Incredibly Useful Advice for Physics Students

Writing a Senior Thesis

Justin Peatross and Michael Ware

A senior thesis submitted to the faculty of
Brigham Young University
in partial fulfillment of the requirements for the degree of

Bachelor of Science

Albert Einstein, Advisor

Department of Physics and Astronomy

Brigham Young University

June 2006

ABSTRACT

Incredibly Useful Advice for Physics Students
Writing a Senior Thesis

Justin Peatross and Michael Ware
Department of Physics and Astronomy, BYU
Bachelor of Science

The abstract is a *summary* of the thesis, *not an introduction*. Keep in mind that abstracts are often published separately from the paper they summarize. In your abstract, give a concise synopsis of the work, emphasizing the conclusions; you need not include the supporting arguments for the conclusions. The purpose of the abstract is to help prospective readers decide whether to read your thesis, but your goal is not necessarily to persuade people to read your thesis. A successful abstract enables people to get an accurate overall view of your work without needing to read it.

Usually, an abstract contains only one paragraph, but it can have more if absolutely necessary. Remember to state the subject of the paper immediately followed by a summary of the experimental or theoretical results and the methods used to obtain them. Avoid equations, graphics, and citations; if a citation is essential it must be cited fully within the abstract. Keep the abstract factual. Avoid vague statements like, “Conclusions are drawn," or “the significance of the experiment is discussed." State the conclusions and findings outright in the abstract.

Keywords: senior thesis, undergraduate research, templates

ACKNOWLEDGMENTS

This page is optional. You may acknowledge whom you will—your advisor, colleagues, family members. Please keep acknowledgments in good taste. I would like to acknowledge Dr. Kristine Hansen and Dr. Elizabeth Hedengren, whose Advanced Writing Seminar motivated this project. I also wish to thank Jean-François Van Huele, Steven Turley, and Ross Spencer for reviewing this document and for ripping it to shreds as every good advisor should do to a thesis draft.

Contents

Chapter 1

Getting Started

1.1 Choosing an advisor

You need a thesis advisor. Try to get one early, preferably before your junior year. If you are unsure who to choose, you might want to visit the undergraduate research opportunites page on the department web site. Visit with prospective advisors during their posted office hours or by appointment. Ask questions about what research they are doing and how you might become involved. Request a tour of any laboratory facilities that the professor uses. Talk to other students who are currently doing research with the professor. Keep in mind that establishing a connection with a professor is a two-way process: You must choose an advisor, but he/she must also choose you. Most professors are happy to have you attend their research group meetings (often held weekly), and this is one of the best ways to get a feel for what they do in their group.

1.2 Themes for projects

When choosing an advisor (and after the choice is made), discuss potential senior thesis projects at every opportunity. This will prod your advisor to think about your specific case, and he/she

will more quickly recognize the right project for you in the research group. Of course, you can give as much input as you like. However, please recognize that professors in general are already committed to certain research agendas. The best tack in the beginning is to assist more experienced students with their research project as you “learn the ropes." You will be amazed at how projects become more interesting when you are involved with them. The problem that you identify as the basis for *your* senior thesis will soon become extremely interesting.

1.3 Financial support

Each summer the Department of Physics and Astronomy supports over a dozen students at 20 hours per week while they work on their senior- thesis research. This means that you can get paid for fulfilling your graduation requirement. To be selected for this, you must submit a simple online proposal,usually due in late February. To apply, go to the department website click on Undergraduate and then Student Employment. In addition, the department supports a limited number of students at about 10 hours per week to do research during the Fall and Winter Semesters. Many professors have research funds that are earmarked to pay undergraduate research assistants.

The Office of Research and Creative Activities (ORCA) also holds a scholarship competition each fall for students involved in research. The award amount is about $1,500 and you can get this on top of the summer or school-year funding. The application deadline is usually early October, and you may apply online. From the BYU home page, choose Students, then Academic Lenis, and then Research Support. For those doing an Honors Thesis, there are some funds available through the Honors Program. Qualifying minority students can apply (through their professor) for funding from the Western Alliance to Expand Student Opportunities (WAESO): (http://www.asu.edu/WAESO).

Finally, you should be aware of the *Research Experiences for Undergraduates* (REU) pro-

gram sponsored by the National Science Foundation. Many universities across the nation participate in this program (including BYU). These universities host undergraduates (mainly from other institutions) and involve them in research during a few summer months. Applications are usually due in February. Visit the National Science Foundation web site of *Student Interests* (http://www.nsf.gov/crssprgm/reu/). Under the heading *For Undergraduate Students*, click on *list of REU sites* for a complete listing of sites and contact information. Please be aware that there are also international REU opportunites as well, which a Google search can help identify.

