**Formal Laboratory Report Materials** http://homepages.dordt.edu/~zwart/formalreportguide_03.pdf
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The following pages are a collection of the handouts, guidelines, and grading sheets used in our peer review/referee methodology. Feel free to adapt them for your own use, but we would appreciate acknowledgment.

As will be clear when you read the following material, some of the pages contain references to a specific experiment. We modify these each year - to avoid tempting our students we change the particular experiment that is used for the formal report from year to year. To encourage good lab notebook use, the students are informed as to the particular experiment a few weeks after they have performed it.

Our basic approach is:

-guidelines provided to students
-poster showing refereeing process provided
-3 copies of draft due at a designated lab period
-peer review/referee checklist provided
-students review 3 reports, spending a minimum of 20 minutes on each
-all drafts and checklists collected
-drafts and reviews quickly scored, "general comments" sheet written
-drafts, checklists, and general comments returned to authors
-final draft due 1-2 weeks after return
-final reports graded using template

Benefits of this approach:

-much improved final reports
-better student understanding of process, rationale for guidelines and for the assignment
-overall reduction of time spent grading (time spent on the process more than saved in grading final drafts)

The following materials are included in this document:

-**Physics 202 - The Formal Laboratory Report** (cover sheet for the guidelines)
-**Guidelines for Writing a Formal Physics Laboratory Report** (specific guidelines)
-**Reviewer's Notes on Formal Lab Report** (checklist used for peer review/refereeing)
-**Formal Report Peer Review Introductory Comments** (directions to students for the peer review/refereeing process)
-**Physics 202 Formal Report Peer Review** (score sheet used to ensure peer review process is taken seriously. Each peer reviewed draft is quickly (1-2 minutes) scored)
-**Comments on 1st draft and peer review – Physics 202 Formal Lab report** (comments returned to students along with their peers comments and the score sheet. Remarkably, this needs little editing from year to year)
-**Formal Report Final Grade Scoring Sheet** (grading template used in grading the final draft We have found using the template helps with grading consistency and provides better feedback to the students. It is used in addition to comments written on the report.)

**Physics 202 - The Formal Laboratory Report**

As discussed earlier this semester, you will have the opportunity to write a formal laboratory report. The formal report uses the format that is used in submitting an article to a physics journal for publication. Please view the poster which shows the steps in a genuine submission process. As the following pages show, there is a strict set of guidelines that are to be followed. A large portion of your grade will be based on how well you follow the guidelines. Each individual must write and submit their own report. In your submission, place yourself as first author and list your lab partners as co-authors.

This year the formal report will be on the "Ring Pendulum" experiment. In your report you should not simply explain what you were asked to do in the instructions for the experiment. Instead treat the lab exercise as a "real experiment" in which you wanted to compare the actual relationship between period and diameter for the ring pendula to the theoretical expectation. What is the theoretical expectation? You have the expertise to derive it and should as part of your report.

On October 17 and 18, the entire lab period will be devoted to a peer review of first drafts of the formal report. Providing a reasonable first draft and doing a careful job of peer review will count heavily towards your final grade. You will need to come with 3 copies of your draft to the lab period. If you do not come with 3 copies of your draft, you will not be allowed to review anyone else's draft. The peer review process is worth 20% of the grade on the project.

For your first draft, make sure you have all the parts of the report done. They do not need to be perfect and do not spend inordinate amounts of time doing fancy computer drawings or computer generated plots. For the first draft a hand drawn sketch and photocopy of a plot from your lab notebook will suffice.

# Guidelines for Writing a Formal Physics Laboratory Report[1]

In preparing your formal laboratory report, we will suppose that you are planning to submit it as a manuscript (paper) for publication in a professional physics journal, or at least a student physics journal such as *The Journal of Undergraduate Research in Physics*. In writing this lab report, you are to suppose that your audience will be students of physics courses in other institutions who have not done the lab experiment you have; they are knowledgeable about physics like you, but have not spent time trying to understand the specific work which is being reported in your paper. They also can read English well and expect the paper to be written by a colleague, not a robot or a computer.

