

## **Guidelines for Preparing Laboratory Reports**

The ability to communicate technical information in clear, concise written English is an exceptionally important skill that should be cultivated by all students of technology. The time and effort spent gathering experimental data is of little value if the results of that effort cannot be interpreted in a way that is meaningful to others, or if conclusions cannot be stated in a way that is both convincing and unambiguous. The technical expertise of an experimenter is often judged solely by the quality of his or her written reports, so time spent learning how to produce a good report can reap significant practical dividends.

The best way to learn how to write good technical reports is to write as many as possible. Through repeated practice, a technical writer learns certain techniques and widely accepted standards for the structure and format of a good report. In the following paragraphs, we summarize these standards and provide guidelines on the correct way to present technical information. The structure we suggest here (i.e., the organization of the topics and the scope of each) is often called that of a "formal" report. You may not be required to submit a complete, formal report that conforms precisely to the suggested format for every experiment you perform. However, you will find useful guidelines for the content of each section in a technical report, no matter how it is organized.

### **THE TITLE PAGE**

The title (cover) page of a report should contain the title of the experiment, the name of the person who wrote the report, the name(s) of any partners who participated in the experiment, the date the experiment was performed, the course name and number, and the date the report is submitted. Although there is no universal standard for the format in which this information is presented, the title of the experiment should be more prominent than the other items.

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## INTRODUCTION

The introduction generally should include Background Information, Purpose and a Hypothesis. The Background information should familiarize the reader with the general subject matter of the experiment being performed. It should only include what is relevant to the experiment. Use your lab manual, textbook and any other source.

The Purpose of the lab report explains **WHY** the experiment is being performed. It should include the objective of the experiment explaining the problem to be solved. **The conclusion to the lab should be directly linked to the purpose of the lab.**

The Hypothesis is a possible explanation of observations or information. Some lab reports will not have a clear hypothesis to include in your lab. Sometimes your hypothesis will not be “backed up” or “proven” by your lab results. A good lab report will explain why these differences exist. An error analysis would also be included in this case.

## EQUIPMENT LIST

The reliability of experimental data depends heavily on the type and quality of the instruments used to obtain it. Experienced investigators can gauge the validity of an experiment from knowledge of the equipment used to perform it. For this reason, it is important to list the make and model numbers of all instruments. A reader who may wish to duplicate an experiment will require some knowledge of the instrument quality needed to obtain similar experimental results.

Depending on how critical the conclusions drawn from an experimental investigation are to the organization sponsoring it, additional information on the equipment may be required. For example, it may be necessary to report manufacturers' serial numbers on the test equipment used in order to permit the reader to verify calibration records or to perform calibration tests. The list of equipment should include **ALL** equipment that was necessary to perform the laboratory procedure.

## EXPERIMENTAL PROCEDURE

The Procedure section of a report should contain a brief description; in the writer's own words, of the experimental procedure that he or she followed when the experiment was conducted. Describe the procedure in sufficient depth to enable such a person to perform the experiment using your description.

Any particularly complex steps in the procedure should be described in greater detail to eliminate the possibility of misinterpretation. Also, include any special precautions that are necessary.

The passive voice should especially be used in procedures section of the lab report. A correct example is as follows: “One hundred grams of soil were added to a 500 ml flask.” An incorrect version of this using the active voice would read as follows: “I added one hundred grams of soil to a 500 ml flask.”

## OBSERVED DATA

The DATA section of a report contains the results of all measurements that were made during the conduct of an experiment. These are called "raw" data. (Incidentally, the word "data" is a plural noun, so "these data" is correct usage. In recent years, common usage has made "data" also acceptable as a singular noun. Therefore, "the data is ..." is also correct.)

Raw data should be presented in data tables. Each table should be given a descriptive title Do not simply write "Table 1." The units of all entries in a data table should be made clearly apparent to the reader. A common method used to show units is to write the units as part of the heading for each column or row of data. Alternatively, its units can accompany each data entry.