It is possible to use your REU research away from BYU as the basis for your senior thesis. If you do, try as much as possible to prepare your thesis *while* you are participating in the REU program. Ask the professor with whom you are working to help you to revise your thesis during the visit. Get started early to allow time for revisions. As part of the REU program, you will be required to write a report on your research experience. While a thesis is much more than a report, you can use your thesis (or portions thereof) in the report. For purposes of completing your senior thesis, you will need a thesis advisor at BYU. Choose one before you go to the REU site. After you return, your BYU advisor can help you to revise your thesis and see that it is satisfactory for submission to the department.

1.4 Academic journals

New physics research is published mainly in journals, rather than textbooks. Journals are collections of scientific articles that undergo scrutiny through an anonymous peer review system. Physicists mainly publish articles about their research in these types of journals. Therefore, journals should be the primary source of background and contextual information in your thesis, as opposed to web sites, for example, which are probably not peer reviewed. Conference proceedings are another important source of information. They are collections of short articles submitted by

participants at scientific conferences.

It takes time for the more relevant information to find its way from journals into textbooks, so it is essential that you study journal articles so you are up to date with the field. Some of the more prestigious physics journals are Physical Review A, B, C, D, and E, and Physical Review Letters, which are published by the American Physical Society (APS). There are dozens of other reputable physics journals, often emphasizing specialized areas, almost all of which can be found in the large new atrium underground wing of the HBLL. However, it is rarely necessary to visit the library to find articles, since almost all of them journal articles can be accessed online. The library pays subscription fees that enables electronic access to the journal archives from any BYU-campus computer.

1.5 Searching for Literature

An electronic search engine is by far the most important tool for finding relevant research information. One of the easiest to use is http://scholar.google.com. Just type in key words or author names and see what comes up. Often there are links to the journal archives, which usually automatically know that you are connected through BYU (a subscriber), and so they allow you to download articles.

The library maintains enormous resources to help you find literature, many of which are probably unfamiliar to you. Contact John Christensen (2323 HBLL, 422-2928) who is the Library Subject Specialist for Physics and Astronomy. He holds training sessions periodically on how to use library resources *for physics research*. **Attend a training session**. He gets paid to teach you. Get as many of your peers in the department as you can to go with you. This training can be more valuable than five quantum-mechanics lectures!

Search engines specifically designed for searching science journals can be accessed through

the Harold B. Lee Library web site (http://www.lib.byu.edu). Choose Find Articles and then select a subject such as Physics. Two excellent search engines are SPIN and Web of Science. You should be aware that BYU pays a lot of money for access to search engines such as SPIN and Web of Science. BYU pays this money partly for *your* sake, so please take advantage of the service. There are other search databases which may wish to try. It is important to use several to make sure to get good coverage in your search. For example, although SPIN is very nice to use, it does not return results from European journals. There are some very good physics search engines such as INSPEC to which BYU does not subscribe (because it is very expensive). Contact John Christensen (2323 HBLL, 422-2928) to be directed to a librarian who can run searches on INSPEC for you. Short searches are complimentary to students, but there is a modest fee for lengthy searches.

1.5.1 Effective searching

When beginning a search, you may initially want to restrict it to articles published in recent years (say, last 10 years) in order to avoid getting deluged with “hits." (The library search engines give you much more control of your search parameters than does scholar.google.com.) You will probably want to begin the search using key subject words. As you locate relevant titles, read the abstracts to decide which articles are important to you. As you find relevant articles, follow up with searches using author names. This may turn up additional related articles. As you search, you will likely encounter dozens of potentially relevant articles. A good search will probably take a few hours as you read over many abstracts.

You will be able to download most articles to your computer in PDF format. If a journal is unavailable, you can order a copy of an article through the Interlibrary Loan Service (free to you, but not free to the library). After acquiring a few articles, begin to read them (or skim) to further assess relevance. Especially pay attention to the introduction where authors summarize the relevant publications of others. Doing this, you will find many new references. This is an efficient

and very important way to network your search back in time. You are relying on other experts in the field to point you towards seminal research articles. As you find these important papers, use the Science Citation Index, which will point you to papers that have referenced them. This is the way to network forward in time.

