FEH Guide to Lab Reports and Memos
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PREFACE

This guide is for students in the Freshman Engineering for Honors (FEH) program at The Ohio State University. Its purpose is to help students through the process of learning to write lab reports and memos and developing general technical writing skills. Although much of the information contained in this document is specific to the FEH requirements for lab reports and memos, some of it can be applied to technical writing in general.
1 INTRODUCTION

As a student in the Freshman Engineering for Honors Program, you have a tremendous opportunity to develop the skills and knowledge that you will need to succeed in the remainder of your formal engineering education and eventually in your career as a professional engineer. The FEH Program is dedicated to providing you with instruction, experiences, and resources to help you through this process.

The laboratory experiences in the ENG H19X courses are designed with two goals in mind. The first is to give you a chance to do some hands-on activities in a variety of engineering disciplines. The second is to develop your teamwork and communication skills. This guide focuses on technical communication, specifically technical writing.

Lab reports and memos have given past students a lot of difficulty and frustration. Don’t be surprised if you find yourself struggling to write good reports. Technical documentation is an art and a skill that takes a lot of practice. Your first few reports will likely take you several hours to complete, but with more experience you will find that you don’t have to spend as long. If you try to learn from the feedback given and work to improve with each report you hand in, the quality and efficiency of your writing will improve quickly.

1.1 Motivation

The most obvious reason that developing technical writing skills is important is this: You will use them – a lot. Even if you are not sure about engineering as your career path, the skills you develop in these courses will help you with communication in almost any professional field. If you do go on to become a professional engineer, these skills will be invaluable to you, and you will likely use them in some form on a daily basis.

1.1.1 Why should you learn technical writing?

Technical communication is of key importance for good engineering work, because all engineering work is done in teams. These teams are multi-disciplinary in nature. Imagine yourself five years from now working on an engineering project, and consider the variety of people that might be involved with that project. Of course you will have some other engineers. Some of them might have a similar background as you, but some might be trained or experienced in a completely different discipline. You may also have technicians who are skilled in the applied aspects of engineering. Communication between those mentioned already starts to get a little tricky. But then add in some of the semi- or non-technical people. There will be leads and managers handling the personnel resources, accountants taking care of costs and supplies, marketing and sales people to make sure there is a fiscal reason for the project, and lawyers to worry about regulatory and patent issues. Now imagine that the project is a success. Then you’re going to bring in manufacturing people, quality assurance and reliability people, logistics people, support and maintenance people, and more. The work of all these people with their myriad backgrounds and areas of expertise will in some way be affected by your work as an engineer, and vice-versa. The only way for something like this to get done is through good communication and documentation. If you thought you could get out of writing by becoming an engineer, think again.
1.1.2 How will this fit into your engineering education?

As an FEH student, you are going to get a crash-course in the art and skill of technical documentation. This is mainly done through learning two specific types of documentation: the lab report and memo. Then, in your third quarter, you will be creating a very extensive set of documents for the design project, including a full design report and a project notebook.

Nearly all first-quarter freshmen, especially those in FEH, have had a good introduction to composition. Many have also had experience writing lab reports for their high-school science classes. However, most first-quarter FEH students have never had exposure to the professional level and quality of writing that will be expected of you in these courses. The length of this document, if nothing else, should give you some idea of how high expectations are. But fear not! You are capable, and you will have all of the resources available to meet these expectations and become a good technical writer. However, the responsibility for learning and developing these skills is largely on you.

No class or lab time is devoted to teaching you how to write lab reports. You are expected to learn on your own, for the most part. This is a concept that most freshman students are not used to, but it is something that will become more familiar to you in the next few years. In college courses, the responsibility for learning is on the student. The instructor is mainly there to facilitate learning and to assess and give feedback. One of the most important things that you will take away from your university education is the ability to learn independently. This is another skill that will serve you well in your career, because engineers have to constantly absorb new information. Ten years from now, you will likely be using some technology in your work that has not yet been conceived of. You’re not going to learn about it in college; you will learn it on-the-job and on-the-fly. The ability to quickly locate the information needed, absorb it, and apply it is an important aspect of both a good engineering student and a good engineer. You will get a chance to develop this skill as you learn to write lab reports and memos.

You are not completely on your own in this process. For this course, nearly all of the resources you will need are given to you. This document provides a lot of information on general guidelines for reports and memos, as well as requirements that are specific to the FEH program. You will also have access to the grading rubrics for each lab. In addition, you are encouraged to get help from your TA’s.

1.1.3 Is this worth the effort?

Most students end up spending a lot of time writing their lab reports and memos, especially during the first quarter. In the past, many have commented negatively about the difficult requirements, high expectations, and large time investment. But eventually, most realize that the time spent was well-invested. You will find that the quality and efficiency of your writing will improve as the year goes on.

By the time you finish this school year, you will be able to write a high-quality technical document in a fraction of the time you spent in October. You will have put together a final report for H193 that is worthy of a senior-year design project. Interviewers for co-op and internship jobs (especially those not familiar with FEH) will be amazed at the quality of this report. Past FEH students have reported being hired based mainly on showing off their report at an interview. Others have reported
comments that their reports produced while on co-ops were on par or better than those of their professional co-workers.

Throughout the rest of your formal engineering education, you will have to write reports. Your experience in FEH will make this much less painful than it is for some of your classmates. When you begin working as a professional engineer, you will be documenting your work on a regular basis. The documents you produce will represent the work you have done. In many case, they will be the only representation of your work that your clients or management will ever see. So if you want the best chance at that contract, promotion, or raise, you will want your documents to be good.

These are a few reasons why the answer to the above question is: yes, it is worth the effort.

1.2 How to use this document

This guide is your primary reference for writing FEH lab reports and memos. It is NOT the end-all guide for how to write lab reports and memos in general. Different university courses, companies, organizations, and publishers usually have their own guidelines and requirements, and these may differ in varying degrees from those presented in this document. The FEH lab report and memo guidelines given here have been developed over time by the instructional team to represent aspects of technical documentation that are common in many engineering fields. As a student in FEH, you are expected to conform to the guidelines and standards given in this document. In doing so, you will gain experience in learning a specific standard, as well as develop general technical documentation skills that can be applied in any situation.