There is a big difference between the comments you write in the margin of your lab notebook and what you should present in a paper for publication in a scientific journal. The general style of writing that you should follow when preparing your lab report (pretending it is a manuscript for publication in a journal) is different from what you would submit to your English literature professor, and is unfortunately not described in Dordt's adopted Write For College.

The narrative is intended to do three things:

a) set the background necessary so that the reader can appreciate and understand the physics being reported,
b) discuss the details of what you did and the implications of your work, and
c) lead the reader through the work in such a way that they must come to the same concluding points that you did.

When the readers finish with your paper, they should not have to go back and try to decide for themselves what you did. Your narrative should lead them through your work in an *unambiguous* manner, telling them what to see and understand in what you did. The interpretation of the data should be done by the writer, not the reader.

You should take care to make sure that the material is presented in a concise logical way. Make sure that your sentences do not have too many dependent clauses; overly complicated sentences make the logic of an argument difficult to follow. Choose a paragraph structure which focuses the attention of the reader on the development of the ideas.

To become familiar with elements of the format described below, you can look at papers in journals such as *Physical Review Letters*, *American Journal of Physics*, *Journal of Undergraduate Research in Physics,* and *The Physics Teacher*.

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[1]Substantially adapted by Arnold E. Sikkema from Rexford E. Adelberger, "On Preparing A Manuscript For Publication", *Journal of Undergraduate Research in Physics*, **8** (1989), 1-3.

Your lab report must have the following format, which achieves these aims:

**Title, Author, Submission Information, Institution, Date**
This is included on the first page of the paper, and not on a separate title page. Submission information means to whom the report is submitted and for what purpose. Each of the remaining sections will have the following titles.

**Abstract**
An abstract is a self-contained paragraph that concisely explains what you did and presents any interesting results you found. Abstracts are often published separately from the body of the paper, so you cannot assume that the reader of the abstract also has a copy of the rest of the paper. As abstracts are often used in computerized literature searches, all key words that describe the paper should be included.

**Introduction and Theory**
This is the section that *sets the background* for the important part of the paper. It is not just an abbreviated review of what you are going to discuss in detail later. This narrative must present the necessary theoretical and experimental background such that a knowledgeable colleague, who might not be an expert in the field, will be able to understand the data presentation. If you are going to use a particular theoretical model to extract some formation from your data, this model must be discussed in the introduction.

Where appropriate, material in the introduction should be referenced. In the case of your lab report, you might be tempted to refer to the lab manual; however, as you wish to present this to an audience to whom this manual will not be available, a reference to a physics textbook would be appropriate. [In some cases, such as the metal samples numbers in Table 1, you cannot avoid making reference to your particular situation.] When presenting background information, you may guide the reader to a detailed description with the statement such as "A more detailed discussion of laminar flow can be found elsewhere [1]", but be sure to present enough material within your paper to make it self-contained.

**Experimental Method**
This section guides the reader through the *techniques and apparatus* used to generate the data. Schematic diagrams of equipment and circuits are often easier to understand than prose descriptions. A statement such as "A diagram of the circuit used to measure the stopping potential is shown in Figure 6" is better than a long inelegant set of words. It is not necessary to describe in words what is shown in a diagram unless you feel that there is a very special part which should be pointed out to the reader. If special experimental techniques were used as part of this work, they should be discussed here.

**Results and Analysis**
Data presentation is the most important section of the paper. This section should lead the reader through the data and how errors were assigned. The data (a plural noun) are the numbers directly obtained in your work. The numerical data values are presented in tables and graphs, each with its own caption. All figures and tables should be referred to by their number. A well-written data presentation results in a reader reaching the same conclusion(s) as the author about the experiment.