Take your time as you search for articles in your field. A poor strategy is to download blindly a long list of potentially useful articles. Rather, decide whether articles are relevant as you go. Make notes to yourself about the content of different papers. Include any references that you received from your advisor in your search from the very beginning. Those articles will often be the most important. After many hours of using search engines and finding articles in the library, you may have considered more than 50 different articles and found more than a dozen that are very relevant to your research. You will likely summarize a number of these in your thesis introduction and refer to many of them at relevant points throughout your thesis. You may have occasion to refer to a few books as well, so don't forget to do library searches for books related to your topic.

1.6 Reading and understanding the literature

Don't be discouraged when attempting to read physics research articles. Feeling utterly lost is quite normal, even for experienced physicists. It takes time to penetrate physics articles, since the information is often presented very compactly, intended for other experts in the field. It is helpful to initially read only the abstract, the introduction, and the conclusion. You might save the interior of important papers for a discussion with your advisor, perhaps during a group meeting. As you read more scientific papers, you will acquire a feel for the overall structure and flow, the manner of documentation and reasoning. In fact, it is exactly this efficient and well-mannered approach to technical writing that should go into your thesis (with a somewhat different audience in mind).

If you struggle to understand articles, you may have trouble with more than just the physics.

Ask someone to read and discuss the article with you. You may be surprised at how well a good reader, even one without a physics background, can identify key issues and conclusions.

Chapter 2

Writing Matters

2.1 Lab Notebooks and Journals

Once you identify your research project, you should immediately begin the writing process. The initial writing process may begin in your lab notebook or journal. (A good physicist keeps a lab notebook or journal.) If you are working on an experimental project, keep track of all the details of your experiment (equipment settings, layouts, etc.) as you make measurements. It is human nature to assume that you will remember these things, but you won't. Writing a thesis is much easier if you can refer back to a good set of notes. As you study papers, also take notes so you can recall where important ideas are discussed.

2.2 Creating an outline

Make an outline (as best you can envision) of your thesis before starting to write prose. An example of such an outline is shown in Table 2.1. In this example, the primary student research project is represented in section 2.3. The student will work on a spectrometer which is just one part of a larger research project involving other group members. Nevertheless, the thesis will encompass the

Title: Development of a Spectrometer to Study the Influence of Counter-Propagating Light on High-Order Harmonic Generation

Chapter 1: Introduction	**Chapter 2:** Experimental Setup	**Chapter 3:** Results
1.1 Overview	2.1 Laser System and Pulse Characteristics	3.1 Measurement of High Harmonics
1.2 Background	2.2 Experimental Setup	3.2 Influence of Counter-Propagating Light
1.2.1 Laser Harmonic Generation	2.3 High Harmonics Spectrometer	3.3 Interpretation of Results
1.2.2 High Harmonic Generation	2.3.1 Design Overview	3.4 Conclusion and Future Outlook
1.2.3 Phase Matching and Conversion Efficiency	2.3.2 Diffraction Grating	
1.3 Using Counter-Propagating Light to Manipulate Phase Matching	2.3.3 Imaging Issues	
	2.3.4 Positioning Controls	
	2.4 Detection	

Table 2.1 Sample outline for a senior thesis.

overall purpose and results of the entire project (even though this will overlap with theses written by other students). Other students, for example, may have developed the equipment described in sections 2.1 or 2.2, and so these items would naturally be emphasized in detail by them (in their theses).

The overview section (1.1) should motivate the reason for the research without relying on specific background that will be introduced in the later sections. You should include general motivational statements (that you might give, for example, to a science news reporter) as in the following example: “Laser high-order harmonic generation is a unique source of directional and bright extreme ultraviolet radiation (EUV). This short wavelength light source may have future applications in ultrafine resolution photolithography. Because the high harmonics are coherent and generated with short pulse lasers, they can be used to probe ultrafast phenomena when high-energy photons are needed..." The overview should also provide the reader with a clear demarcation of the scope of your contribution to the overall project.

Near the end of Chapter 1, as you narrow to the specific problem to be addressed, be sure to provide a more detailed outline of the overall project than was given in the opening section. Again, be specific about your role in the project. Briefly introduce and summarize what will be discussed in the remainder of the thesis. As is evident, the content of the first chapter depends strongly on

what is written in subsequent chapters. Therefore, the first chapter is typically the last chapter to be completed. Nevertheless, it should also be one of the first chapters that you begin to write.

It may happen that, while a student makes a meaningful contribution to the overall project, the final results are not obtained before the senior thesis is submitted. This is not ideal, but this happens to students quite often. In this situation, the final chapter might be entitled “Discussion." If attempts were made at obtaining data, the concluding chapter might describe the reasons (especially reasons involving physics) why the attempts were unsuccessful. The final chapter should provide suggestions on how to remedy the situation (which can be helpful to future students who continue the project). If the data-taking stage is not reached, the concluding chapter might describe preliminary checks of equipment and expected roles for the new equipment in the overall project.