Right now you may be thinking: “This thing is long! Am I really going to have to know everything in here?” The short answer is: pretty much. This guide is long and not exactly exciting reading. However, it is very detailed and contains everything you need to know about writing an “A” report. You are required to read this guide before the second lab of autumn quarter, and you are encouraged to re-read it again when writing your first few reports. Once you are familiar with the contents, however, you will probably only need to refer to small portions of it.

In addition to the requirements and guidelines presented, there are also many suggestions or hints for making your reports and memos better. There is some redundancy. Information that it repeated usually pertains to some common mistake made by students. Many students would prefer (and have asked for) a one-page list of the requirements. This is not done for two reasons. First, it is not possible. There is far too much to fit onto a single page. Second, the process of learning this material, of finding and applying the important information, is an important part of the learning experience (see 1.1.2).

Sections 2 and 3 of this guide give details of what should be included in reports and memos and how they should be organized. Section 3 contains information and tips on what should be included in each section. It will be especially important when writing your first few reports. Section 4 deals with language and gives some general guidelines for appropriate style and level of detail. Section 5 details the specific formatting requirements for FEH reports and memos. It contains information about the proper presentation of auxiliary information such as figures and tables. Section 6 explains how reports and memos are graded and offers some tips for improving your score. Section 7
is a brief summary in list form of the important guidelines presented in the rest of the document. It does not contain everything you need to know. It is intended as a checklist for you to use after finishing your report or memo. Section 8 contains information about where to get additional help with technical writing.
2 CONTENTS: What should go in a Lab Report?

This section covers what information should go into a lab report or memo.

The purpose of any technical document is to communicate information. Deciding what information to include and what to leave out is not always an easy task. Many of these decisions will be determined by the type of document you are writing. Most companies (and most lab courses you will take) have different standards and requirements for different types of documents. The requirements specific to content of FEH lab reports and memos are given below.

The main factor to consider when making decisions about what to include is your reader. You need to be aware of what your reader already knows and what he or she wants to know. The technical background of your reader will influence the content of your document, as well as the level of detail and the technical level of your writing (discussed more in Section 5 of this document).

2.1 To include or not to include? General guidelines

Remember that your reader has a purpose for reading your document. He or she is looking for some specific information and expects to find it. It is your job to make sure that all of the important information appears in your report or memo so that your reader does not have to look elsewhere. You must also keep in mind that your reader does not have an unlimited amount of time or attention to get the information he or she wants. This means that you have to be careful about putting too much in your document. The balance between being complete and not overloading your report or memo with unneeded information can be tricky.

In general, anything that directly relates to the purpose or objective of the lab should be included in your memo or report. Also, any information that is necessary for your reader to understand your results, discussion, and conclusions should be in there.

The next three sub-sections give some specific requirements for content that should and should not be in your document. However, there may be some additional information that you think could be appropriate. So, should you include it? Often times a single technical document is read by a variety of people with different backgrounds and interests. There may be information that only a few of the readers really need but most don’t. Should it go into the document?

The blanket answer to these questions is: yes, go ahead and include it, but not in the body of the document. If you are unsure, it is usually safe to put the information in an appendix (for reports) or attachment (for memos). That way, it is still accessible to anyone who might be interested, but it is not in the way of anyone who is not. Please note that all content must be referenced and briefly described in the body of the report or memo, even if it appears in an attachment or appendix.

2.2 Information to Include in FEH Lab Reports

FEH lab reports should be written to give the reader a complete description of the experiment, including the procedure and equipment used, the results, and an interpretation of the results. For reports, assume that your reader knows little to nothing about your specific experiment. However, you may assume that the reader is familiar
with the basics of the topics covered in the lab. That is, assume that he or she has the background information presented in the lab write-up and the lecture slides.

The following is a break-down of the type of information that should appear in your report (specific to FEH lab reports).

- **Purpose of the experiment** – You should include one or two sentences that describe why the experiment was done and what the objective was. Note that this should not be about your experience as a student, but rather the experiment itself.

- **Description of the report contents** – Tell your reader exactly what is found in the body of the report and where to find it.

- **Materials and equipment used** – Include a detailed description of what you used. Give known specifics of any measuring devices, such as accuracy or scale. Describe the experimental set-up (it often helps to include a figure). Any apparatus that is not considered typical (i.e. you couldn’t buy it from an equipment catalog) should be thoroughly described.

- **Experimental procedure** – Tell what you did in the experiment. Describe how you used the materials and equipment to get your results.

- **Experimental results** – Present the data you collected in the lab. Give all measurements, as well as any objective observations made during the lab.

- **Calculations made on the data** – Describe in detail any manipulation of the data. This includes showing and describing any methods, formulas, or equations used (be sure to define all variables) and giving sample calculations when necessary. Give the results of the calculations or manipulation.

- **Description of results** – Often you will present raw data in some other form to make it easier to read or analyze (for example, as a graph). This requires some (usually brief) description. Anything that you add to aid in interpreting the data should be thoroughly described (for example, trend lines).

- **Discussion of the results** – Include an objective treatment of your results. Show relationships between the data. Make comparisons if applicable (for example, between experimental and theoretical). Suggest reasons for trends based on theory or observations (but be careful to be objective). Develop objective support for your conclusions based on your results. (The lab write-ups will often give you some clues about what might be appropriate to discuss.)

- **Limits of findings** – Note any possible problems with the equipment or procedure. Describe how these issues could have affected your results. If no such problems exist, state so.

- **Conclusions** – Draw appropriate conclusions based on your results. All conclusions should be supported by your objective discussion of the results (see above). Conclusions should reflect the purpose of the experiment.

- **Suggestions for further experimentation (optional)** – If you were unable to provide strong conclusions based on your data, suggest what further experiments could be performed. If there are problems or issues with the procedure, suggest changes that might address them.

- **Sources** – anything appearing in your report that you did not create.
2.3 Information to Include in FEH lab memos

FEH lab memos are meant to represent typical engineering memos. These are still considered technical documents. However, they do not contain the same depth of information as reports.