However, as a general rule, data should be recorded with the same units in which it is measured. Avoid the use of numerical multipliers or divisors in data headings.

## SAMPLE CALCULATIONS

This section of the report should contain **one** example of **each** type of calculation used in data reduction or in theoretical computations. Present each sample calculation with a heading that makes the purpose of the calculation clear. Be sure to include units.

## CALCULATED DATA

Reduced data are the results of computations that are performed on the raw data. **THE OBSERVED DATA AND CALCULATED DATA CAN BE PRESENTED IN THE SAME TABLE IF IT CAN BE SHOWN SEPARATELY.** For example using a word processor each can be shown using different type settings and/or different colors with a corresponding key.

## RESULTS

Graphs can be a very effective way of presenting both raw and reduced data. They are considered part of the results section of a report but should not be used to replace tables containing actual measured values.

The horizontal and vertical axes of a graph should always be labeled with the quantities they represent and their units. Place numbers along each axis to make it clear what range of variation is represented by the intervals between major divisions. Provide a descriptive title for each graph. Data points should be plotted so they are clearly visible. Do not make tiny "dots" and then obscure or obliterate them with a line. Instead, use a symbol such as  $\odot$  or  $\otimes$  to represent each experimental data value plotted.

A graph showing experimental data is often drawn incorrectly because the individual who constructed it did not really understand its purpose. The purpose of any graph is to demonstrate a relationship between variables. Often the graph is used to show how well experimental data conform to a

theoretical relationship. In these cases, both the theoretical relation and the experimental data should be plotted on the same set of axes.

Sometimes the graph is used simply to show that there is a certain kind of relationship between variables, for example, a linear relationship, rather than to show that it conforms to a specific equation. In these cases, the "best" theoretical relationship should be plotted between the data points. For example, suppose the data consists of voltage across a fixed resistor and current through it, and we want to show that current is linearly related to voltage, that is, that current is directly proportional to voltage. Then a straight line should be fitted between the data points plotted on the graph. The "best" straight line can be precisely defined using a statistical method called regression analysis, but this method is beyond the scope of our discussion. For our purposes, the line should be drawn in a way that best seems to fall between the data points.

One of the most common and most flagrant errors made by students plotting graphs is to draw straight line segments between data points. The graph that results consists of a jagged, zig-zag plot that completely obscures the true relationship between the variables. The relationships between physical quantities in nature are always smooth, that is, their graphs are smooth curves, not zig-zags. It is better to draw no line at all between data points than it is to force an artificial line to fit every data point and thereby portray some unrealistic relationship. Even if a line drawn between data points is smooth, it should not show ambiguous "humps" or "dips" caused by forcing the line to go through every data point.

Figure A.1 shows examples of correct and incorrect graphs drawn through a set of experimental points for which there is a theoretical linear relationship.