The format suggested in Table 2.1 is very flexible and would likely be somewhat different, for example, in the case of a thesis based on theoretical work. You should decide what works best for you in consultation with your advisor. You may want to examine several senior theses written by previous students which are available in the physics department reading room (N288). There are examples of good and not-so-good theses there. Exemplary theses were written by Shannon Lunt, Deborah Paulsen, and Michael Ware.

2.3 Basic mechanics

It is not your advisor’s job to fix mechanical errors in your thesis such as punctuation, dangling or misplaced modifiers, or shifts in tense and perspective. However, these problems often get in the way of what students are trying to say and can make a manuscript unreadable. Most students have serious difficulties with the mechanics of writing. If you think you don’t, ask yourself whether you understand the difference between “effect" and “affect." Should the period in the previous sentence be placed before or after the quotation mark? Fortunately, you can get help from the BYU Writing

Paragraph Unity and Coherence	Comma Splices and Fused Sentences
Dangling and Misplaced Modifiers	Punctuating Quotations
The Zen of Pronoun Usage	Active vs. Passive Voice
Shifts and Perspective Defined	Combining Sentences
Punctuating Parenthetical Words or Word Groups	

Table 2.2 A sampling of handouts available from the Reading Writing Center.

Center. Visit their web site right now (http://english.byu.edu/writingcenter/) and download a series of their one-page handouts that you think will be most helpful to you. You may especially consider downloading the handouts listed in Table 2.2.

Before submitting drafts of portions of your thesis for review by your peers and by your advisor, always have the common courtesy of doing the simple things:

1. Run your spell checker.
2. Re-read your document *at least* a day after you have written it and fix all of the obvious things.
3. Use correct page layout and formatting, including double spacing so that editors can insert comments.

Near the beginning of the writing process, you may want to take advantage of one-on-one feedback from a tutor in the Writing Center, which is a free service. Make a half-hour appointment to discuss any aspect of the writing process. Be aware that the tutors will not edit your thesis.

2.4 American Institute of Physics Style Manual

The American Institute of Physics (AIP) promotes physics research and education in the US and world wide. Their member societies include such organizations as the American Physical Society

(APS) and the Society of Physics Students (SPS). To promote uniformity and clarity of writing throughout the physics community, AIP publishes a Style Manual (AIP 1990) that standardizes the rules for good physics writing. Most physics journals adhere to the AIP style manual, and you should become familiar with it as you write your thesis. Download the style manual from the the American Institute of Physics web site (http://www.aip.org/pubservs/style.html) and study the section titled “Writing the paper" starting on page 6. This is worth more than ten quantum mechanics lectures! (I am not implying that quantum mechanics is unimportant.) Of course, there are many other sections in the AIP style manual that would be good for study. (Note: Astronomy journals follow slightly different style rules, but for department purposes astronomy students are permitted to follow AIP style rules.)

2.5 References

You will be tempted to delay including references in your thesis until the end of the writing process. This is a big mistake. Prepare your list of references as you go, from the very beginning of the writing process. Otherwise, you may fail to give appropriate credit when you summarize ideas and results, which is a form of plagiarism. Do not reference work that you have not read (at least in part including the introduction and conclusion). Developing your list of references as you write is much less work in the end.

Students often think that the references are not important and are careless when transcribing author and journal names. You must double check each detail of every reference listed. Scientists get very annoyed when their names are misspelled. Journal editors, referees, and type setters get very annoyed when misinformation and incorrect protocol are used in references. Advisors get annoyed when they have to correct the reference lists in theses because students are casual about it. The references matter. A list of various references appears at the end of this document as examples.

The list includes a reference to a journal article (Peatross et al. 2000), a reference to a page in a book (Jackson 1998), a reference to multiple pages in a book (Born & Wolf 1980), a reference to an individual author contribution to an edited volume (Peatross et al. 1996), a reference to a conference proceeding (Peatross et al. Santa Clara, CA, Sept. 1999), a reference to a work that is not yet published (Ware et al. to be published), a reference to a dissertation (Peatross University Rochester, Rochester, N.Y., 1993), a reference to a web page (David Accessed April 15, 2006), and a reference to a private communication (Peatross 2008). The AIP style manual includes examples of other types of references. It also has a complete listing of abbreviations for journal titles (see Style Manual Appendix G).

