Appendix II. Reports & Worksheets

revised April 07, 2006

A. Introduction

Reports and worksheets will be the foundation of your grade in the laboratory. A report is required for every lab except the first and last ones of the semester; you will hand in worksheets for these. (The report for the IP lab is a "fill-in-the-blank" report and there is detailed guidance for the report for the CME lab.)

Each report should be similar in format to a professional technical paper. It should be a free-standing document and must include sufficient information so that a reader whose background is similar to your own (but who is not familiar with the experiment) can understand your work and your conclusions. The report *should not* include all the details of your work; the graders will be able to refer to your laboratory notebook for such details.

Most of the text should be composed on a computer and printed, but please feel free to write in equations and drawings by hand, as long as you do this neatly. Although these may look better if they are also composed on a computer, doing so generally requires more time than is appropriate for this class.

You should expect to devote an average of roughly three hours every other week to writing a lab report and/or completing worksheets. To help you learn what is required in this class, a sample report is included in this manual, as Appendix XI. The sample report illustrates the format and writing style expected for reports as described below.

To help you decide what should be included in your report, the most important measurements and analyses in each experiment are underlined in the write-ups. Before handing in your report, be certain that it addresses each of these underlined topics.

Fill out a "Cover Letter" (*grading sheet*) and staple it to the front of your report and/or worksheet before dropping the package in your TA's mailbox on the 4th floor.

B. Report Format

Each report must follow the format described below (*this format is common to many technical journals*). Decisions on which sections of a report should contain which information are not always clear. For example, it may be either clumsy or useful to separate the discussion of results from the analysis that led to those results. Nevertheless, you should try to follow the format described below.

Be sure to define all symbols used in your text and equations. Sequentially number any equations that you use so that you can refer to them later by number. The same principle applies to figures and tables. They should be numbered sequentially and referred to by number. Any figure, table or equation that you introduce should be referred to somewhere in the text.

Each figure in a publication closely follows the point in the text that first refers to it. However, when *submitting* a publication, it is common to group all of the figures at the end of the paper, before any appendices. You may use either method.

B.1. Cover Page

When one submits a paper to a journal, a cover letter to the journal's editor is normally attached to explain your intentions, provide contact information, etc. In this class, a standard cover page, or *report cover*, will be provided to you. This cover page will also serve as the grade sheet on which your

TA marks your grade for each week's work and indicates areas that need improvement. **Fill in all of the information requested on this Cover Page and attach it to the front of your report.**

Your signature on the cover page indicates that the report is **your own work**. While your lab partner(s) and you will normally have identical data and perhaps very similar or the same analysis of that data, you must write your own report. We permit (and even encourage) partners to work together to analyze the data; such collaboration needs to be properly acknowledged or referenced. However, you need to write the words to your report yourself. **Making direct or edited copies of your partner's or someone else's text (without attribution) is considered a serious breach of ethics and will be dealt with harshly.** University regulations require that the minimum penalty for plagiarism is a zero for that report and forwarding of the evidence of plagiarism to the Office of the Dean of Undergraduate Studies.

You agree that by taking this course, all required lab reports or other assignments submitted for credit may be submitted to MyDropBox.com or similar third parties to review and evaluate for originality and intellectual integrity and that if the results of such a review support an allegation of academic dishonesty, the course work in question as well as any supporting materials may be submitted to the Office of the Dean of Undergraduate Studies for investigation and further action. A description of the services, terms and conditions of use, and privacy policy of MyDropBox.com is available on its web site, http://www.MyDropBox.com. Understand that all work submitted to MyDropBox.com will be added to its database of papers.

B.2. Header

The first page of your report begins with a header, which should be at the top of a new page and center-justified. The first line(s) of this header is the title of your report, printed in bold letters with the first letter of most words capitalized. Following, on a separate line, is a list of authors. This list should start with the first author (*you*) and include all co-authors. The next line gives your affiliation. In your case, this should read *Department of Physics, Case Western Reserve University, Cleveland, Ohio, 44106-7079.*

B.3. Abstract

The abstract should be on the first page, separated from the header by a blank line. In a few sentences, give a very brief description of what you were trying to measure, how you made the measurement, a summary of the main numerical results with their uncertainties and the main conclusions you were able to draw.

It is generally best to write the abstract last, after you've completed the main body of the paper, so that you are certain of the points that you wish to highlight in the abstract. The latter part of the abstract can often be very similar in content to the Conclusions described below.

B.4. Introduction & Theory

The purpose of this section is to motivate your investigation and to show how you will analyze your data. It's purpose is *not* to prove to your TA that you read the lab manual; do not simply regurgitate the lab manual.

This section should be brief and written in your own words. ***Do not copy sections from text books or the lab manual without attribution.*** Such copying is plagiarism and is a breach of ethics and the law. You may, however, refer the reader to the lab manual or to your textbook for further reading.

The discussions that you do include explicitly should be minimal, since you aren't generally deriving it yourself. Give only the concepts required to understand your work and the equations that you used in analyzing the experiment. The Theory should show how you will analyze your data.

B.5. Experimental Procedure

In this section you should describe your experimental technique. Do not just copy the instructions from the manual and do not write a numbered list of steps-you are not telling your reader how to do the experiment; you are telling your reader how you did the experiment. The paper should be written as full sentences in normal paragraphs. A figure showing your setup is often appropriate. Describe how you acquired your data and any special instrumentation that you used. You should also describe how you arrived at the error estimates associated with each directly measured quantity. For example, you might say that you used a meter stick to measure a coil diameter, the meter stick had markings spaced by 1 mm and you could estimate a position to the nearest ½ mm.

