

## *Writing the Lab Report*

### **Overview**

This document describes a general format for lab reports that you can adapt as needed. Lab reports are the most frequent kind of document written in engineering and can count for as much as 25% of a course yet little time or attention is devoted to how to write them well. Worse yet, each professor wants something a little different. Regardless of variations, however, the goal of lab reports remains the same: document your findings and communicate their significance. With that in mind, we can describe the report's format and basic components. Knowing the pieces and purpose, you can adapt to the particular needs of a course or professor.

A good lab report does more than present data; it demonstrates the writer's comprehension of the concepts behind the data. Merely recording the expected and observed results is not sufficient; you should also identify how and why differences occurred, explain how they affected your experiment, and show your understanding of the principles the experiment was designed to examine. Bear in mind that a format, however helpful, cannot replace clear thinking and organized writing. You still need to organize your ideas carefully and express them coherently.

### **Typical Components**

- Title Page
- Abstract
- Introduction
- Methods and Materials (or Equipment)
- Experimental Procedure
- Results
- Discussion
- Conclusion
- References
- Appendices
- Further Reading

**1. The Title Page** needs to contain the name of the experiment, the names of lab partners, and the date. Titles should be straightforward, informative, and less than ten words (i.e. Not "Lab #4" but "Lab #4: Sample Analysis using the Debye-Sherrer Method").

**2. The Abstract** summarizes four essential aspects of the report: the purpose of the experiment (sometimes expressed as the purpose of the report), key findings, significance and major conclusions. The abstract often also includes a brief reference to theory or methodology. The information should clearly enable readers to decide whether they need to read your whole report. The abstract should be one paragraph of 100-200 words (the sample below is 191 words).

### **Quick Abstract Reference**

#### **Must have:**

1. Purpose
2. Key result(s)
3. Most significant point of discussion
4. Major conclusion

#### **May Include:**

1. Brief method
2. Brief theory

### **Sample Abstract**

*This experiment examined the effect of line orientation and arrowhead angle on a subject's ability to perceive line length, thereby testing the Müller-Lyer illusion. The Müller-Lyer illusion is the classic visual illustration of the effect of the surrounding on the perceived length of a line. The test was to determine the point of subjective equality by having subjects adjust line segments to equal the length of a standard line. Twenty-three subjects were tested in a repeated measures design with four different arrowhead angles and four line orientations. Each condition was tested in six randomized trials. The lines to be adjusted were tipped with outward pointing arrows of*

varying degrees of pointedness, whereas the standard lines had inward pointing arrows of the same degree. Results showed that line lengths were overestimated in all cases. The size of error increased with decreasing arrowhead angles. For line orientation, overestimation was greatest when the lines were horizontal. This last is contrary to our expectations. Further, the two factors functioned independently in their effects on subjects' point of subjective equality. These results have important implications for human factors design applications such as graphical display interfaces.

**3. The introduction** is more narrowly focussed than the abstract. It states the objective of the experiment and provides the reader with background to the experiment. State the topic of your report clearly and concisely, in one or two sentences:

#### **Quick Intro Reference**

##### **Must Have:**

1. Purpose of the experiment
2. Important background and/or theory

##### **May include:**

1. Description of specialized equipment
2. Justification of experiment's importance

**Example:** *The purpose of this experiment was to identify the specific element in a metal powder sample by determining its crystal structure and atomic radius. These were determined using the Debye-Sherrer (powder camera) method of X-ray diffraction.*

*A good introduction also provides whatever background theory, previous research, or formulas the reader needs to know. Usually, an instructor does not want you to repeat the lab manual, but to show your own comprehension of the problem. For example, the introduction that followed the example above might describe the Debye-Sherrer method, and explain that from the diffraction angles the crystal structure can be found by applying Bragg's law. If the amount of introductory*

*material seems to be a lot, consider adding subheadings such as: Theoretical Principles or Background.*

#### **Note on Verb Tense**

Introductions often create difficulties for students who struggle with keeping verb tenses straight. These two points should help you navigate the introduction:

- The experiment is already finished. Use the past tense when talking about the experiment.

"The objective of the experiment was..."

- The report, the theory and permanent equipment still exist; therefore, these get the present tense:

"The purpose of this report is..."

"Bragg's Law for diffraction is ..."

"The scanning electron microscope produces micrographs ..."

**4. Methods and Materials (or Equipment)** can usually be a simple list, but make sure it is accurate and complete. In some cases, you can simply direct the reader to a lab manual or standard procedure.