For most physics students, reference numbers should appear in square brackets throughout the text in numerical order (as shown in the previous paragraph). For astronomy students, the references should be in Author-Year format like this: (Jackson 1998). The same reference number may appear more than once in the text, but undue repetition should be avoided. Place your reference list at the end of the thesis unless your advisor asks for something different.

2.6 Equations

Punctuate equations appropriate to the sentence that contains them (AIP 1990). (You get a brownie point if a sentence structure requires a question mark immediately following an equation, but this rarely occurs.) Let entire equations function as a noun (or the restatement of a noun) in a sentence, although it is permissible to allow an equal sign to function as a verb (less desirable). All significant equations should be offset to a line of their own and given a reference number. Small and less important equations can be embedded within the text unless they require line numbers for later reference. The equations in chapter 1 should be indexed as (1.1), (1.2), etc., and the equations in chapter 2 indexed as (2.1), (2.2), etc. The example below, extracted from the middle of an article,

shows a variety of equation usage.

We use a time expectation integral (proposed by Smith in 1970 (Smith 1970)) to specify the arrival of the pulse:

$$\langle t \rangle_{\mathbf{r}} \equiv \int_{-\infty}^{\infty} t \rho \left(\mathbf{r}, t \right) \, \mathrm{d}t, \tag{2.1}$$

where $\rho \left(\mathbf{r}, t \right)$ is a normalized temporal distribution of the Poynting flux at $\mathbf{r}$:

$$\rho \left(\mathbf{r}, t \right) \equiv \hat{\eta} \cdot \mathbf{S} \left(\mathbf{r}, t \right) \Big/ \hat{\eta} \cdot \int_{-\infty}^{\infty} \mathbf{S} \left(\mathbf{r}, t \right) \, \mathrm{d}t \, . \tag{2.2}$$

As usual, the Poynting vector is defined as

$$\mathbf{S} \left(\mathbf{r}, t \right) \equiv \mathbf{E} \left(\mathbf{r}, t \right) \times \frac{\mathbf{B} \left(\mathbf{r}, t \right)}{\mu_0}. \tag{2.3}$$

The denominator of (2.2) may be transformed immediately via Parseval's theorem

$$\int_{-\infty}^{\infty} \mathbf{S} \left(\mathbf{r}, t \right) \, \mathrm{d}t = \int_{-\infty}^{\infty} \mathbf{S} \left(\mathbf{r}, \omega \right) \, \mathrm{d}\omega, \tag{2.4}$$

where the frequency representation of the Poynting vector is given by

$$\mathbf{S} \left(\mathbf{r}, \omega \right) \equiv \mathbf{E} \left(\mathbf{r}, \omega \right) \times \frac{\mathbf{B}^* \left(\mathbf{r}, \omega \right)}{\mu_0}. \tag{2.5}$$

2.7 Figures

Take the time to generate professional-looking artwork for your thesis. Schematics of experimental setups should be simple, well organized, and labeled as illustrated in Fig. 2.1. Use vector graphics rather than raster graphics unless the figure is a photograph. Figure captions should be concise and descriptive. Write figure captions using a smaller font (10 point). For graphs, be sure to include appropriate units and to provide a legend referring to the different curves as in Fig. 2.2. Each figure should be described carefully within the text of your thesis.

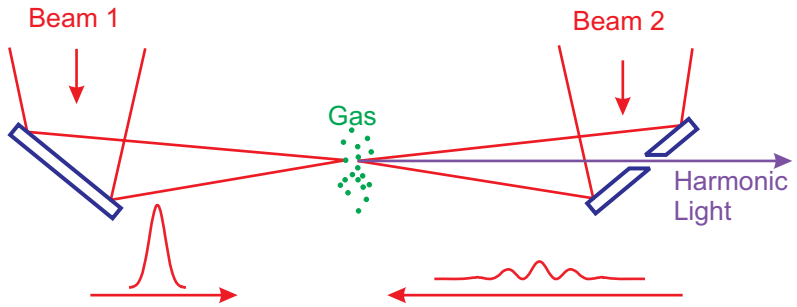

Figure 2.1 A mirror with a hole is used to extract high-order harmonics generated in counter-propagating laser beams.