***Notes on Figures and Tables***

Tables and figures are to be relevant, separately and consecutively numbered (*e.g.* Table 1, Table 2, Figure 1, Table 3, Figure 2, *etc.*), captioned, and placed near the text referring to them. (Any figure or table that is not discussed in the narrative should be eliminated.) An example of a graph of a set of data is shown in Figure 1, and a sample list of data is given in Table 1. Note that if a table presents data which can be readily graphed, a graph should presented and not a table. You should ensure that the graph fits the box, error bars are shown with the data points and all lines drawn on the graph are identified.

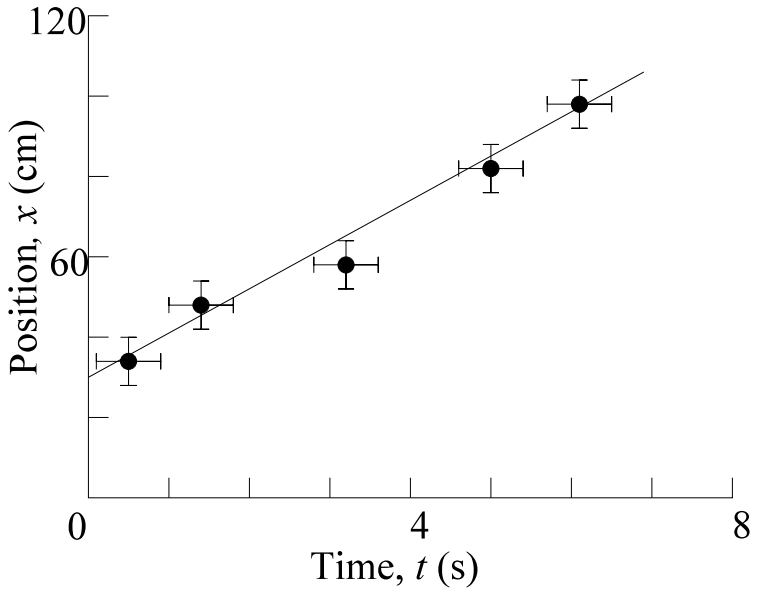


Figure 1. Measured position of cart as a function of time elapsed. The straight line is a best fit to the data.

You should be careful that the figures and tables you present are not too busy. If you try to put too much information on a single figure, it becomes difficult for the reader to pick out the important parts. The object of the paper is to bring the reader to an understanding of what you did rather than to direct a game of hide-and-seek.

Table 1: Linear expansion coefficients for various metal samples; tabulated values are from Ref. [1].

| **Metal Sample Number** | **Measured Linear Expansion Coefficient ($10^{-6}$/K)** | **Metal Name Assigned** | **Tabulated Linear Expansion Coefficient ($10^{-6}$/K)** |
|---|---|---|---|
| 1 | 15.9 ± 0.9 | copper | 17 |
| 2 | 11.3 ± 0.2 | steel | 11 |
| 3 | 22.6 ± 0.7 | aluminum | 23 |

All experimentally measured numbers reported in your paper, in either or narrative, must include an uncertainty. Use scientific notation when presenting numbers, *e.g.* $(7.34 \pm .03)\times 10^7$ mg/s, taking care to have the correct number of significant figures in your results. Just because a computer or calculator prints out 6 digits does not mean that they are significant.

**Conclusions**

Every experiment will come to a clear and meaningful conclusion. A concise statement of your conclusion(s), which often has similar wording to parts of your abstract, is necessary here, reviewing all important results. Comparisons (in terms of standard deviations) of your results with those found elsewhere should be done here. In cases where further research should be done to provide a better result, and if you cannot do this yourself at this time, this should be suggested as well. General implications of your work, if any, should also be presented here.

**Acknowledgments**

This short section should acknowledge help you received (unless it is already referenced in the references section following) from others. This is where you would give credit to a lab partner or someone who gave you equipment, ideas, or feedback.

**References**

All references, in numerical order of appearance in your paper, are collected together at the end of the paper (not as footnotes). In the text, refer to references like this [2]. Following is the required format.

*If the reference is a text:*

1. A.F. DeSmith, J.F. Smuckersma, & C.S. Smythers, Basic Physics For Everyone (New York: Addison Wesley, 1992) pp. 168-171.