Assume that the reader of your memo is familiar both with the basics of the subject matter and with the experiment you did. As such, you do not need to include detailed information about the materials, equipment, or experimental procedures used. However, it is still good practice (and a requirement) to remind your reader about these things by including a brief summary (1-3 sentences) of the experiment in your memo.

All items in the bulleted list found in the previous sub-section (2.2) should be included in FEH lab memos, with the exception of “materials and equipment used” and “experimental procedure.”

2.4 Information that should be omitted from FEH lab reports and memos

The following is a list of things that should almost never be included in reports and memos. Note that there is some grey area here. If you are unsure, ask your TA. If you really think that something on this list might be important enough to put in your document, it is probably best to include it as an appendix (report) or attachment (memo).

- Information about specific people – Except for your title page or header, you should not talk about any students in your section or group. Likewise, do not mention any members of the teaching team.
- Your experience as a student – If your boss asks you to write a report, chances are she doesn’t want to hear about your professional and personal growth. She wants to hear about the work you’ve been doing. In your FEH reports and memos, do not talk about what you think the lab is trying to teach you (Many students are tempted to do this especially when writing about the purpose or conclusions). Write about the experiment itself.
- Lab requirements or questions from the write-up – Write the lab as if you were on the team that developed the procedure. If specific questions are posed in the lab write-up, do not mention them or answer them directly. Your answers should flow together with the rest of the report or memo.
- Instructions for using basic equipment – Don’t describe how to use an oscilloscope or how to get a reading from a micrometer. In general, if you are talking about a standard piece of equipment (i.e. you could buy it from an equipment catalog), just mention what it was and what you used it for. Do not describe how to use it.
- Background theory – You can assume that you reader already knows the basics. You do not need to define any technical terms that are presented in the write-up or presentation.
3 ORGANIZATION: Where should all this information go?

This section covers how to organize your report or memo. When deciding how to organize any technical document, it is again important to keep your reader in mind. It should be your goal to make sure that the information contained in your document is clear and easy to find. As a professional engineer, you may be writing reports that will be read by many different people with different responsibilities or levels of technical background. Some of these people will only be interested in a specific portion of your document. Good organization is key to making sure they can quickly find all of the information they want without having to read the entire document.

3.1 Required sections for FEH reports and memos

In FEH, the job of breaking your report into sections is done for you. Every report/memo is required to have the sections that are outlined here. The reason for this particular organization is to break your document into logical parts. In doing so, you allow readers who want to read only part of your report to skip directly to the appropriate section. Although the required contents of each section are specific, it is important to keep in mind that none of these sections can truly stand alone. There is an overall flow to the entire document, with each section building on the information in those before it. You must make sure that, in addition to having everything in the right place, your memo or report also links the information presented in each section together. Pay particular attention to this if you are writing a group report and decide to split up the work by section.

Your report or memo should lead your readers from the purpose of the experiment to your conclusions in the following way: The Introduction states the purpose or objective and gives a brief summary of what was done. The Experimental Methodology section tells what materials and equipment were used and how the data were collected. The Results and Description section presents the collected data and explains any manipulation done on it. The Discussion section draws relationships between the data and develops objective support, based on your observations and data, for your conclusions. The Summary and Conclusions section summarizes what was done (again) and gives your conclusions, which should relate to the purpose stated in the Introduction and should be based on the support developed in the Discussion.

More detailed explanations of the required contents for each section are given in 3.1.1-3.1.5.

3.1.1 Introduction

The first section of your report or memo must do three things: give the purpose of the experiment, summarize what was done in the experiment, and describe the contents of your report/memo.

The purpose is usually given in one or two sentences and describes the overall goal or objective of the lab. The conclusions you come to should reflect the purpose
given in the Introduction. Remember that you should not be reporting on your experience as a student, but instead on the experiment that was done. As such, your purpose should reflect the objective of the lab in general and not what you personally learned from it. The purpose may be given in the lab write-up (but please don’t copy word-for-word). If not, sometimes it helps to wait until you have finished the rest of your report to write the purpose.

Your introduction should also include a summary of what was done in the lab. This should not be more than a few sentences. It should describe the basic tasks and analyses that were performed. Someone who is not interested in the details of the experimental procedure should be able to read the summary and get the basic idea of what you did. A summary is also required for lab memo introductions, as it serves to remind the reader of the procedure.

The last paragraph of your introduction should outline the contents of the memo or report. It should include a sentence for each section stating what the reader will find there. This will help readers to find specific information quickly in the case that they are not interested in reading your entire document.

3.1.2 Experimental Methodology (Report format only)

This section should not appear in FEH lab memos.

The goal in writing the Experimental Methodology section is to give your reader enough information that he or she could reproduce your experiment and get similar results. You need to completely describe all steps of the experiment as well as what materials and equipment were used.

It is often helpful to use figures to show the experimental set-up. If you only have a couple relatively small figures (1/2 page or less) you could put them in the body of this section. If there are several, or if you have larger figures, it is usually best to put them in an appendix and reference them in the text.

You should name all of the lab equipment used. Give known specifics of any measuring devices, such as accuracy or scale. It is not necessary to give a detailed description of how to use basic lab equipment (see section 2.4), but any apparatus that is not considered typical (i.e. you couldn’t buy it from an equipment catalog) should be thoroughly described.

Be careful that your Experimental Methodology section only contains a description of the procedure and equipment. Do not include any of the data gathered or analysis of the procedure. This section must be completely objective.

3.1.3.a. Results and Description (Report Format)

This section will present all of your experimental results. This includes data gathered, calculations made on the data, and objective observations made during the lab. You must decide how to present your data. Use the following guidelines to help you organize the information in this section:

- Key numerical data should be given in the text (ex. “The median speed was 28 mph”).
- Think about how to best present your data. In many cases, a table or figure may be appropriate to show larger quantities of data. If you have a lot of numbers in
the text, consider making a table instead. (Be sure that, in the text, you describe and properly reference all figures and tables.)