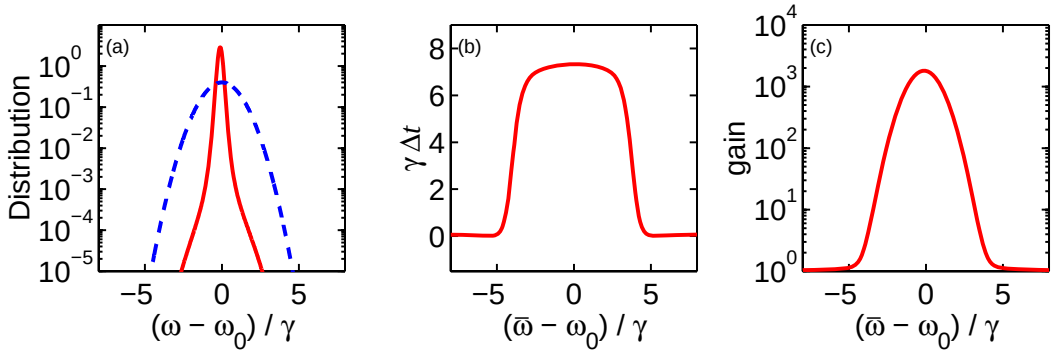

Figure 2.2 (a) Normalized spectral distribution ρ for the broadband pulse centered on resonance before (dotted) and after(solid) propagation. (b) Total delay as a function of $\bar{\omega}$ for the broadband pulse. (c) Overall pulse transmission as a function of $\bar{\omega}$

Chapter 3

Clear Thinking

3.1 Importance of feedback

Obtain feedback at every step of the writing process. Go over your outline with your advisor. It is much less painful to rearrange or to delete sections before you write them, when they are represented merely in outline form. Make brief notes indicating what will go into each section (e.g. a summary of research by Group X and Y, a schematic of an experimental setup, a blowup view of a critical part, etc.). Discuss your initial ideas and brainstorm together with your advisor.

You should start writing portions of your thesis early, even though some sections will need to wait until after the research is concluded. When possible, begin making figures—even hand-drawn sketches in your lab notebook. Remember to develop the overall outline before writing specific sections. This helps to avoid writing material that might later have to be discarded. As you write portions of your thesis, show them to your advisor and to other members in your research group for valuable feedback. Your advisor will be much happier reviewing short pieces of your writing periodically, as opposed to reviewing it all at once near the due date. As you receive feedback along the way, you can apply it to sections not yet written. The periodic feedback helps you to

revise and reshape your outline continually and guides you in developing a clear scientific writing style. The writing process forces you to organize your thoughts and to keep a clear vision of your research. This helps you to avoid long periods of stagnation by bringing to the foreground the next logical step in the research. The important thing is to keep moving forward. No matter what, you will make many mistakes, so try to make them as fast as you can. This is the difference between experience and inexperience.

3.2 Audience

You should consider as your audience the other students in your research group. In particular, after you graduate, your thesis might be used as a resource for students who will move into your former role. Avoid making your thesis too basic; you may assume a certain level of sophistication on the part of the reader. However, the thesis should be easily understandable to a physics professor whose research expertise is in a different field.

3.3 Coherence

Just as the overall outline of the thesis should have a clear and logical organization, the sequence of information presented in each section and paragraph should also follow a logical flow. Continually ask yourself which paragraphs should appear before others. You should be aware of a key sentence in each paragraph which usually appears near the beginning and defines what the paragraph is conveying. If a paragraph is very lengthy, don't hesitate to break it into two (at a logical place). Read your own writing for logical progression and for smoothness. Develop the skill of crafting smooth transitions.

3.4 Conciseness

Cut out the lard. Avoid long strings of prepositional phrases in sentences of theses written by students in their senior year for the physics department at BYU as a graduation requirement for the degree of Bachelor of Science. (Did you get the joke?) Use simple declarative sentences often, but not exclusively. Make every word count. Vary sentence length. Intermingle short with long sentences in an aperiodic fashion. You might inadvertently kill a reader with boredom if your sentences all have the same length.

In your writing, be as quantitative as the subject matter permits, and avoid inexact word usage. Continually ask yourself how your writing might be misinterpreted. Make sure that arguments are logically complete.

3.5 Active voice

Remember that active verb construction generally captures the reader's attention more than does passive construction. This does not mean that passive voice should never be used. Just keep in mind that an over reliance on passive verb construction results in a rather bland document.

3.6 Document format

This document has been written following the format requested for your thesis. Use a 12 point serif font such as Times for the main text. If you desire variation, you can use a sans serif font such as Helvetica for chapter and section headings. Set the margins to one inch on all sides. Allow the right-hand side of the text to run ragged if you use a regular word processor; text is easier to read if it is not stretched and compressed in order to create a straight right margin. LaTeX is a little fancier in its hyphenation and word spacing and can usually pull of full justification fine. Double

space your lines. This makes the text easier to read and allows for the insertion of mathematical expressions into the text without disrupting the line spacing.

