saying "This is my sister, Emma". If you mention Emma again a week later, it's safe to assume your roommate will know who you are talking about.

1.4.2 Calculations

Any calculations made as part of your data analysis must be explained in the Results section. The best way to present calculations to the reader is to do so in the order in which you actually completed them.

Formatting Equations – General

$$\sigma = E\varepsilon \tag{1}$$

Equation 1 highlights how to format an equation. First and foremost, equations must be written using an equation editor. Equations belong on their own line with center alignment and corresponding numbering aligned to the right. Leave a space above and below to offset the equation from the rest of the text. Equations are numbered sequentially as they appear in the text.

While your Results section must include how you *used* the equations, the equations themselves can be *introduced* in either the Background or the Results sections. The best way to introduce an equation is to insert it into an "equation sandwich". The top slice of bread introduces the equation by stating what the equation solves for and names the equation (if it has a name). The bottom slice of bread further explains the equation by defining all variables. This is analogous to how you would include quotations in a history paper and gives your equation context [3]. Trust that the reader can read your equations. Do not write out the mathematic operations in words.

- *Avoid:* In Equation 1 the stress (σ) equals Young Modulus (E) multiplied by the strain (ε).

How do you know if you've included enough information? The reader should have all the equations and values needed to redo your calculations. Check that each variable in the equation has been defined and a value provided, including units. If the values are in a table, make sure the reader knows which one. This is a great way to catch missing information from your Procedures section.

If your analysis requires a lot of calculations, then include only the governing equations in the body of the text and reference supplementary calculations in an Appendix (page 10). This includes any code (e.g. MATLAB script) used in your analysis.

Formatting Equations – Introduced in the Background and Used in the Results

> The stress (σ) in each member of a truss can be calculated using Hooke's Law.
>
> $$\sigma = E\varepsilon \tag{1}$$
>
> In Equation 1, Young's Modulus is E and ε is the strain in the member.

This example highlights how to *introduce* an equation in your Background section using an "equation sandwich". The first sentence names the equation (Hooke's Law) and states what it can be used for. The second sentence defines the remaining variables. Notice that this is in the present tense and written generally for any member, of any truss, made out of any material, and under any strain (review section 1.2 for how to write a Background).

Once an equation is introduced you can reference it by number and *use* it in your Results section. This is why it's important to number your equations. Think of it like giving it a name. You might first introduce someone to your CO by saying "This is Yuuma, he's in my major". If you mention Yuuma again a week later, it's safe to assume your CO will know who you are talking about.

> The predicted stress in member 1 was calculated using Equation 1 and the strain values in Table 1. Young's Modulus was 29×10^6psi. The predicted stresses are listed in Table 1.

Notice that all the specific details related to the experiment which were left out of the introduction are included here. The reader can now complete the same calculations you did.

Formatting Equations –Both Introduced and Used in the Results Section

The predicted stress (σ) in member 1 was calculated using Hooke's Law.

$$\sigma = E\varepsilon \quad (1)$$

In Equation 1, Young's Modulus (E) was taken as 29×10^6psi and the values for the strain (ε) can be found in Table 1. The predicted stresses are listed in Table 1.

This example highlights how to *introduce* and *use* an equation in your Results section using an "equation sandwich". The first sentence names the equation (Hooke's Law) and states what it was used for. The second sentence defines the remaining variables and provides their corresponding values either directly in the text or by referencing a table. Notice this is written in past tense (what was done!).

Once an equation has been introduced you can reference it by its number later on in your report. This is why it's important to number your equations. Think of it like giving it a name. You might first introduce someone to your friend by saying "This is Chantelle, she's in my major". If you mention Chantelle again a week later, it's safe to assume your friend will know who you are talking about.

1.4.3 Plots

Plots are also an excellent way to communicate information to the reader. Histograms, bar charts, and scatter plots are common plotting styles. Data visualization is a field unto itself, but in the words of William Cleveland, a leader in this field, the best guidance is simply the following [4]:

"Make the data stand out. Avoid superfluity"

Keep in mind that plots are more than just pretty pictures, they are a method in which you can identify and quantify trends within your data. A poorly designed plot can lead to false conclusions. Imagine the following situation: your data acquisition system collected one data point every 10 seconds over a span of two minutes, giving you a total of 12 data points. If you plot these 12 points in a scatter plot formatted as a solid line that implies you measured what the values were at all times, not just every 10 seconds. This is both a visualization problem (the reader doesn't know you only measured 12 points) and also an analysis issue (the line may make you see trends that are not real). Discrete data must be plotted as discrete datapoints using markers without connecting lines. Be warned that plotting software (e.g. Excel and MATLAB) often, by default, format scatter plots as solid lines. Solid lines (without markers) are acceptable when plotting predicted or theoretical data obtained from a calculation (you could calculate the value at every point!). Dashed lines (without markers) can be used for lines of best fit. Make sure you've introduced and used the corresponding equation(s) first if your plot contains calculated data.