*[Use pp. for multiple pages; p. for a single page.]*

*If the reference is a journal:*

2. J. Botswain, "Solid-Liquid Interfaces in Spinning Cylinders", *Journal of Irreproducible Results*, **22**, 122-127 (1986).

*[The boldface number is the volume number; issue numbers are required only if pages are always numbered starting from 1 in each issue. Often abbreviations are employed for the journal name; if you use one, ensure it is a standard abbreviation.] (There is actually a journal with the above name; it's a science humor journal! See www.jir.com.)*

*If the information is taken from someone you have reason to trust, and is to your knowledge not published anywhere:*

3. R.J. VanRaalson, private communication.

There are of course other forms of references but you are not likely to run into them in the production of your paper.

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*For additional information and tips, please see:*

Christopher S. Lobban & Maria Schefter, Successful Lab Reports: A Manual for Science Students (Cambridge: Cambridge University Press, 1992). [call # Q183.A1 L63 1992 in LRC-CL]

or: search the web with the quoted phrase "How to Write a Lab Report".

Author's Name: _____

Reviewer's Name: _____

**Reviewer's Notes on Formal Lab Report**
*PHYS 202 — Dordt College*

*Title:*
- ☐ missing
- ☐ not specific enough
- ☐ should not just be experiment title from lab manual
- ☐ should not be a sentence
- ☐ should not be on separate page

*Author:*
- ☐ missing

*Submission Information:*
- ☐ missing
- ☐ submitted to whom, for what purpose

*Institution:*
- ☐ missing

*Date:*
- ☐ missing (even rough draft should have a date)
- ☐ should be date of submission of paper, not of experiment

*Abstract:*
- ☐ missing
- ☐ result must be given
- ☐ save details for elsewhere

*Introduction and Theory:*
- ☐ missing
- ☐ background not well established
- ☐ general introductory remarks should be made
- ☐ save experimental details for next section

*Experimental Method:*
- ☐ missing
- ☐ don't include results here

*Results and Analysis:*
- ☐ missing
- ☐ put experimental method in previous section

*Figures and/or Tables:*
- ☐ missing but required
- ☐ not referred to in text
- ☐ caption missing
- ☐ some detail missing

*Conclusions:*
- ☐ missing
- ☐ incomplete
- ☐ too grand or general
- ☐ general implications should be presented
- ☐ suggestions for further study should be made

*Acknowledgments:*
- ☐ missing
- ☐ lab partner should be acknowledged

*References:*
- ☐ missing
- ☐ not used in body
- ☐ must be in order of appearance
- ☐ improperly formatted
- ☐ insufficient references

*General Comments:*
- ☐ excellent work
- ☐ good work
- ☐ narrative difficult to follow
- ☐ work not properly divided into the various sections
- ☐ too site-specific; write from more general point of view
- ☐ you must type final report

*Other Comments:*

**Formal Report Peer Review Introductory Comments** (to be announced at beginning of period used for review)

-those arriving without a draft will not be able to participate in the peer review process.

-each review should take a minimum of 20 minutes. In order to enforce this, turn in 2 of the 3 drafts.

-for first round, trade drafts with your lab partner. After 20 minutes, the next draft for review will be handed out.

-in reviewing, use the provided check list as a starting point. Write on the draft as well as making additional comments on the checklist. Basically anything you find that could improve the paper should receive a comment.

-Part of your grade (20%) will be based on the quality of your reviews.

-feel free to jot some notes to yourself on a separate sheet that can be used to improve your own paper.