Use page breaks judiciously so that section headings do not become isolated from their subsequent text on the bottom of a page. Strategic positioning of figures within the text can help to avoid large white spaces created when a figure's size forces it onto the next page. If possible, you should avoid inserting figures before they are discussed in the text. Your document should be printed single-sided if it is less than 50 pages. However, if preferred you may position figures on the backs of pages if this facilitates keeping them close to the text describing them (located on the adjacent page).

This document was prepared using LaTeX. Many professors and students choose to use LaTeX or variants such as REVTeX (a form used by APS journals like Physical Review Letters). LaTeX can be downloaded free of charge. For more information, go to the website of the TeX Users Group (www.tug.org). Supplementary REVTeX macros can be obtained from the website of the American Institute of Physics (www.aip.org). You can also use Microsoft Word and MathType (or the built in equation editor) for equations if you prefer. Check with you advisor to find out which option will work best for you.

3.7 Appropriate length

How long does a senior thesis need to be? The answer is that it should be as long as necessary to communicate your ideas succinctly. There is no set length. The written document is not an end in itself, but a vehicle to convey your ideas as efficiently as possible to the reader. However, if the main body of your thesis (excluding title pages and appendixes) is only 10 pages, you probably have not included sufficient context and motivation for your work. If the main body of your thesis exceeds 30 pages, you are probably not concise enough. Professors and others don't really want

to read a lot of pages. A long thesis may also mean that you have done more work than expected. Remember, you are not asked to complete a masters project, rather a comparatively modest project in your senior year. In the example in Table 2.1, the introduction chapter might have 8 pages, the experimental setup chapter might have 11 pages (emphasizing the work actually performed by the hypothetical student in the example), and the results chapter might have 6 pages (assuming results are obtained through a group effort).

3.8 Deadlines

You must register for 2 credit hours of Physics 498R (499R if you are in the honors program, 492R if you are in applied physics) in any semester before graduation (usually when you are actively involved in the research). At the end of the semester, if the thesis is still in progress, you will receive a T grade. Then, when your thesis is completed, your advisor will change it to a letter grade. In order to allow for an adequate evaluation period, your thesis should be submitted for review at least six weeks before graduation. (Honor's theses are required ten weeks before graduation, submitted first to the Honor's program and then indirectly to the department.) After the thesis has been approved and signed by your advisor, take it to the Senior Thesis Coordinator, currently Eric Hintz. If it meets the established criteria, the Senior Thesis Coordinator will recommend your thesis to the Department Chair for acceptance. The Coordinator will then forward the manuscript for binding and archiving in the Physics Department library and web site.

Appendix A

Things that belong in an appendix

The purpose of an appendix is to provide supplementary information which would distract if included in the main body of the thesis. Items appearing as an appendix might include lengthy derivations. If students feel compelled to include a brief tutorial on relevant background information (not new research), it should appear as an appendix. An appendix might also consist of portions of unique computer code that was developed as part of the project.

Appendix B

Presenting a talk

When presenting your thesis work in a talk, you will want to convey an overview of your thesis as a whole. However, you must pick and choose what to emphasize since time will be limited. There is no formal oral defense requirement for the senior thesis (although there is for an Honor's Thesis). However, the department encourages students to make at least one formal presentation on their research. All students doing a senior thesis, and especially those receiving department funding, are expected to participate in the annual Student Research Conference held each March here at BYU. Depending on available travel resources, students may also have the opportunity to present a talk at a professional meeting outside of campus.

For short talks, you should have no more than two thirds as many slides as you have minutes allocated for your talk. For longer talks, you should have somewhat fewer slides. Create a title page which acknowledges everyone who has contributed to the work. Prepare an outline slide that will let the audience know what you are going to be presenting. (If time is extremely short (e.g. 7 minute talk), you may dispense with the outline slide.) At least a third of your talk should be introductory in nature, providing background that will help the audience appreciate the work. The main goal in giving a talk is to convey to the audience a sense that your work is important; the goal is not to give the audience a lot of details which they will never remember nor even get straight in