A line of best fit can help provide a shape (linear, polynomial, exponential) and quantitative values (e.g. slope, maxima/minima, etc) to your experimental data. Be sure to examine the R^2 value to check for how good the fit is. Lines of best fit work best when there are enough data points to support a fit. Always question whether a 'perfect' fit is real or simply a mathematical proof (3 points will always define a quadratic function!)

Formatting Figures – Plots

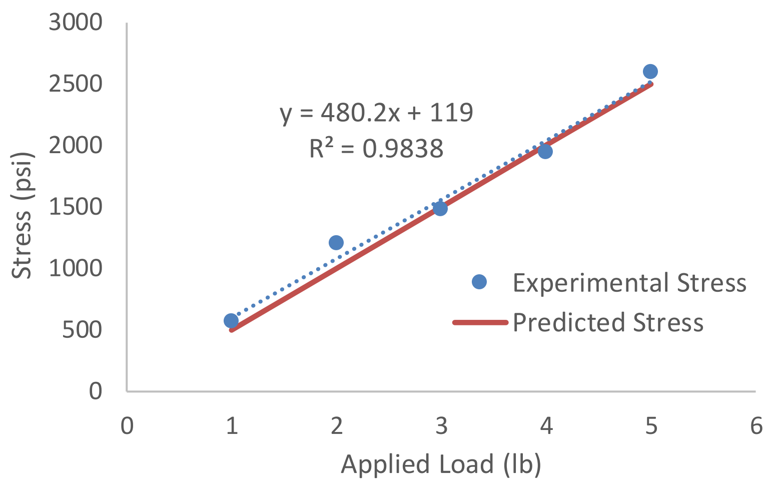

Figure 2: Experimental and Predicted stress vs applied load in member 1.

Figure 2 highlights how to format a plot. Plots are a type of figure, therefore the general guidance is the same as when formatting any other figure (see page 2). Care must be taken to make sure your plot clearly and correctly conveys the data. Every plot must have its axes set to a range which minimizes whitespace and emphasizes the data, axes labeled (with corresponding units), a legend (if more than one dataset), and the equation for the line of best fit (when applicable). Keep in mind that you'll usually be printing in black and white, so using different marker shapes or line styles is often more effective than changing the color. Do not include a plot title (that's what the caption is for!).

Plots must be introduced in the text, just as you would for any other figure (see page 2). The introduction must identify the dependent and independent variables (what is on the Y and X axes) and describe the dataset(s) plotted with corresponding line(s) of best fit (if applicable). An introduction for Figure 2 might be:

> *In Figure 2 both the experimental and predicted stresses in member 1 are plotted as a function of the applied load. A line of best fit for the experimental data is also included.*

1.4.4 Presenting Evidence

It is not sufficient to simply present the reader with plots and tables and expect them to identify the important evidence they contain. As the writer you must explicitly do this within the text. First and foremost, it is important that you follow what your experimental data shows you and nothing more. Take Figure 2 as an example:

- *Incorrect:* The data in Figure 2 is linear.
- *Correct:* The experimental data in Figure 2 shows a positive correlation between the stress in member 1 and the applied loads tested. The line of best fit suggests this trend is linear with a slope of 480 psi/lb.

At first glance, the *Incorrect* statement might not appear that bad, however it contains significant mistakes and omissions. First, it is unclear which dataset is being referred to: experimental or predicted.

Second, the experimental data is not linear, the line of best fit is. All that the experimental data show is a correlation between the dependent and independent variables. Third, it does not specify whether this correlation is positive or negative. Fourth, it is necessary to recognize that any observed trends are only true over the range of tests conducted.

Trends are used to describe experimental datasets, not predicted (or theoretical). Predicted data comes directly from known physical or empirical equations. For example, you do not need to plot Equation 1 to know that the stress and strain will have a positive, linear relationship with slope equal to Young's Modulus. Predicted datasets are plotted in order to provide a visual comparison with experimental data. Remember a comparison between experimental and predicted results is a common lab objective!