- Put information in a logical order. For example, say your Experimental Methodology describes several tasks in some order. Organize your Results and Description so that the data obtained from those tasks is presented in the same order.
- Consider what data is most important, and make it easy to find. Try to keep important tables and graphs on the same page where they are described. If possible, don’t make your reader flip to another page or the appendices to find important information. If you can’t keep the figure on the same page, make sure to tell the reader where to find it.
- Do not crowd your report with a lot of unimportant or overly-detailed data. Put this in an appendix instead. (You still need to reference and describe it in this section.)
- Think about how you and your reader will be using the data. If you will be making comparisons between values, be sure that the appropriate data appears together.
- Make tables and figures easy to read. Tables in the report body should only contain essential data. Put the rest in an appendix. Size figures in the report body as small as possible so that the important features are still easy to see. If a figure takes up a whole page, consider putting it in an appendix.
- Balance text and figures/tables on the page. Try not to have a page with no text and only figures or tables. Move things around, or put something in an appendix.
- Label and reference all data consistently and properly. See Section 5 of this guide for more information.

Any manipulation of the data must be described in this section. Show any equations or formulas used, or describe methods of calculation. When giving equations, make sure to define all of the variables. Complex equations or derivations may be given in an appendix or attachment. All sample calculations, if required, should appear in the appendices or attachments.

This section should also be objective. Don’t comment on the data or the methods used to gather it. Do not make comparisons or draw any conclusions. Simply present the data so that it is clear and easy to find. Be careful of the language you use in this section. Especially when recording observations, students will often use vague words and phrases like “very,” “fairly,” or “close to.” Try to quantify these observations.

3.1.3.b. Results and Description (Memo Format)

The organization of the Results and Description section for lab memos is slightly different than for reports. Because a memo is meant to be more concise than a report, only the most important data should appear in this section. Key numerical data should still be given in the text, but generally no figures or tables should appear in the body of the memo. Instead, put these in an attachment and reference them in the text. You may include a small table if there are several important values and you think this will make the section clearer.
Numerical results of data manipulation should also be given in the body of the memo. However, methods of calculation should appear in the attachments and referenced in the text.

Aside from these differences, all other general guidelines mentioned in the previous subsection (3.1.3.a.) apply to the Results and Description for lab memos.

3.1.4 Discussion

In the Discussion section, you should objectively treat the data presented in the Results and develop support for your conclusions. This is usually the most difficult and time-consuming section to write. The amount and type of information in your discussion will vary widely between the labs in this course sequence. It is up to you to determine what is appropriate to discuss based on the nature of the lab experiment. The following bullet points give some tips on what type of material to include in your discussion:

- The lab write-ups will often give you some guidance for this section. Many contain questions about the data or experiment. These should usually be answered in your Discussion. Note that you should never directly answer a question posed in the write-up. The answer should flow with the rest of your discussion.
- Look for theories, concepts, or phenomena presented in the lab write-up or presentation that apply to, or are illustrated by, your observations and data. Make comparisons; discuss similarities and differences.
- Consider what you are presenting in your Results section. Try to draw relationships between your data and observations. Make comparisons between similar types of data. If you observed something that may have affected your data, discuss it. Try to explain any trends that you see in terms of theory or observations. In the case that you used two different methods to measure the same thing, make comparisons.
- Discuss the significance of any manipulation you did on the data. Tell why it was done and what it shows.
- Keep your purpose and conclusions in mind. The purpose or objective in your Introduction should state the point of collecting the data and what you are trying to show with it (your conclusions). Include any interpretation of the data that is necessary to support your conclusions.
- Look for problems with the experiment. The point here is not to discredit your experiment or results, but to disclose any factors that may have limited your findings. Talk about anything that might have significantly affected your results and what the possible effects were. Discuss the possibility of errors resulting from measurement or procedure. Be specific. It is not enough to say something like, “measurement errors could have affected the results.” Tell where the errors came from (equipment, instrument use, etc.), which results were affected, and what the likely effects were.

This section must also be objective. Everything you discuss must be based on some quantifiable observation or measurement. Your intuition, gut feelings, or common knowledge should not come into play. Avoid drawing any conclusions here.
Language and wording can be tricky in the Discussion section. Avoid vague language. Try to quantify any comparisons made (e.g. “The median and mean speeds are within 5 mph of each other” is better than “they are fairly close to one another”). Do not use phrases like “it is clear that…” Be careful about making assertions. If your data or observations cannot absolutely prove some fact, your language should reflect your uncertainty. Use words and phrases such as: could be, might be, may be, likely, possible, etc.

3.1.5 Summary and Conclusions
The final section should summarize the key points of the report and make conclusions.

Your summary should include a brief description of what was done. Note that when skimming technical documents, people will often only read the Introduction and Conclusions. If you decide to be tricky and use the exact same summary in both sections, these people may notice. This could result in your document appearing unprofessional. That being said, your summary in this section will look very similar to the summary you gave in the Introduction. You may also want to summarize any important information from your Results or Discussion, but do not present any new information.

The conclusions you draw should reflect the purpose or objective given in your Introduction. They should be based on the experimental data and the support you developed in your Discussion. Do not draw broad conclusions about the importance of the topic covered in the lab. Do not conclude on whether the lab was effective in teaching you something. Conclude only on your results and their treatment in the discussion.

This section may also include suggestions for further experimentation. If your results did not lead to strong conclusions, suggest how the experiment could be preformed differently. If you mentioned any potential problems in your discussion, address them here. Tell how they could be avoided in future experimentation and how the results might be affected.

3.2 Appendices and Attachments
Appendices (report format) generally contain auxiliary information from the Experimental Methodology, Results and Description, and Discussion sections. The following content may appear in your appendices:

- Figures and tables that are too big, too numerous, or too detailed for the report body.
- Complex equations, formulas, or derivations.
- Sample calculations.
- Lists of raw data.
- Source code for computer programs. (should be well-commented)
- Any other content that may be of interest to some readers, but is not important enough to be part of the report body.

Attachments (memo format) typically contain the same type of information as appendices. The only difference is that for memos, attachments will usually contain all of the figures, tables, and equations for the document (see 3.1.3.b.).
Everything that you put in your attachments or appendices must be referenced in the body of the document.

You must decide how to organize your attachments/appendices. Try to make all of the information easy to find and easy to read. If you have a lot of auxiliary information, or if you have distinct types of information, use multiple attachments or appendices. Group the content logically. Within each attachment/appendix, the contents are typically placed in the same order in which they are referenced in the body of the document.

