Lab Report Guidelines

Authors: Alexandre Courtemanche and Ashraf Suyyagh

This document explains how to write a proper lab report. These guidelines were set so that it most closely follows the guidelines that are set by academia. Please follow these guidelines in writing your report. This guideline is divided into two parts, the first addresses the way of how you should format your report (i.e. writing and report style). The second part is how to present your idea (i.e. what to talk about and how to present your experiment).

Part I: Report Formatting Guidelines

Writing a lab report is like writing the story of the experiment you performed. A lab report will have a reader, and you are trying to get that reader understand what your experiment was about and how it turned out. Any text written in the report should be pertinent to the point you are trying to get across. This means that there should not be words or phrases that are in that report that do not help in getting the reader understand what is going on.

Writing Style

It is perfectly fine to refer to the first person while writing the lab report, such as "we tried this" or "I changed that", but you have to be consistent with this during the whole lab report. If you decide to make it impersonal ("It was decided that this approach was better"), you should be consistent throughout your lab report.

When you are writing your report, avoid being too personal. That is, never write "We felt happy/frustrated/sad that this worked/did not work" or "A (good/helpful/nice) TA told us to". As said above, a report should be telling the story of your experiment, but this story should be presented in a technical manner and should convey useful information to the reader. Avoid writing something like:

> *"We had this problem, we did not know what to do, but after searching we found out an equation in the technical manual, but it was not so good. A friend of us advised to use another one which works fine".*

Instead, you can present your story in a professional non-personal manner as:

> *"We were required to (do something), our first approach was to use Equation 1 from [2]; however it did not give the desired result(s) (try to justify). Instead, we used the equation from [4] and it gave better results. We believe this is because of …"*

Try to avoid one or two sentence paragraphs like this one.

Take time to organize the flow of your report. Don't start talking about things assuming the user knows what you mean by them. If you feel it is necessary to mention those things and you already have a section/subsection detailing them, refer the reader to that section. Use Acronyms/ Abbreviations after at least mentioning once what they stand for earlier in the text.

Report Formatting

When you are writing your report, always try to present in it in the most professional way. Not only are the technical details important, but also how good your document looks like. It will sure impress the reader and convey the idea of how attentive to details you are. It will also tell that if you care about how you present your data, you are also meticulous in carrying out your experiment. In general, keep the following in mind:

- Always use text justification. It makes your report look nicer.
- Use professional fonts (i.e. Times New Roman, Arial, and Serif). Avoid using comical fonts or those sophisticated to read (i.e. Handwriting fonts, Old English, Calligraphic). By default use regular font. Font size between 10 and 12 is adequate depending on the font style.
- Do not forget page numbering.
- Do not put each subsection on a separate page (i.e. do not write the abstract or any other section on a page of their own). Your report should be continuous. The only exception is the Appendix. It should start on its own separate page.
- The text and figure captions should all have the same colour. However, it is permitted in the lab report to have a different colour for section headers.
- Your submitted document should always be in PDF format.
- Always read proof your report. It should be syntactically and grammatically correct and free of spelling mistakes. Each one in the group should read the report at least twice before submitting it. It all shows the effort you have made in writing an excellent report.

Figures, Tables and Equations

When you are using figures, tables and equations, follow these guidelines:

- Tables and Figures must be indexed at all times as well as contain an appropriate description/caption (e.g. "Figure 1 - Plot of the position of the system under conditions Y").
- When you write down the caption, they *go below the figure (centered) but top of the table (left justified)*. Generally, the captions have smaller text size than the rest of the document and are bolded. If you have footnotes to clarify table entries, they go last inside or below the table.
- A figure or table must not be included in the report unless there is a specific reference to it. For example, if you want to show how the algorithm of your program looks like in a flowchart, then you must reference it specifically in the text (e.g. "My program does X, Y and Z, which is shown in the flowchart in Figure 4"). Further, they should be placed as close as possible to the text you are referring to them from.
- Tables and Figures should be numbered independently. Should you include a Table of Figures/Tables, both should be separate from each other.
- Figures and Tables should be able to standalone and be interpretable, that is the reader could understand it without referring to the text. To help with that, include legends to

convey information as much as possible but at the same time, keep your figures/tables/legends/captions simple.