Comparison of two values must be presented quantitatively. Take the following example:

- *Incorrect:* The experimental stress is much bigger than the predicted stress.
- *Correct:* The experimental stress is 200 psi greater than the predicted stress at an applied load of 2lb.

The *Correct* statement contains three components: the things being **Compared** (experimental and predicted stress), the quantitative **Calculation** that compares them (200 psi greater), and the **Context** for which this data was obtained (at an applied load of 2lb). **Clarity** is achieved by combining these three components in a single statement with no contradiction or redundancy. In short, a good quantitative statement consists of the **4C's: Comparison, Calculation, Context, and Clarity** [5]. Here are additional examples:

- The strain at a load of 3lb is 1.5 times greater than the strain at 2lb.
- The percent error between the predicted slope and the experimental slope determined from the line of best fit is 4%.

How do you know if your comparison is quantitative not qualitative? Check that it required comparative math (e.g. finding a difference, a percent error, a multiple, etc).

1.5 Discussion

The Discussion section is where the lab objectives are addressed. It is critical that your statements in this section are supported with evidence presented in your Results section.

- *Unsupported*: The stress in member 1 can be predicted with good accuracy.
- *Supported*: The low percent error for the predicted stress in member 1 suggests that Hooke's Law can be used to predict the axial stress within members of a truss.

You want to avoid absolute words like "always", "completely", and "never". A single experimental study rarely "proves" something [3]. Stick to phrases more like the following:

- The data suggest / demonstrate __________.
- The results contradict the commonly accepted theory that __________.
- The data support/are __________ which is consistent with the work of X.

If your results vary from the expected values you will need to address possible sources of error. Under no circumstances should you claim "human error" (so you're saying you messed up?).

- The difference between __________ and __________ is likely do to __________.

1.6 Conclusions

The Conclusions section is similar to an executive summary, usually only a paragraph long. Begin by restating the lab objectives followed by a brief description of the experiment, then present the major findings from the Discussion section (including quantitative evidence). A lazy reader should be able to skip right to the Conclusions section and get the gist of what you did, why you did it, and what you found. Avoid general musings, vague comments about what you learned (pedagogically speaking), or how you *feel* about the results. No new information belongs in this section. If it's showing up here for the first time that means it's missing from one of the previous sections.

1.7 References

As a general rule, you must provide a reference for anything that isn't common knowledge. *Failure to properly reference work that is not your own is considered plagiarism, which is an honor offense.* Be careful to check that your sources are reputable, especially when found online. If you completed the lab as a group but are writing individual lab reports it is expected that each group member makes their own plots and tables and writes their own code (if applicable).

All references must be compiled in the Reference section. You can type them directly or use endnotes but footnotes are never acceptable. A reference used more than once does not get repeated in the reference list (it only has one reference number!). Write your references following Chicago style, details of which can be found here: http://www.chicagomanualofstyle.org/tools_citationguide.html

Formatting References

[1] Alley, Michael. "Laboratory Reports." Writing as an Engineer or Scientist. Leonhard Center at Penn State, accessed August 23, 2023. https://www.craftofscientificwriting.org/laboratory-reports.html.

[2] Schiavone, Peter, and R. C Hibbeler. *Engineering Mechanics: Statics 14th Edition*. Hoboken, New Jersey: Pearson Prentice Hall, 2016.

[3] Graff, Gerald. *They Say/I Say*. New York: W.W. Norton & Co., 2012.

[4] Cleveland, William *The Elements of Graphic Data*. AT7T Bell Laboratories, 1994

[5] Ruscetti, Tracy, Krueger, Katherine, and Christelle Sabatier. "Improving Quantitative Writing One Sentence at a Time." *PLOS ONE* 13(9): e0203109, 2019.

[6] Anne Greene, *Writing Science in Plain English*. Chicago: The University of Chicago Press, 2013.

References are numbered sequentially as they appear in the text using either (1), [1], or [1] notation. A reference cited twice uses the same number. This is why it's important to number your references. Think of it like giving it a name. You might first introduce someone to your sponsor family by saying "This is Alex, he's my teammate". If you mention Alex again a week later, it's safe to assume your sponsor family will know who you are talking about.

Note: The example provided is the actual list of references used in this guide!

1.8 Appendices

Appendices exist for information that is useful to the reader but not critical enough to be included in the main text. This includes code, supplementary figures and calculations, and large tables. An Appendix can contain multiple items, so long as they are of the same type (equations, figures, etc). Your instructor may ask you to include the lab handout as an Appendix.

