FACULTY OF APPLIED SCIENCE AND ENGINEERING
ENGINEERING COMMUNICATION CENTRE

SANDFORD FLEMING B670, 35 ST. GEORGE ST., UNIV. OF TORONTO, TORONTO, ON.

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:

1. Title Page
2. Abstract
3. Methods and Materials
4. Experimental Procedure
5. Results
6. Discussion
7. Conclusion
8. References
9. Appendices

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: a) the **purpose of the experiment** (sometimes expressed as the purpose of the report) b) **key findings**, c) **significance** and d) **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). ***(See also Components of Documents / Abstracts & Executive Summaries)***

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 focused than the abstract. It **states a) the objective of the experiment** and b**) provides the reader with background to the experiment.** State the topic of your report clearly and concisely, in one or two sentences. When determining the objective, be sure to identify the end goal of the experiment itself, not the pedagogical goal of the experiment:

The objective of this experiment was to learn how to use the SEM. *(The Professor's reason for having you do the lab, but not the objective of the lab itself).*

The objective of the experiment was to determine the composition of an unknown sample using Scanning Electron Microscopy. *(This is your key result)*

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: "Equipment was set up as in CHE 276 manual."

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:

Using the calculated lattice parameter gives, then, R = 0.1244nm.

Graphics need to be clear, easily read, and well labeled (e.g. Figure 1: Input Frequency and Capacitor Value) ***(See also Components of Documents / Using Visuals in Writing)***. 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. The 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, **a) Analysis** and **b) Interpretation.**

a) 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, 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.

b) **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 desirably 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:

i) 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.

ii) 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.

iii) 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?

iv) 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.

v) 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.

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

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 ***(See also Components of Reports / Conclusions).***

9. References: include your lab manual and any outside reading you have done. (***See Online Handbook / Accurate Documentation*** for an appropriate way to reference in your field).

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."

Useful Further Reading: Porush, David. *A short guide to writing about science*. Toronto: HarperCollins, 1995. Although, this book uses the "scientific article" as the basic form for writing, it essentially views that as an extended lab report. Therefore, it has useful chapters on each of the sections of a lab report.

Our pages in the ***Online Handbook / Components of Reports*** Section may also be useful.