See Section 4 of this document for formatting guidelines for appendices and attachments.

3.3 Paragraphs and Sub-sections

General guidelines for the contents of the required sections are described in 3.1. However, the job of organizing the information within these sections is up to you. One of the things you can do to make your document more readable is to break it into smaller chunks. Use paragraphs appropriately to break up your ideas. Paragraphs should never be longer than one page, double-spaced.

For the sake of clarity or organization, you may decide to further break the required sections into sub-sections. If so, use a numbering scheme similar to the one used in this document, and give each one a descriptive title. Do not indent sub-sections any more than the rest of the document. There should be some text (like a brief introduction) in the main section before the first sub-section, and there should never be just one sub-section (otherwise you didn’t need to break up the main section to begin with).
4 LANGUAGE: Good practices for technical writing

Lab reports and memos should be written using formal language. Proofread your work for spelling, punctuation, and grammatical errors. Attention must also be paid to clarity, level of detail, and technical level.

4.1 Grammar, punctuation, spelling

The preferred writing style is third-person past tense in the passive voice. For example: “The water temperature was measured using a digital thermometer.” It is important that you are consistent with tense/person. Always proofread your documents. Do not trust your grammar/spellchecker to catch all mistakes.

A note on capitalization: Only capitalize where appropriate. There is no need to capitalize or otherwise set apart (bold, italics, underlining) key words in your document. (A common error: “...the Frequency was 100 Hz.” Here, “frequency” should not be capitalized.)

4.2 Clarity

The overriding goal of technical documentation is clarity. You want your reader to understand precisely the information you are trying to convey. When you proofread, look for portions that may be ambiguous or unclear. Avoid awkward language. Try to have someone else read your report, preferably someone who did not do the experiment. If this is not possible, proofread your own document from the point-of-view of your reader. If you have to go back to re-read a sentence or section, this is an indication of awkward language. Try rewording to make that portion clearer.

4.3 Level of detail

Good technical writing strikes a balance between being thorough and being concise. One of your goals should be for your reader to get all of the important information in the shortest amount of time possible. To do this, you must be aware of what your reader already knows and what he or she wants to know.

Assume that your reader is familiar with the basics of the topics covered in the lab. That is, assume that he or she has the background information presented in the lab write-up and the lecture slides. Do not assume that he or she knows anything about the results. If you are writing a lab memo, you may assume that the reader is familiar with the experimental procedure. This is not the case for lab reports.

The body of your report should contain all of the most important data and descriptions from your experiment. Deciding what is most important is not an easy task. Keep in mind the purpose or objective of the lab. Anything directly related to this should probably be in the report body. Also think about what you are trying to convey to the reader – what you want your reader to take away from your report. Any information that is key to understanding this should also appear in the body of your report.

If there is additional information that your reader may or may not need (or be interested in), it should be included in an appendix or attachment. This information should still be mentioned in the report body along with a reference to tell the reader where to find it. Generally, if you are unsure about whether or not to include something,
it is safe to put it in an appendix or attachment provided it is not important enough to appear in the report body.

You do not need to define the technical terms that are presented in the write-up and lab lecture. It is important, though, that you understand these technical terms and use them appropriately (see the following section).

You may assume that your reader knows how to use basic laboratory equipment. Don’t include a description of how to read the value from a micrometer or how to use an oscilloscope. However, if you use some apparatus or set-up that was built by you or someone else (like the lab supervisors), you should thoroughly describe it in your report. Usually you should also include and reference a figure depicting the set-up.

Any equations that you use should be given in the report. Be sure to define each variable in the equation. (See Section 5 for more information.) You need not show the derivation of equations unless the derivation is a specific requirement of the lab. Generally, when derivations are necessary, they are given in an appendix or attachment and referenced in the report body. Sample calculations should likewise appear in the appendices or attachments.

4.4 Formal and technical level

Your lab reports and memos should be written in a formal style. Avoid colloquial (street) language and contractions. (The language in this document wouldn’t be considered formal.) The technical level of your writing should make it clear that you know and understand the basic terminology used presented in the lab. It is a good idea to look for terms that are defined in the lab write-up and lecture and to use them correctly and appropriately in your report.

Your report or memo should be about the experiment and not about your experience in the lab. Do not mention specific group members. Do not mention the requirements of the lab. Don’t talk about what you learned as a student. Write as if you are reporting on an experiment done in a professional setting.
5 FORMAT: FEH-Specific formatting guidelines

All reports and memos should be typed with a 10-12 point font. For grading and commenting purposes, reports and memos should be double-spaced (although this is not typical for professional reports). Include the main sections described in Section 3 of this document, and use the section headings given. If you need to use sub-sections, give each one a descriptive title.

Tables and figures should be done using a computer whenever possible. If you must include something done by hand, it should usually go in an appendix or attachment. It is preferred that you create equations using Microsoft Equation Editor or something similar.

Sections 5.1 and 5.2 give the general formatting requirements for reports and memos. Sections 5.3-5.6 describe the proper way to present, label and reference auxiliary content (figures, tables, equations, and others).

5.1 Report-specific formatting

Reports must have a title page that gives the following information:

- Title of the lab
- Name of course
- Quarter and year
- Name and seat numbers of all members of lab group (if the report is individual, put your name in bold text)
- Course instructor
- Course section
- Lab section
- Date of experiment
- Date of submission

The title page is considered the first page, but is not numbered. All other pages of the report should be numbered (starting from the second page) at the bottom. If a page is printed horizontally (landscape), it should be viewed with the staple or binding at the top.

Each appendix should have a separate title page containing a descriptive title (for example: “Appendix C: MATLAB Code”). Appendices are lettered (Appendix A, Appendix B, etc.), and pages within each appendix are enumerated using the appendix letter and a number (A1, A2, A3, B1, B2, etc.). Although not specifically required, you may list the contents of the appendix and their corresponding page numbers on the title page.
5.2 Memo-specific formatting

Memos should begin with a memo header using the following format:

Memorandum

To: Professor A Einstein

From: Kat Knapper (Seat 11), Day Dreamer (Seat 17), Bull Dozer (Seat 22),

Ivana Sleepalot (Seat 34)

Date: 09/15/2003

Re: Short and Long Term Effects of Skipping Class

If turning in an individual memo, include names for all group members, but put your name in bold lettering.

