Guidelines for Final Papers
Physics 258-259, Fall 2005

Prepared by E. Eyler, with some borrowing from earlier P258 handouts

I. Grading

Your final paper will normally be based on the last laboratory that you performed, unless you arrange otherwise with your TA. A first draft of the paper must be handed in to me by Friday, November 18. I will read and comment on your draft, returning it after the Thanksgiving break. If special arrangements are needed due to unusual circumstances, email or call me (eyler@phys.uconn.edu, (860) 486-3988). After one or more additional review cycles, a final revised version is due on Friday, Dec. 9, the last day of regular classes. The revision process is mandatory, and it works to your benefit, so be sure to leave enough time for the revision cycle. The relative weights in grading final papers will be approximately as follows:

Scientific logic, analysis of uncertainties, and discussion:	4
Clarity:	3
Style, organization, and appearance:	3
Oral presentation	4

The oral presentation grade will be based on a short final presentation by each student, to be given during the lab period in the last week of classes on Dec. 6, 7, or 8. It should be planned to take no more than ten minutes, and should be based on the content of your final paper. A computer projector for Powerpoint presentations is available, as is an overhead transparency projector.

Major deficiencies include such things as errors of logic, mistakes in the analysis of uncertainties, and conclusions that do not follow from the available information.

Moderate deficiencies often involve a lack of clarity to the point that the reader cannot tell what is meant, including "nonsense sentences." They can also involve sentences that, although clear, make statements that are clearly not intended by their author. Also in this category are omissions of appropriate physical dimensions, major inadequacies in the introduction, or major omissions in the abstract, such as an abstract that omits the results of an experiment. More information is given below on the introduction, the most important part of a paper other than its abstract.

Minor deficiencies can be anything from errors in layout to grammatical or stylistic blunders. A few examples are the use of excessive numbers of significant figures, inappropriate abbreviations, and poorly designed paragraph structure. A very common error in lab reports that I've seen recently is the use of pronouns with ambiguous or incorrect antecedents, particularly the misuse of the word *it*. Here are a few slightly gruesome examples from Robert A. Day's short book, *Scientific English* (2nd Edition, Oryx Press, Phoenix, 1995):

> It is all right to give raw milk to your baby, but first boil it.
> He stole seven bicycles from neighborhood kids. Most were later found in pieces.

Although I have discussed grading first because it's usually first in the mind of a student, this is probably the least important aspect of preparing the final paper. In the remainder of this article I describe some of the mechanics and the craft of creating a good technical document.

II. Getting Started

Think: Who will be the audience for my paper? What is the story I'm trying to tell? How can I tell it so that it will not only be understood, but also appreciated, and even enjoyed?

Once you have decided on the target audience, put yourself in the mind of the reader.

Before beginning to write, decide on the journal to which you will submit your work, and closely follow that journal's recommendations for the format and style of your manuscript. In the case of final papers for Physics 258 and 259, follow the conventions of the *Physical Review*. These conventions are described in the *AIP Style Manual*, available on the Web at http://www.phys.uconn.edu/~eyler/phys258/W/AIP_Style_4th_Ed.pdf, and more specifically, although less readably, in the *Physical Review Style and Notation Guide*, available at http://www.phys.uconn.edu/~eyler/phys258/W/styleguide.pdf.

Next, start the writing process by drafting an outline to define the structure and organization of your paper, subsequently filling in the details. This outline will form the basis of the section headings in the finished product. Detailed remarks on section headings, including several examples, are provided below.

As you design your outline, prepare a list of figures and tables to present your data and illustrate your designs and concepts as needed. You will usually want to prepare preliminary versions of the figures and tables before writing the body text, since they will probably be referenced frequently in the text.

III. General Issues

Clarity is essential in scientific writing, and should be at the forefront of your thinking as you write. Don't use elaborate grammatical and syntactical tricks for effect, if they detract in any way from readability. Simple declarative sentences are entirely acceptable if not used to great excess. Because the scientific community is international, you will find that if you are even moderately successful in science, your papers will have a large readership of non-native English speakers, who take little pleasure in disentangling unnecessary complexity.