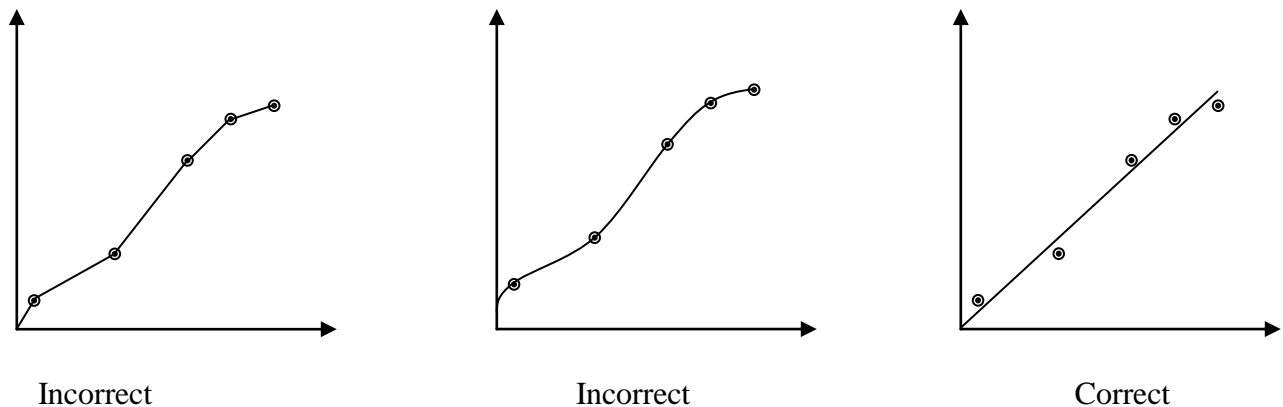


Figure A.1

## ERROR ANALYSIS

This section does not always exist in a lab report. It should only be included when needed. The Error-analysis section of the report should list, describe, and justify any sources that the writer believes may have contributed to errors in the experiment. Among these sources are instrument accuracy, component tolerance, and human error. Be specific. State, for example, the manufacturer's specified accuracy of each instrument used, and attempt wherever possible to relate it to the percent errors or differences calculated from the data.

Error analysis is admittedly a speculative endeavor that often requires a considerable amount of guesswork. However, it is a worthwhile endeavor since it gives the reader some insight into the conduct of the experiment, an insight that is best supplied by the person who actually performed the experimental procedure. In addition, the very process of contemplating the error and speculating on its source can be very rewarding. Looking for trends and asking oneself "why?" stimulates thought processes and produces shrewd guesses-- guesses that the experimenter is best qualified to make.

## CONCLUSION

This section of the report contains the investigator's written interpretation of the experimental results and the conclusions that he or she has formed based on the results. **This is one of the most important parts of a report.** The conclusion should show that there is concrete evidence to support the relevant theory, or demonstrate that certain important insights have been gained as a result of performing the work. It should state what has been learned from doing the experiment. The data should "back up" the conclusion.

Avoid the tendency to make sweeping generalizations for which there is no real basis in the data. Do not use the word "prove," as in "These results prove Ohm's Law." No experimental investigation can absolutely prove any theoretical relation. Say instead "the results tend to confirm the validity of Ohm's Law."

**Conclusions should refer to the specific objective(s) (Purpose) that are given at the beginning of the report.** Do not form conclusions that are not relevant to these objectives or for which you have no supporting evidence. Unless there is experimental data in your report that you can use to back up a conclusion, don't state that conclusion.

If there was a hypothesis stated in the Introduction of the report then the conclusion should support it with the results. As in the preceding example, always cite data as evidence for conclusions. Be specific and be quantitative; that is, refer to numerical results that support your conclusions.

In the conclusion you should explain your results as they pertain to the Background Information you discussed previously in the report. Any correlations should be made in the conclusion section.

If the results do not support your hypothesis then the discrepancy should be explained in this section. Sometimes more can be learned from incorrect results and the need to explain the reasoning for it.

## **RECOMMENDATION**

This section of the report should contain any recommendations that the writer feels are relevant to the conduct of the experiment. For example, a suggestion on how to change the experimental procedure to reduce measurement error would be an appropriate recommendation. Also appropriate would be a recommendation to investigate further any unexpected result brought to light by the data.

## **APPENDIX**

The appendix should include any information that is relevant to the lab report that does not fit into one of the above-mentioned sections. The “RAW DATA” sheet that was written on in lab should be included in the appendix. If any tables or charts were used in the calculations to retrieve information they should be included in this section and referred to in the body of the report.

## **REFERENCES**

**This section is one of the most important sections of the lab report.** Since all students are expected to write an independent lab report they must make sure not to plagiarize anyone else’s work. Citation of all work must be done in this section and should follow the MLA procedure for referencing work done by others. If you are ever in doubt about whether to reference a source of information, please err on the side of caution and REFERENCE IT.