- Any figure or table which is large should be placed in an appendix and referenced to there in the text.
- When using equations in text, each should be in a single line. Do not stack equations next to each other.
- Each equation should have a number. You have to refer to each equation by its number inside the text.
- Use mathematical notation in presenting your equation. Microsoft Word tools (ver. 2007 and up) have a nice way to write down equations.
- When you are including equations, all terms appearing in the equation should be clear to the reader. The reader should not guess what each variable and its unit is. Take time to list/explain them properly. For example, Equation (1) describes the relationship between the resonance frequency of a circuit and the values of the reactive components:

$$\omega_0 = \frac{1}{\sqrt{LC}} \tag{1}$$

Where ω_0 is the resonance frequency of a circuit in sec^{-1}, L is the inductance of a circuit measured in Henry, and C is the capacitance in Faraday.

References

Make sure that if you make any assertions about facts, figures or equations, you must be able to either **back them up by experimentation or by a solid reference**. Wikipedia is **not** a solid reference. A textbook, journal or conference paper and technical reference manuals; however are good references. A TA is not a reference, saying you did something because the TA/professor told you it works is wrong. You should be able to find out why, find a proper reference and use it.

When you cite a source in your text, simply use this notation ([1], [2]) or (Clark and Yu, 2012) or similar. Try to keep your reference numbers in ascending order. (Don't start with reference [9 then [5] then [7]]). References should have their own section and they go at the end of your report. Do not put your references in page footnotes. The author(s), Article/paper name, publisher, pages, year, reference document and similar should be included. The reader should easily pinpoint and find the paragraph you referred to should he wish to go back to it. There are many referencing styles, such as IEEE's, Harvard, Chicago and APA. Use any of them but remain consistent throughout your report. MS Word has a reference tab, familiarize yourself with using it.

Visual Algorithm Descriptions

For algorithm descriptions, flow charts are generally a good way to get the reader to understand the form of the algorithm. However, if a system is too big, a state diagram might be better. Keep in mind that while drawing flowcharts, steps take different shapes depending on the operation; input, output, processing or conditional have different geometric shapes to represent them. They are not all rectangles, read on how to properly document your design flow process using flowcharts. Do not draw your flowcharts in Paint or MS Word or similar programs. Use professional specialized programs like MS Visio.

Your flowchart descriptions should be in clear simple English language. For example, avoid writing a conditional such as (register&0x2A ! = 0). Instead, write something like (Is Data Ready?) or (Did ADC conversion end?).

Part II: Lab Report Contents

Your report should include the following sections, each will be detailed below:

- Abstract
- Problem Statement
- Theory and Hypothesis
- Implementation
- Observations
- Conclusion
- Appendix

Abstract

Unless the report you are writing is excessively long (such as a thesis), the type of abstract that should be used is *informative abstract*, which means that it should give the reader a general idea of the experiment that was done in the report. The purpose of an abstract is to allow the reader to judge whether it would serve his or her purposes to read the entire report. A good abstract is a **concise summary** of the purpose of the report, the data presented, and the author' s major conclusions. There should not be specific figures in this section unless absolutely necessary. This section is expected to be **one** paragraph. It is the shortest section in your report.

Avoid starting your abstract by saying something like "In this experiment we have used interrupts, timers and sensors to show something". Instead, start by stating the goal of this experiment, and if necessary you might introduce the general means by which you carried your experiment (don't get too technical though).

Problem Statement

This section should give in detail the specifics of the problem you are trying to solve with your experiment. A lot of this would be given from the lab handout, but you can give details as to what you define as success if necessary. Do not discuss any implementation details or your design process here. Be very careful about copy-pasting stuff from the handout, it is preferable if you refer to it instead. If absolutely must refer to a table in the handout, instead of copy-pasting the table in this section, you should place it in the appendix at the end. You may also give more details about what you think are additional challenges.