Make your writing concise but complete, providing the reader with everything needed to understand your scientific motivation, your logic, your procedures, and your results. The level of completeness required for a scientific journal is much higher than for an article in the popular press that describes the same work. A journal article should provide enough information to enable an intelligent reader to repeat the experimental and theoretical work it describes, without having to contact the author to ask for additional information. In particular, in experimental papers it is essential to provide information on experimental apparatus and procedures, and on methods used for data analysis, unless they are trivial, obvious, or described elsewhere.

Previously established results and methods should be supported by citations, unless they are universally known. For example, no physicist would bother to cite James Clerk Maxwell's book when making reference to Maxwell's equations. Citation styles vary between publications. For Physics 258-259, you should use the citation format of the *Physical Review*. A few examples appear at the end of Section IV below.

Never surprise the reader. Scientific articles do not follow the same conventions as fictional short stories, and the use of prolonged irony or intentionally misleading prose will only confuse the reader. Physics is already difficult enough; there's no need to make it any harder!

Use spelling and grammar checkers where available, but don't rely on them to excess. The following little ditty by Janet Minor is published in another book by Robert A. Day, *How to Write and Publish a Scientific Paper* (5th Edition, Oryx Press, Phoenix, 1998):

> I have a spelling checker
> It came with my PC;
> It plainly marks four my revue
> Mistakes I cannot sea.
> I've run this poem threw it,
> I'm sure your pleased too no,
> Its letter perfect in its weigh,
> My checker tolled me sew.

(By the way, things are slowly improving---my grammar checker correctly flagged one of the errors in this text. Just nine more to go!)

Avoid redundancy, imprecision, and unintended oxymorons. (An example cited by Day: "Monotheism is a gift from the gods.") Good writing is the enemy of bad logic; it's remarkable how often a faulty argument will become obvious if you attempt to set it down clearly in print. Remember that your reader generally has less background information than you, and will be unable to sort out logical reasoning that is stated incompletely or imprecisely.

IV. Sections and Section Headings

In good scientific writing, headings are chosen to aid the reader in understanding the organization of the paper and in locating information. Generally, they should not be chosen in accordance with a rigid prescription, but instead, they should clearly and succinctly indicate the flow of the story the paper tells. The set of "standard" headings distributed in many first-year physics and chemistry courses is a good starting point, but should be altered to fit the needs of each particular situation.

Here are some examples of major section headings taken from the September 1999 issue of *Physical Review A*, picked more or less at random (the typography and indentation are altered for better readability):

1. From a collaboration of theorists and experimentalists:

> Title, Authors, and Contact Information
> Abstract
> I. Introduction
> II. Experiment
> III. Theory
> IV. Potentials and Dipole Moment
> V. Results
> VI. Discussion and Conclusion
> Acknowledgements

2. From a long experimental paper:

Title, Authors, and Contact Information
Abstract
I. Introduction
II. Theory
    A. Phase damping
    B. The two-bit phase damping detection code
    C. Bulk NMR quantum computation
III. Two-bit Code in NMR
IV. Apparatus and Experimental Parameters
V. Results and Discussion
    A. Decoded Bloch spheres
    B. Discrepancies
    C. Overlap fidelity
VI. Conclusion
Acknowledgements
Appendix A: Mixed state description of the Two-bit Code
Appendix B: The Case of Very Different T_2's

3. From a long theory paper:

Title, Authors, and Contact Information
Abstract
I. Introduction
II. Angular Distribution of Photoelectrons from Polarized Atoms in the Nonrelativistic Approximation
    A. General treatment
    B. Single-configuration approximation
        1. Atoms with *S* symmetry
        2. Atoms with *P,D, F* symmetry
III. Implications for the Dichroism in Photoelectron Spectra
    A. Sum rules
        1. Atoms with *S* symmetry
        2. Atoms with *P,D, F* symmetry
    B. Spectral patterns of dichroism in photoelectron spectra
        1. Atoms with *S* symmetry
        2. Atoms with *P,D, F* symmetry
IV. Experimental Examples
    A. Nonresonant photoionization far above threshold
        1. The 3*p* shell of Cr
        2. The 4*f* shell of Eu
        3. The 3*p* shell of Fe
    B. Resonantly enhanced photoionization near threshold
V. Conclusion
Acknowledgements

A few of the sections are so important that they are exceptions to the general remarks about flexibility, appearing without variation in every one of the above examples. Taking these in order, they are:

1. Title, authors, and contact information.

The title should be descriptive but succinct. It should seek to inform and not just to index---use "Measurement of *G* with a Cavendish Pendulum" rather than "Cavendish Pendulum." The author list should follow the format of the journal for which you are writing; here we use *Physical Review* conventions. Here's an example from an article in *Physical Review Letters*:

Observation of Ultracold Ground-State Potassium Molecules

A.N. Nikolov, E.E. Eyler, X.T. Wang, J. Li, H. Wang, W.C. Stwalley, and P.L. Gould
University of Connecticut, Department of Physics, U-46, Storrs, Connecticut 02629

2. Abstract

In an actual scientific publication, the abstract will be widely distributed by electronic indexing services, available throughout the world. It should be a clear summary of the principles, results, and conclusions of the paper, completely self-contained. Its length is typically 5-10% of the length of the main body of the article.

3. Introduction

This is the only part of an article other than the abstract that every reader will examine. If it is unclear or uninteresting, the reader will go no further! It should define the precise subject of the paper, the scope of its coverage, and the purpose of the paper, including its point of view and its emphasis. It should also delineate the organization of the sections that follow, unless there is only a single block of body text. Finally, the introduction should describe the historical context of the work, providing descriptions and citations of any related research by others. Usually it is impossible to write a good introduction until the main body of the article is already complete.

4. Conclusion

This should be a summing up of the paper and a graceful termination, not just a verbatim repetition of the abstract or introduction. The conclusions should follow directly and logically from the data, results and discussion, and should deliver on the promises made in the introduction. This is also the place to summarize additional work still in progress, or to speculate on future possibilities opened up by the results of the present paper. Do this only if you really have something to say. Otherwise, you might leave an unfortunate reader pondering something like the following sentence, which was actually published as the conclusion of a physics article some years ago:

> "Future work is now in progress."

Acknowledgements

Who helped? Who paid for the work?

References

All citations should be collected at the end in a single list. They can be referenced in the text using either an older superscript style, as shown in this example,[1] or a newer style that employs square brackets[2], the currently accepted method in AIP journals. Note that the superscripts follow punctuation marks, but the brackets precede them. The title can optionally be listed after the author list, but does not appear in print in the *Physical Review* journals.

[1]A.N. Nikolov, E.E. Eyler, X.T. Wang, J. Li, H. Wang, W.C. Stwalley, and P.L. Gould, Phys. Rev. Lett. **82**, 703 (1999).
[2]A.N. Nikolov, J.R. Ensher, E.E. Eyler, H. Wang, W.C. Stwalley, and P.L. Gould, Phys. Rev. Lett., to be published.

V. Stylistic Considerations

Good writing style cannot be taught in an afternoon, or even in a month, but a good start can be made by referring to any of several excellent and succinct guides directed specifically to scientists. One very useful reference is a short article by the Assistant Editor of *Reviews of Modern Physics*, Karie Friedman, titled *"Writing a Better Scientific Article."* It is an appendix to the RMP style guide, which is available on the Physics 258 Web page at http://www.phys.uconn.edu/~eyler/phys258/W/rmpguide.pdf. Don't completely ignore the section on p. 31 that is nominally addressed to "Non-Native Writers of English." Some of these mistakes have become common in the writing of natives and non-natives alike! For further information on scientific writing and preparing articles for submission, I recommend the two books: Robert A. Day's short book, *Scientific English* (2nd Edition, Oryx Press, Phoenix, 1995), and Michael Alley, *The Craft of Scientific Writing* (3rd Edition, Springer, 1996).

There are also numerous guides on the more general craft of writing. Arguably the best-known, and certainly the shortest, is the classic book by William Strunk Jr. and E. B. White, *The Elements of Style* (4th Edition, Longman, 2000). It's also available in an illustrated edition, just released by Penguin Press. The illustrator's biography is a minor masterpiece of succinctness carried to humorous extremes:

> "born. bucolic childhood. culture-stuffed adolescence. played piano. stopped. danced. stopped. wrote. discarded writing. drew. reinstated writing. married Tibor Kalman and collaborated at iconoclastic yet successful design studio…"

Of the many larger style guides in common use, the most definitive for writers of American English is the *Chicago Style Guide* (15th Edition, Univ. of Chicago Press, 2003).