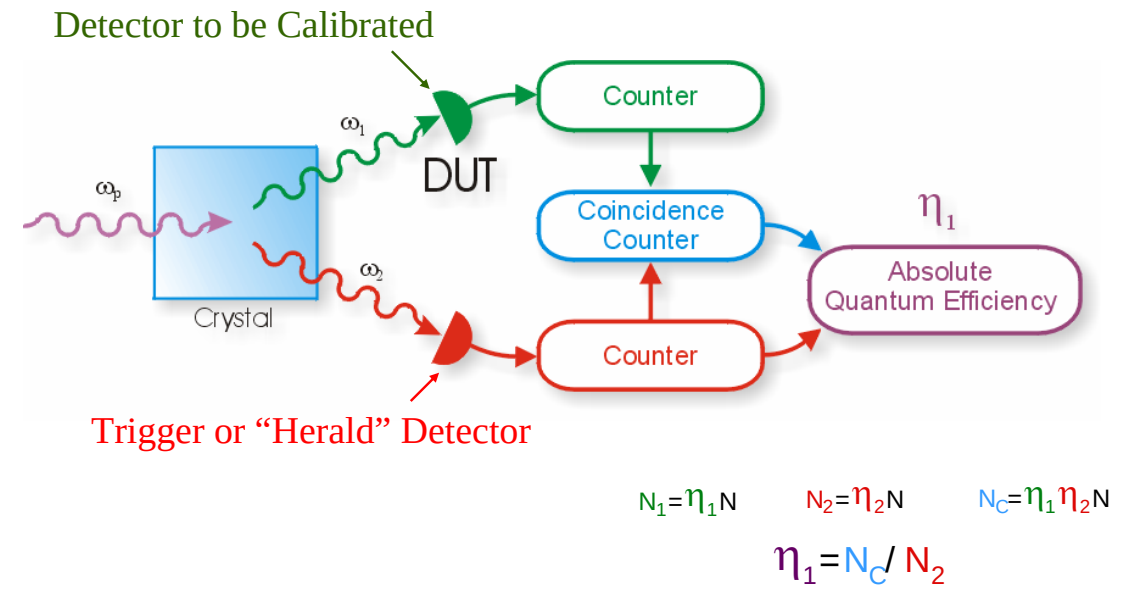

Figure B.1 A sample slide from a presentation

the first place. Less is more. A conclusion slide can be used to remind the audience of your main points and to summarize the significance of your work. Keep it brief. The conclusion slide may be omitted if it seems too redundant, depending on how you presented the material.

Many of the figures that you prepare for your thesis will be useful for your slide presentation. Keep slides simple and uncluttered. Include less information on a view graph than you plan to talk about. Be sure that important labels are present (such as the units on graph axes). Use large fonts so that your slides are easy to read, even for people in the back. It is a good idea to place a single large "header" sentence at the top of each view graph (no more than two lines using a 24 point

font). Think of the main idea that you want an audience member to get from a slide, and use that for the header sentence. These headings can help keep you on track and help the audience member who's mind has temporarily wandered to catch up to you. Use color freely, but keep it tasteful. Figure B.1 shows an example of a view graph.

Practice your talk to yourself and to others in your research group, especially your advisor. Time your practice runs. If you do not practice, you will most likely give too many extraneous details and muddle through or even miss your main points for lack of time, a sure recipe for a boring talk.

Bibliography

AIP. 1990, AIP Style Manual, 4th edn. (Woodbury, NY: American Institute of Physics)

Born, M., & Wolf, E. 1980, Principles of Optics, 6th edn. (Oxford: Wiley), 20–23

David, K. Accessed April 15, 2006, http://www.intel.com/technology/silicon/lithography.htm

Jackson, J. D. 1998, Classical Electrodynamics, 3rd edn. (New York: Wiley), 23

Peatross, J. 2008, Private communication

—. University Rochester, Rochester, N.Y., 1993, Ph.D. dissertation

Peatross, J., Dibble, W. E., Glasgow, S. A., & Ware, M. Santa Clara, CA, Sept. 1999, presented at the 15th Annual Interdisciplinary Laser Science Conference (OSA/ILS XV),

Peatross, J., Glasgow, S. A., & Ware, M. 2000, Phys. Rev. Lett., 84, 2370

Peatross, J., Zhou, J., Christov, I., Rundquist, A., Murnane, M. M., & Kapteyn, H. C. 1996, in High Technology, Vol. 13, Proceedings of 4th Conference on Super Intense Laser-Atom Physics (SILAP IV, Moscow, Russia, August 1995), ed. H. Muller & M. V. Fedorov (Dordrecht/Boston/London: Kluwer Academic Publishers), 455–466

Smith, R. L. 1970, Am. J. Phys., 38, 978

Ware, M., Dibble, W. E., Glasgow, S. A., & Peatross, J. to be published

Index