Memos should be numbered at the bottom starting from the first page using the convention “n of N,” where n is the number of the current page and N is the total number of pages in the body of the memo.

If there are any attachments, they should be listed in the body of the memo immediately after the last section. There should be a line for each, with the word “Attachment”, a description of what is in it, and the number of pages it contains. For example:

Attachment. Torque-Speed Curves for Acroname and Twin-Tank Motors, 2.
Attachment. Pictorial of Experimental Set-up, 1.

Pages in attachments should be enumerated using the “m of M” convention. Here, m is the number of the current page (with each attachment starting over at 1), and M is the number of pages in that particular attachment. A descriptive title should appear at the top of the first page of the attachment.

5.3 Figures

For our purpose, the word “figure” refers to any graph, chart, diagram, schematic, or pictorial representation. No matter which sub-category a figure falls under, it should be labeled and referenced as a “figure” and not anything else. Whenever possible, figures appearing in your report or memo should be produced electronically. If you must include a hand-drawn figure, it should appear in an appendix or attachment, and not in the report/memo body.

Figures should be centered on the page and labeled immediately below the figure with the word “Figure”, a number, and an appropriate descriptive caption. The label font should be slightly smaller than the rest of your text to make it distinguishable. Text will typically appear above and below the figure; text does not flow around a figure. Size figures as small as possible so that the important details are still easy to see. If a figure requires a full page, consider instead placing it in an appendix [1].

All charts and graphs should have appropriate labels with units on the axes. Charts and graphs may also have an appropriate title at the top as well as the descriptive caption below. Diagrams, schematics, and pictorials should contain labels where appropriate. If you include any figure that you did not produce yourself, you must give the source either in the caption, in your text, or in a footnote.
Figure 1, below, shows an example of proper labeling and orientation of a figure. Note that although this is a chart generated by Microsoft Excel™, it is still labeled as a “figure.” It is relatively small but easy to read, has proper labeling of axes (with units), contains an appropriate title above the chart, and is labeled with a descriptive caption that includes a reference to the source of the figure.

![Figure 1: Graph of Output Amplitude (dB) vs. Frequency (Hz), taken from “Beams’s Crash Course in Tables, Figures, and Appendices”, FEH Labs website: http://feh.eng.ohio-state.edu/Labs/figures,%20tables,%20appendices.doc](image)

Figures should be numbered, starting from one, in the order that they appear in your document. Tables and figures are numbered separately. You may have Figure 1, 2, 3, 4, etc. and Table 1, 2, 3 etc. appear within your text concurrently [1]. For lab reports, figures appearing in the appendices should include the appendix letter and figure number, and numbering should begin at one for each appendix (ex. Report body contains Figures 1, 2, and 3; Appendix A contains Figures A1 and A2; Appendix B contains Figures B1, B2, and B3). For lab memos, just use a number, and do not start re-numbering in each attachment (ex. Memo body contains Figure 1; first attachment contains Figures 2 and 3; second attachment contains Figures 4, 5, and 6.)

All figures (even ones in attachments or appendices) must be referenced at least once somewhere in the body of your report or memo. They should be referenced in the same order in which they appear. The first reference must include the figure number and a brief description. For example, “Figure 1 shows an example of proper labeling and orientation of a figure.” Or, “An example of the proper labeling and orientation of a figure is given in Figure 1.” Subsequent references should also give the number and location of the figure. An example of something that might appear in a Discussion section is, “As can be seen in Figures 2 and 3 in the Results and Description, the speed distribution on both roadways is approximately normal.” Here, Figures 1 and 2 would have already been referenced and described in the Results and Description section. Note that the word “figure” is always capitalized when referring to a specific figure.

Figures in the document body should appear close to the text that first references them, preferably on the same page. If this is not possible, it is a good idea to tell the reader where to find the figure. Some examples:

- Next page: “Figure 3, on the following page, shows…”
- In an appendix (report format): “…are shown in Appendix A, Figures A2 and A3.”
• In an attachment (memo format): “Figure 3, attached, gives a…”

5.4 Tables

The guidelines for labeling and referencing tables are identical to those given in the previous sub-section except for two differences: the word “Table” is used in place of “Figure” (duh), and the label (Table #: caption) goes immediately above the table. Just as with figures, tables must:

- be centered on the page
- NOT have text in-line with them
- be numbered in the order in which they appear
- be numbered independently of figures
- be numbered in the same manner as given in the above sub-section (reports: appendix table numbering includes appendix letter and starts over with each appendix; memos: do not start over for each attachment)
- be referenced at least once in the body of the document
- be described in the first reference

Tables should be created using a spreadsheet or word processing program. Use cell borders to make your tables easier to read. Keep the entire table, with label, on one page; don’t split tables over two pages. If your table appears in the body of your report or memo, try to keep it on the same page as the text that first references it. Otherwise, make sure to tell your reader where to find it (see examples in previous sub-section).

Give columns and rows descriptive labels. Generally, you will need to describe the data presented in a table when you first reference it. If it contains any calculated values, you need to give the method of calculation. An example of a table and the text that references and describes it is given below:

… and blah, blah, blah, end of preceding paragraph.

<table>
<thead>
<tr>
<th>Table 3: Recorded Frequency and Peak Amplitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq (Hz)</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>500</td>
</tr>
<tr>
<td>1000</td>
</tr>
<tr>
<td>1200</td>
</tr>
<tr>
<td>1400</td>
</tr>
<tr>
<td>1600</td>
</tr>
<tr>
<td>2000</td>
</tr>
</tbody>
</table>

The results of the testing are given in Table 3. The sixteen test frequencies (in Hz) and the measured voltage amplitude responses are shown, as well as the amplitude responses in dB, calculated using the following formula:

\[ Amp_{db} = 20 \log_{10}(Amp_v) \]  

(1)

Be sure to consider carefully whether your table should go in the body of the document or in an appendix or attachment. See Section 3 for more help with this.
5.5 Equations

Equations should be done using Microsoft Equation Editor or a similar package. They should be numbered in the order in which they appear. Center equations on the page with the number (in parentheses) in the right margin. Make sure that all variables used are clearly defined.