A common mistake is that when you say that the biggest challenge you faced is you are not familiar with the processor, IDE, programming language, peripherals … etc. This does not reflect back good on you since these are basic things you are required to learn (and they have a fast learning curve in general). They are not considered challenges at all. A challenge should be a technical one, that is, something related to timing issues, or preserving data consistency or having better performance with lower power consumption…etc.

Theory and Hypothesis

In this section, you should detail everything related to the science and theory behind the experiment you will be performing. This is where you should state the relevant equations, diagrams, **references to any external sources which relate to the science of the experiment.** For example, if you are designing a firmware that implements a digital band-pass filter on an incoming signal, you should explain the theory of why the filter you want to experiment on would be good at filtering a signal for a designated bandwidth.

If applicable, you would want to provide a short summary of what you think is going to happen during your experiment. How confident are you that your experiment will be successful? Is this a long-shot? Is the theory behind the solution sound?

Implementation

In this section, you will explain in the report how you managed to solve what was presented in the problem statement in the earlier section. This is where you put most of the details of the solution. It is useful to show any modeling you did for the design (such as UML, state diagrams, etc). They should be placed in the appendix if you feel they are too big for a single page. You should use your judgment.

You should also fully document the design process and how you got to your final solution. Were there other alternatives? Did you try any of them? If so, how did it turn out? Were the system parameters entirely based on theoretical calculations or was there tuning involved? Was there any trial and error? You should place any information in here that you would judge to be related to the design process.

In particular, system/peripheral configuration should go here. You should clearly state what configuration settings you have used and justify why you chose them in the first place. What you did is a scientific experiment, and the results and observations should be reproducible. For that, the reader should be able to reconstruct / build your system knowing all the configuration settings you did. Moreover, operating system frequency, sampling rates, software delay frequency / timer or interrupt frequency should be clearly stated with meaningful units. For example, saying that we had a delay of “0x3FFF” makes no sense. Avoid including code screenshots (especially for the configuration part).

Testing and Observations

This is the place where you describe how you tested and validated your system. What were the metrics used? Why were these chosen? You can place some test results for some of your previous designs that did not generate the desired results but the emphasis should be placed on the final solution’s results.

This is a good place to put your program benchmarks and/or behavior as well as the results of all your testing. **You should describe how you performed your observations** and how you obtained the values you wanted. If you are benchmarking, you should choose the metrics that are related to what was asked in the lab handout. For example, if the lab handout talks about obtaining a minimum runtime for a certain task, then it would be definitely be appropriate to give the amount it took for your system to execute a said task. Small benchmarking tables can be placed inline, whereas big tables should be placed in an appendix.

This would be a good place to show statistics such as the variance of the data, the failure rate, etc. For example, if the object of your experiment is to design an embedded system that can correctly detect an external event, you should have many trials of said event and see if the system can detect every time and with how much accuracy. You would provide metrics such as the distribution of the results.

This is also the section where you discuss your experiment's results. You should mention if this were the results you were expecting or not. If not, how far were they off the mark? For which metrics in particular were you expecting better results? Could you attribute certain characteristics of the results to external factors? Could you attribute certain characteristics of the results to the way the system was designed?

Conclusion

This section should be a brief summary of your experiment. Your conclusion should be very similar to the abstract, except with more emphasis on the design and results of your experiment. You should still restate the problem statement to remind the reader what it is you were trying to say. It should also be a little shorter. It should not be more than one paragraph. You should discuss the implications and significance of your experiment. Does it break new frontiers? Was it a complete waste of time?

Avoid starting your conclusion section by saying "The experiment was success" or "The hypothesis was true" or similar. Moreover, saying that you have leant new techniques, to use a peripheral / processor or a certain programming language is certainly of no interest to the reader and is surely not to be included in this section.

Document History
Ver. 1.0, 1.1 Alexandre Courtemanche
Ver. 1.2, 1.3, 1.4 and 2.0 Ashraf Suyyagh