**Physics 202 Formal Report Peer Review** Name of Reviewer_____

Review #1 – Name of Author_____
(Each section will be scored on a scale of 0-3)

____Completeness (all sections reviewed?)

____Constructive comments (are the comments helpful?)

____Depth of critique (is the critique thorough?)

Review #2 – Name of Author_____

____Completeness (all sections reviewed?)

____Constructive comments (are the comments helpful?)

____Depth of critique (is the critique thorough?)

Review #3 – Name of Author_____

____Completeness (all sections reviewed?)

____Constructive comments (are the comments helpful?)

____Depth of critique (is the critique thorough?)

Draft of report

____Completeness (all sections there?)

____Depth (enough information in each section?)

____Good faith effort (reasonable attempt?)

____Total

**Comments on 1st draft and peer review – Physics 202 Formal Lab report**

First, some general observations on the papers

Do look at examples of published papers in Physical Review Letters, or Physical Review or other peer reviewed physics journals.

My scoring on the sheet returned to you is scaled to a first draft effort – i.e. getting 3/3 does not mean "perfect, do not change a thing", but means "not bad for a first try."

Read the guidelines!!!!

Do the theory, but you do not need to include every step of algebra.

Do not assume all peer comments are correct. Some are dead wrong.

Many of the reports were far too brief. More detail is needed to make them understandable by someone who is unfamiliar with the experiment.

Do not use "computerese" in place of standard mathematical notation (eg use $d^n$, not d^n). If your word processor does not include the symbol, write it in by hand.

Any figures and tables must be referred to in the text. Neat hand drawn ones are fine. Graphs must follow the rules for good graphing (titles, units, etc). Use the titles "Figure 1," " Table 1", etc.

Second, some specific comments on sections.

Title, author, etc - Do not use To: From: format. A title page is appropriate, but not necessary. Make the title stand out.

Abstract – single paragraph only, do not exceed 200 words (less is better). Do include your results and whether they agree with theory or other experimental results.

Intro and Theory - Put in a paragraph of introduction (what are you trying to accomplish). Do not simply say "The important equation is ...." but develop it. Use references appropriately. Do not include experimental details. Key formulas should be numbered and be put on their own line.

Experimental Method - Use the words "Figure" and "Table." Figure covers diagrams and graphs, table is for organized lists of numbers. Write what you did in narrative style. You are not writing a lab manual, so you should not be using the imperative voice. Don't have lists of equipment. Do not include your results in this section.

Results and Analysis - tell what numbers you measured and explain what you did with them. Properly calculate experimental uncertainties. You do not need to include the steps of your calculations. Percent error (difference between theory and what you got) is meaningless!!!

Conclusions - Do not be trite. Discuss whether the experiment was successful or not, based on your error analysis. If not successful, explain why not. Simply saying human error is not enough.

References - these must reflect specific references in the body of your paper. Unless you were born with the theory in your mind, you had better explain where you got your information.

**Formal Report Final Grade Scoring Sheet** Name_____

Grading of the formal report was done as indicated below.

Title & Abstract (10 points)
___Title and submission information 1 pt
___Techniques description 2 pts
___Results reported, including uncertainties 3 pts
___Comparison to theory 3 pts
___Length (too long?), spelling, grammar 1 pts

Introduction & Theory (13 points)
___Purpose stated 2 pts
___Theory developed for period and diameter relation for ring pendulum 8 pts
___Spelling, grammar, structure, clarity 3 pts

Experimental Method (17 points)
___Completeness (sketches/description of equipment, methodology) 9 pts
___Technique (care in data taking, uncertainties estimated,...) 5 pts
___Spelling, grammar, structure, clarity 3 pts

Results & Analysis (21 points)
___A and δA and n and δn presented 5 pts
___Calculations done correctly 7 pts
___Comparison of results to theory, discrepancies explained 6 pts
___Spelling, grammar. structure, clarity 3 pts

Conclusion (4 points)
___Good summary and closure 4 pts

References (5 points)
___Proper use in body of paper 3 pts
___Citations done correctly 2 pts

Figures & Tables (8 points)
___Referenced properly in paper 2 pts
___Captions done correctly 2 pts
___Correct units, labeling, ... 4 pts

Acknowledgments (2 pts)
___

Draft and Peer Review work (20 pts - scaled from scoring done earlier)
___

_____ Total score 100 maximum possible)