B.6. Results & Analysis

This is the section in which you show your data and your mathematical analysis of that data. Some more thoughtful discussion of the experiment can occur here or in the following section.

Do not print large tables of computer data, although you may need to show some raw data and demonstrate how it was treated to arrive at your final numbers. In general, you should be able to reduce larger quantities of data to the form of a table or graph.

Explain your analysis procedure with brief comments to let a reader follow your work. If you use equations introduced earlier in your report, include references to them. You may include some calculations, but place longer calculations in an appendix. Even then, you may show in detail only one sample calculation that is applied to a much larger body of data. Computer calculations, such as those done with Origin, should be illustrated with samples. Show the calculation details, *i.e*. write each equation neatly. Directly below the equation, substitute in the values of the variables. Show enough steps so that the procedure of the calculation is clear.

Refer to your estimates of the uncertainties in measured quantities and discuss which ones may be neglected. Refer to the equations you used to calculate each derived quantity and apply one of the error propagation methods to determine the effect of each significant uncertainty on the final calculated quantity. Details of the error calculations may also be placed in an appendix.

B.7. Conclusions

Compare your results to expected values, quantitatively and including error estimates. State clearly in a few words the goals of your experiment and summarize clearly and concisely your success or failure in reaching them. For example, suppose you measured the value of g and determined the uncertainty in that measurement. You might quote your result as $g = (9.98 \pm 0.06)\ \mathrm{m/s^2}$, note that your result is about 3 standard deviations away from the accepted value, which may indicate the presence of some systematic error (*or a remote possibility that the accepted value is wrong and you are right*). You might then write a brief discussion of possible explanations. Do not claim or assume that your suggested explanation must be correct. "Human error" is a meaningless term and should not be cited as the cause of a discrepancy.

Point out areas of agreement and/or disagreement with other published results. Discuss problems that you have found and any suggestions you have for how they could

be overcome. Clearly state the significance of your work and your conclusions. Even if results are consistent with expectations, do not claim that you have proved a theory. The highlights of this section will also appear as part of your abstract.

B.8. Acknowledgements

You should acknowledge those who gave significant help in collecting data (*i.e., your lab partners*) or other areas of the report that are of a nature that an explicit endnote and reference is cumbersome. You do not need to acknowledge help from the laboratory director or your teaching assistant. An example of an Acknowledgement section is in the sample lab report. A scientific paper for publication would also acknowledge outside sources of funding (NSF, NASA, NIH, etc.), but it is extremely unlikely that you will have such a source of funding for an introductory laboratory.

B.9. References or Citations

You should clearly acknowledge the use of all external reference sources, including your textbook. However, it is not necessary to cite help received from the laboratory director or your teaching assistant. Examples of citations are included in the sample report.

Learn how to cite references that give more information that might be useful to a reader but which you don't want to include explicitly in your paper. For example you can write that a certain formula or derivation can be found in some particular book.

There are several acceptable formats for references. One is to put a superscript on a piece of text that refers to a reference. Such superscripts should be numbered sequentially. The actual references appear as a numbered list at the end of the main body of the report, before any appendices. The information provided in this list includes the authors, book or journal, date of publication, and page numbers.

If you are unsure about how or if to reference assistance, ask your TA or the Lab Director.

B.10. Appendices

There may be reasons to include in a report discussions that would interrupt the natural train of thought of a reader and, while they must be included to produce a complete document, do not merit inclusion in the main body of your report. Put such items in an appendix, with a separate numbered appendix for each topic. The appendices should be referred to somewhere in the main body of your text.

The Lab Manual may occasionally instruct you to place some discussions in a appendix. For example, a long detailed error analysis may be better suited for an appendix. Make sure you refer your reader to such an appendix at the appropriate place in the main body of the text.

C. Report Checklist

On the next page is a checklist so you can ensure you have properly covered subjects in your report.

✓	**Item**
	General
	Numbers correctly reported as measurement intervals (sig. figs.) (Appendix V, Section D)
	Numbers reported with correct units
	Underlined items from lab manual addressed
	Clear presentation
	Abstract
	Quantity measured or principle tested
	How measurement was made
	Numerical results
	Conclusion (numerical comparison with theoretical or other experimental result)
	Introduction & Theory
	Basic principle stated
	Main equation(s) to be used in analysis
	Picture/diagram of apparatus either here or in Procedure section
	What will be plotted; what you expect the plot to look like (usually a straight line)
	Fitting parameters related to quantity(ies) to be measured. (For each measured quantity, final equation with measured quantity = function of other measurements, constants, and parameters.)
	Procedure
	Detailed description of how measurements were made
	What the uncertainties were
	Justification of those uncertainties
	Data record here, in analysis, or in an appendix
	Analysis & Error Analysis
	Discussion
	Equations
	Calculations (here or in appendix)
	Presentation of graphs and tables (see Appendix VII)
	Results reported
	Results reasonable (*not necessarily in agreement with "expected" result*)
	Discussion & Conclusions
	Numerical comparison of results with "expected" value or theory
	Logical conclusions
	Discussion of possible systematic or random errors (systematic if not consistent with "expected" value or theory, random otherwise.)
	Suggestions of how to reduce systematic or random errors (systematic if not consistent with "expected" value or theory, random otherwise.)
	Acknowledgements
	Acknowledge your lab partner(s) help
	Acknowledge other helpers (you need not acknowledge the Lab Director or your TA)
	References
	Listing of all work referenced in the text

This page intentionally left without useful information.