Formatting Appendices

Appendix A: Data Analysis MATLAB Script

```
% Lorem Ipsum
% Lab 1

% Clear the workspace, close figures, clear command window
clearvars
clc
close all

% Define Constants
E = 29e6;    % Young's Modulus (psi)
```

(Partial script provided just so you get the idea!)

Appendix A highlights how to format an appendix. Start each appendix on a new page with the corresponding title at the top. Appendices are lettered alphabetically as they appear in the text.

Appendices need to be introduced in the text so the reader understands what they are looking at. An introduction for Appendix A might be:

The MATLAB script used to calculate the stress in each strut is provided in Appendix A.

Once an appendix has been introduced you can reference it by its letter later on in your report. This is why it's important to letter your appendices. Think of it like giving it a name. You might first introduce someone to your SEL by saying "This is Jordan, they are a friend from back home". If you mention Jordan again a week later, it's safe to assume your SEL will know who you are talking about.

2 – Writing for Clarity

Section 1 covered specific formatting and style guidance for figures (page 2), tables (page 4), equations (pages 4-6), plots (page 7), references (page 9), and appendices (page 10) highlighted in the grey boxes. This section provides general guidance and tips on how to write clearly and format the entire report. ***It is expected that you have proofread the lab report in its entirety prior to submission.*** Do not rely solely on Microsoft Word or Google Docs to identify your spelling and grammatical errors.

2.1 General Formatting

Formatting must be consistent throughout the entire report. This can be especially challenging for group reports. A change in font or text spacing might seem minor but it can be very distracting to the reader. Formatting should be both the first and last thing you consider. Deciding on a formatting style before you begin to write will prevent errors and giving the full report a final review will catch any that slid by.

Begin your report with a header (or cover page) that includes your name, the name of your group members (if applicable), the submission date, the course name and number and section, and a title. The title should be center aligned and separated above and below by a space. Use size 12 font for the text. Your instructor will let you know if they prefer double or single spaced. Paragraphs should be left justified with no indentation on the first line and separated by a space. Begin each section with an easy to identify header (e.g. bolded, numbered, etc).

Try to avoid excessive 'whitespace' on the page. This usually occurs when a figure or table is too large to fit on the bottom of a page, so it's bumped to the next page. Consider rearranging the text or figure/table to minimize this spacing issue. Sometimes a few lines of whitespace is unavoidable (look at the bottom of page 3!) but again, the goal is to limit the distraction to the reader. For example: if a header lands at the bottom of a page you should move it to the top of the next page. The reader is far more likely to miss the header than notice a little extra whitespace.

2.2 Writing Style and Voice

Sentences should be concise and written in the third person, avoiding the use of pronouns (e.g. I, we, they, etc). While it is tempting to try to sound smart by using 'Academic-speak' this often leads to long, confusing sentences. Allow yourself to write in straightforward, 'Everyday-speak', but still avoiding slang or other informal speech [3]. A good test is to read the sentence out loud. If it sounds good, then it likely reads well.

- *Academic-speak:* The physical manifestation of stress responses have been shown to vary greatly between metals, ceramics, and polymers.
- *Everyday-speak:* Metals, ceramics, and polymers behave very differently in response to an applied stress.

Both sentences convey the same content, but the second is significantly easier to understand. The distinct difference is the choice of noun (underlined) and verb (double underlined) in each sentence. The Academic-speak is abstract while the Everyday-speak is much easier to visualize. [6].

It is also important that your sentences flow with one another so the reader can follow your train of thought. If a paragraph sounds choppy you may need to include transitional words [3].

- similarly
- for instance
- despite
- in contrast
- in addition
- likewise
- therefore
- consequently
- specifically
- whereas
- although
- in other words

2.3 Writing with Numbers

There are two situations in which you'll include numbers in your writing. The first is measured or calculated quantities. These values should be formatted numerically with a corresponding unit abbreviation when applicable. Be sure to consider significant digits and use scientific notation to avoid the appearance of presenting data with more precision than was actually available. As a general rule, four significant digits is the most you'll ever be able to report. Include a zero in front of the decimal place for values less than one. When using numbers to count, spell out the number if its absolute value is nine or less but format it numerically if its value is 10 or more (see this sentence as an example!).

- *Incorrect:* The strut had a mass of .31 pounds and its length was twenty-one.
- *Correct:* The strut had a mass of 0.31 pounds and its length was 21 in.