**5. Experimental Procedure** describes the process in chronological order. Using clear paragraph structure, explain all steps in the order they actually happened, not as they were supposed to happen. If your professor says you can simply state that you followed the procedure in the manual, be sure you still document occasions when you did not follow that exactly (e.g. "At step 4 we performed four repetitions instead of three, and ignored the data from the second repetition"). If you've done it right, another researcher should be able to duplicate your experiment.

**6. Results** are usually dominated by calculations, tables and figures; however, you still need to state all significant results explicitly in verbal form, for example:

### Quick Results Reference

1. Number and Title tables and graphs
2. Use a sentence or two to draw attention to key points in tables or graphs
3. Provide sample calculation only
4. State key result in sentence form

Using the calculated lattice parameter gives, then,

$$R = 0.1244\text{nm.}$$

Graphics need to be clear, easily read, and well labeled (e.g. Figure 1: Input Frequency and Capacitor Value). An important strategy for making your results effective is to draw the reader's attention to them with a sentence or two, so the reader has a focus when reading the graph.

In most cases, providing a sample calculation is sufficient in the report. Leave the remainder in an appendix. Likewise, your raw data can be placed in an appendix. Refer to appendices as necessary, pointing out trends and identifying special features.

**7. Discussion** is the most important part of your report, because here, you show that you understand the experiment beyond the simple level of completing it. Explain. Analyse. Interpret. Some people like to think of this as the "subjective" part of the report. By that, they mean this is what is not readily observable. This part of the lab focuses on a question of understanding "What is the significance or meaning of the results?" To answer this question, use both aspects of discussion:

#### Analysis

What do the results indicate clearly?

What have you found?

Explain what you know with certainty based on your results and draw conclusions:

Since none of the samples reacted to the Silver foil test, therefore sulfide, if present at all, does not exceed a concentration of approximately 0.025 g/l. It is therefore unlikely that the water main pipe break was the result of sulfide-induced corrosion.

#### Interpretation

What is the significance of the results? What ambiguities exist? What questions might we raise? Find logical explanations for problems in the data:

Although the water samples were received on 14 August 2000, testing could not be started until 10 September 2000. It is normally desirable to test as quickly as possible after sampling in order to avoid potential sample contamination. The effect of the delay is unknown.

More particularly, focus your discussion with strategies like these:

#### **Compare expected results with those obtained.**

If there were differences, how can you account for them? Saying "human error" implies you're incompetent. Be specific; for example, the instruments could not measure precisely, the sample was not pure or was contaminated, or calculated values did not take account of friction.

#### **Analyze experimental error.**

Was it avoidable? Was it a result of equipment? If an experiment was within the tolerances, you can still account for the difference from the ideal. If the flaws result from the experimental design explain how the design might be improved.

#### **Explain your results in terms of theoretical issues.**

Often undergraduate labs are intended to illustrate important physical laws, such as Kirchhoff's voltage law, or the Müller-Lyer illusion. Usually you will have discussed these in the introduction. In this section move from the results to the theory. How well has the theory been illustrated?

#### **Relate results to your experimental objective(s).**

If you set out to identify an unknown metal by finding its lattice parameter and its atomic structure, you'd better know the metal and its attributes.

#### **Compare your results to similar investigations.**

In some cases, it is legitimate to compare outcomes with classmates, not to change your answer, but to look for any anomalies between the groups and discuss those.

**Analyze the strengths and limitations of your experimental design.**

This is particularly useful if you designed the thing you're testing (e.g. a circuit).

**8. Conclusion** can be very short in most undergraduate laboratories. Simply state what you know now for sure, as a result of the lab:

**Quick Conclusion Reference**

**Must do:**

1. State what's known

Justify statement

**Might do:**

1. State significance
2. Suggest further research

*Example: The Debye-Sherrer method identified the sample material as nickel due to the measured crystal structure (fcc) and atomic radius (approximately 0.124nm).*

*Notice that, after the material is identified in the example above, the writer provides a justification. We know it is nickel because of its structure and size. This makes a sound and sufficient conclusion. Generally, this is enough; however, the conclusion might also be a place to discuss weaknesses of experimental design, what future work needs to be done to extend your conclusions, or what the implications of your conclusion are.*

**9. References** include your lab manual and any outside reading you have done.

**10. Appendices** typically include such elements as raw data, calculations, graphs pictures or tables that have not been included in the report itself. Each kind of item should be contained in a separate appendix. Make sure you refer to each appendix at least once in your report. For example, the results section might begin by noting: "Micrographs printed from the Scanning Electron Microscope are contained in Appendix A."

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