The following is an example of an equation and its description from the Results and Description section of a report:

The average speed of the runners, $v_{avg}$, was calculated using the following equation:

$$ v_{avg} = \frac{d}{t_{avg}} \quad (2) $$

Here, $d$ is the length of the course, in kilometers, and $t_{avg}$ is given by

$$ t_{avg} = \frac{1}{n} \sum_{i=1}^{n} t_i \quad , \quad (3) $$

where $n$ is the number of runners and $t_i$ is the finish time of the $i$-th runner, in hours, given in Table B1. This resulted in a calculated average speed of 3.5 km/hour.

(Note: In the above example, the second equation is probably not necessary. You could assume that your reader would understand if you simply wrote “…and $t_{avg}$ is the average finish time for all runners.” However, it is included here for the sake of showing an example of using an equation to define a variable in another equation.)

Equations can be referenced with the word “Equation” and a number (ex. “…by completing the square and rearranging terms in Equation 4…”) or by simply using the number in parentheses (ex. “…substituting (3) into (2) yields…”).

You may decide that there are too many equations to put into the body of your document. In this case, a good idea is to include an attachment or appendix titled something like “Formulas and Equations Used” that contains a list of the equations (numbered) with variable definitions. Then you can just reference the appendix in the body of your report or memo.

5.6 Sample Calculations

Sample calculations should be included if specifically required by the lab write-up. They should always appear in an appendix or attachment and be referenced in the body of the document. For neatness and clarity, it is best to use an application such as Microsoft Equation Editor to present sample calculations. However, if you choose to do it by hand, be sure that your writing is very clear and neat.

Sample calculations should be labeled above with a title. Use something like: “Sample Calculation of Standard Deviation.” If it spans more than one page, label each subsequent page at the top with the same title and “, continued” (ex. “Sample Calculation of Average Speed, continued”).

When presenting sample calculations, show all of your work in steps. Start with an equation with variables only, and define each of the variables if you have not done so elsewhere in your document. Subsequent steps should show any manipulation of the
equation in terms of the variables only. Do not substitute in values until the final step. Don’t forget to include units.

Usually, a sample calculation will be referenced in the document body after the value it applies to is given. For example, “The calculated average speed was 25.6 mph (see Appendix A for sample calculation).”

5.7 Other Content
Auxiliary content other than figures, tables, equations, and sample calculations should usually be placed in an appendix or attachment and referenced in the text. Make sure that the content is neat and clear, and give it some sort of label or title.

An example of this might be source code for a computer program. This would be included as a separate attachment or appendix and labeled something like “MATLAB Code for Neural Network Simulation.” It should be well-commented. It is also a good idea to include a brief one- or two-paragraph introduction that gives a description of what the program does.

5.8 Referencing Content from an Outside Source
Anything that you quote, paraphrase, or copy from an outside source must be referenced clearly in your document. This could be text, data, figures, or anything else that you or your lab group did not create yourselves. The source must be given in the text, caption (for a figure or table), or a footnote. For content from websites, give the name of the site or online document and the full URL address (http://...). For other sources, give the same type of info you would give in a bibliography. If, for some reason, you are using data collected by another lab group, give the names of the group members, their instructor, and the section time.

Failure to properly reference content taken from an outside source carries serious consequences. It is considered academic misconduct, and the guidelines set forth by The Ohio State University’s Office of Academic Affairs will be followed (see http://oaa.osu.edu/coam/home.html for details).
6 ASSESSMENT AND FEEDBACK: How are reports/memos graded, and how can you improve your grade?

Lab reports and memos are graded using a rubric. These are posted online, and you are expected to read them and attach a copy to your report or memo. The rubrics are designed to show you what is expected of your work and reflect the more detailed guidelines presented in this document.

The rubrics are divided into two main sections: content and form. The content section covers the information that you include in your document. This section will change for each lab to reflect the specific requirements. In order to help you through the process of developing your technical writing skills, the first few rubrics will give the requirements for specific content that will be graded. Typically, these lab-specific requirements will appear in the Experimental Methodology, Results, and Discussion sections. In later rubrics, the lab-specific requirements will not be given. You will be expected to determine what content is appropriate to include based on the lab presentation and write-up, the lab procedure, and your collected data. In these later labs, the rubric will show only the total number of points assigned to the lab-specific requirements for each section.

The form section covers organization, language, and formatting. The categories in this section will remain the same throughout the course, but the point distributions may change.

For each item on the rubric, there are three or four levels of correctness or quality. Each contains a description and a point value for that level of work. These are designed to give you an idea of where your work falls in relation to what is expected and what you need to do to improve it.

Most of the feedback you will get on your lab reports and memos will come from the rubrics. The level that your work is assessed at for each of the items will give you some information on what you need to work on in future reports or memos. The grader may highlight some key words in the descriptions that pertain to your work. Also look for written comments on the rubric and on your actual report or memo.

Many students are frustrated by their grades on memos and reports, especially during the first part of autumn quarter. The first few reports take most students a very long time to write, and the level of quality expected is quite high compared to what most freshmen are used to. If you are not satisfied with your grade, the following is a list of hints that will help to improve the quality of your reports and memos:

- Prepare before the lab – Read through the lab write-up and look at the presentation slides before you come to lab. Make sure that you either understand the concepts or know what you need to learn or ask questions about. Know what will be expected in the report or memo and what data/observations you need to record. Try to anticipate what kind of information you will include in your Results and Description and in your Discussion section.
- Get started early – Don’t wait until the night before the report is due to start writing it. By this time, you’ve had almost seven days to forget about what you did.
• Get familiar with this document – Yes, it is long. But it contains everything you need to know to write good reports and memos (and get a good grade).

• Read the rubric – This is what your TA will use to grade your work, so make sure you know what is expected. When you finish your report or memo, go over the rubric again to make sure you didn’t miss anything.

• Re-read the lab write-up and lecture slides – Before writing your report, look through the write-up. Make sure you understand the concepts and the requirements. Look for concepts that are illustrated by your results, and write about this in your discussion. Look for questions that are implied or given explicitly. When you are finished, check the write-up again to make sure that you included everything that was required and appropriate.

• Refer to feedback from previous reports and memos – Look at your returned work. Check the rubric to see what areas you need to improve. Look over comments on the rubric and on your returned document. Don’t make the same mistakes twice.

• Ask for help – Talk to your TA. It is best to do this outside of class in office hours or a scheduled appointment, when your TA will have time to sit down with you. The TA’s are happy to answer specific questions about current or graded reports and give suggestions for improvement. Time permitting, your TA might also be able to quickly read over a draft and make suggestions.
7 CHECKLIST: A quick summary of important guidelines

This section is provided to give a brief summary of the guidelines presented in this document. It does not contain everything you need to know to write a good report or memo. It will, however, be useful as a quick reference when writing or proofreading your document. References to sections with more detailed descriptions of these guidelines are given in parentheses.

✓ Includes all required content in the correct sections (2, 3)
  o Introduction – gives purpose of experiment, summarizes what was done, describes report contents and sections (3.1.1)
  o Experimental Methodology – describes the materials and equipment, gives the procedure, tells what was done and how, is objective (3.1.2)
  o Results and Description – presents all data collected and observations made, describes and manipulation of the data and gives results, is objective (3.1.3.a., 3.1.3.b)
  o Discussion – analyzes the information in Results, draws relationships between data and observations and theory, develops support for conclusions, is objective (3.1.4)
  o Summary and Conclusions – summarizes what was done, draws conclusions reflecting purpose and based on support developed in Discussion (3.1.5)
  o Appendices/Attachments – contain additional information that is referenced in the body of the document (3.2)

✓ Write-up guidelines followed
  o Questions answered (answers flow within the text) (2.4, 3.1.4, 6)
  o Lab-specific required content included (explicitly stated in write-up or rubric OR appropriate based on experiment, procedure, data) (6)

✓ Data well-organized (3.1.3.a., 3.1.3.b)
  o Important numerical data in the text
  o Important info in the report/memo body
  o Extra or overly-detailed info in appendices/attachments
  o Data easy to find/read
  o Organization reflects how reader will use data
  o Text/figures/tables balanced on page (no pages with only figures and/or tables)
  o Data labeled and referenced correctly (5.3-5.7)
  o All data referenced in the text

✓ Document proofread for spelling, punctuation, grammar (4.1)
✓ Third person, past tense, passive voice used throughout (4.1)
✓ Language appropriate (4)
  o Formal language used (no contractions, colloquial language) (4.4)
  o Technical terms used appropriately and correctly (4.4)
  o Language is clear (not awkward) (4.2)
  o Language is complete (vague words and phrases avoided) (4.3)
  o Language is concise (not too wordy) (4.3)
✓ Formatting correct (report body) (5.1)
  o Title page included with all required info
  o All pages except title page numbered at bottom (title page not numbered, Intro. starts on page 2)
  o Required section heading names used
  o Section headings appear with text (not alone at bottom of a page)
  o Double-spaced
✓ Formatting correct (report appendices) (5.1)
  o Title page for each appendix
  o Appendices lettered (A, B, C, etc.) and have descriptive titles
  o Appendix pages numbered (A1, A2, …, B1, B2, …)
  o Figures/tables numbered correctly (5.3, 5.4)
  o Appendices’ content neat and well-organized
✓ Formatting correct (memo body) (5.2)
  o Memo header included with all required info
  o All pages numbered (if $N$ is # of pages in memo body: 1 of $N$, 2 of $N$, …, $N$ of $N$)
  o Required section names used
  o Double-spaced
✓ Formatting correct (memo attachments) (5.2)
  o Attachments listed after Conclusions section
  o Title of attachment at top of first page
  o Attachment pages numbered (if $M$ is # of pages in an attachment: 1 of $M$, 2 of $M$, …, $M$ of $M$)
  o Figures/Tables numbered correctly (5.3, 5.4)
  o Attachments’ content neat and well-organized
✓ Figures correct (5.3)
  o Centered on page
  o NO text in-line
  o Contain appropriate labels with units
  o Have caption below with Figure #: Description
  o Numbered in order in which they appear (independent of tables and equations)
  o Referenced at least once in the text
  o Described in text in first reference
  o Located near reference in text, or reference gives location
✓ Tables correct (5.4)
  o Centered on page
  o NO text in-line
  o Columns/rows appropriately labeled with units
  o Have caption above with Table #: Description
  o Numbered in order in which they appear (independent of figures and equations)
  o Referenced at least once in the text
  o Described in text in first reference
  o Located near reference in text, or reference gives location
o DO NOT span multiple pages
✓ Equations correct (5.5)
  o Centered on page
  o Numbered in parentheses in right margin
  o Created using Microsoft™ Equation Editor or similar application if in document body
  o All variables clearly defined
✓ Sample Calculations correct (5.6)
  o Appear in appendix or attachment
  o Contain a descriptive title at top of first page
  o “Your Title Here, continued” at top of subsequent pages
  o Neat and clear
  o Equation variables defined
  o Show all steps from equation/formula to numerical result
  o Numbers not substituted for variables until last step
✓ Other auxiliary content appropriately labeled, located, referenced, and described (5.7)
✓ Content from outside sources properly referenced (5.8)
8 ADDITIONAL RESOURCES: Where can you get more information or help?

Your TA is happy to answer any specific questions about reports, memos, or the labs. He or she can also give you more in-depth suggestions or feedback. The best way to get help from a TA is to go to posted office hours or schedule an appointment outside of class.

*A Guide to Writing as an Engineer*, by David Beer and David McMurrey (2005, John Wiley & Sons) is another great resource about technical writing. Be aware, however, that there may be some differences between the formatting presented in the book and that which is required for FEH reports and memos.

If you would like more personal in-depth help with technical writing, contact OSU’s Technical Communications Resource Center in Hitchcock Hall, room 203, or the Center for the Study and Teaching of Writing at the Younkin Success Center (call 688-4291).