Writing an Honours Thesis

some notes by
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What is an honours thesis? For whom is it written? How should it be written?

In most cases, your thesis is a real research report. The report concerns a problem in physics and it should describe what was known about it previously, what you did towards solving it, and what you think your results mean.
A thesis is not an answer to an assignment question-there is a big difference. The reader of a student's assignment is usually the teacher who has set it. S/he already knows the answer (or one of the answers), not to mention the background, the literature, the assumptions and theories and the strengths and weaknesses of them.
The readers of the thesis will not know what the "answer" is-usually your research project is to discover something hitherto unknown. More importantly, one of the readers (the examiner who is not your adviser) will have at best only a basic idea of the relevant background, literature etc. Write for that reader-your adviser will not be too bored while you explain it: it is always interesting to read something about one's own field put in different words.
Your thesis will, of course, be read and marked, and then put away on a shelf in the School library. However it may also be used seriously in the future as a scientific report, especially by future research students working on related projects. Write your report with this audience in mind.

The structure.

The list of chapter headings suggested below may be appropriate for some theses. In some cases, one or two of them may be irrelevant. Results and Discussion are often combined in one chapter. Think about the plan of chapters and decide what is best to report your work. Then make a list, in point form, of what will go in

each chapter. Try to make this rather detailed, so that you end up with a list of points that corresponds to subsections or even to the paragraphs of your thesis. At this stage, think hard about the logic of the presentation: within chapters, it is often possible to present the ideas in different order, and not all arrangements will be equally easy to follow.
Once you have a list of chapters and, under each chapter heading, a list of things to be reported or explained, you have struck a great blow against writers' block. When you sit down to type, your aim is no longer a thesis - a somewhat daunting goal - but something simpler. You will start by writing the paragraph or section about one of your subheadings. It helps to start with an easy one: this gets you into the habit of writing and gives self-confidence. Often the Materials and Methods is the easiest to write - just write down what you did.

Abstract.

This is best written towards the end, but not at the very last minute because you will probably need several drafts. It should be a distillation of the thesis: a concise description of the problem, your method of solving it, your results and conclusions. An abstract must be self-contained. Usually they do not contain references. When a reference is necessary, its details should be included in the text of the abstract (Jones, P. 1987, J.Abs.Soc. 13, 25).

Introduction.

What is the problem and why is it important? Make the problem quite clear: and remember that you have been working on this project for a few months so you will be very close to it. Try to step back mentally and take a broader view of the problem. How does it fit into the broader world of physics? Especially in the introduction, do not overestimate the reader's familiarity with your field. Physics is pretty specialised and most of us are unable to keep pace with developments in all fields. You are writing for a physicist, but not a specialist. It may help to imagine such a person - think of some physicist who knows almost nothing about your field (if your thesis is in solid state physics, for example, imagine you are trying to explain it to me). This section should be interesting. If you bore the reader here, then you are unlikely to revive his/her interest in the materials and methods section. For the first sentence or paragraph, tradition permits prose that is less dry than the scientific norm. If want to wax lyrical about your topic, here is the place to do it. Try to make the reader want to read the slab of A4 that has arrived uninvited on his/her desk.

Literature review.

Where did the problem come from? What is already known about this problem? What other methods have been tried to solve it? This is often a difficult chapter to write: you have only been in the field for three months and you are trying to review it! Journal review articles are helpful to give you an idea, as are the literature review chapters in the Ph.D. theses of students from the same lab. Unless your thesis is a review thesis, the review need not be exhaustive, but you will need to make it clear to the reader that you are familiar with the state of knowledge in the area of your thesis.

Materials and Methods.

This varies enormously from thesis to thesis, and may be absent in theoretical theses. The important thing to remember is that it should be possible for a competent physicist to reproduce exactly what you have done by following your description.

Theory.

You do need to include sufficient material to allow the reader to understand the arguments used and their physical bases.
Sometimes you will be able to present the theory *ab initio*, but you need not reproduce 20 pages of algebra that the reader could find in a standard text.
Concentrate at least as much on the physical arguments as on the equations! What do the equations mean? What are the important cases?

Results.

The data often take the form of graphs, though this varies from thesis to thesis.
Make sure that you have described the conditions which obtained for each set of results. What was held constant? What were the other relevant parameters? Make sure too that you have used appropriate statistical analyses. Where applicable, show measurement errors and standard errors on the graphs. Use appropriate statistical tests, such as t and chi squared.
Take care plotting graphs. The origin and intercepts are often important so, unless the ranges of your data make it impractical, the zeros of one or both scales should usually appear on the graph. You should show error bars on the data, unless the errors are very small. For single measurements, the bars should be your best estimate of the experimental errors in each coordinate. For multiple measurements these should include the standard error in the data. The errors in different data are often different, so, where this is the case, regressions and fits should be weighted (i.e. they should minimize the sum of squares of the differences weighted inversely

as the size of the errors.) (A common failing in many simple software packages that draw graphs and do regressions is that they do not treat errors adequately. UNSW student Mike Johnston has written a plotting routine that plots data with error bars and performs weighted least square regressions. It is at http://www.phys.unsw.edu.au/3rdyearlab/graphing/graph.html)

Discussion.

What do your results mean? How do they fit into the existing body of knowledge? Are they consistent with current theories? Do they give new insights? Do they suggest new theories or mechanisms?

Conclusions and suggestions for further work.

Well, what did you find? It is often the case with scientific investigations that more questions than answers are produced. Does your work suggest any interesting further avenues? Are there ways in which your work could be improved by future workers? This section should usually be only a page or three.

References.

How many do you need? There are often hundreds of references in a Ph.D. thesis. The appropriate number in an honours thesis varies between say several for a highly specific technical project, to perhaps a hundred in a thesis whose main component is a literature review.

Appendices (if any).

If there is material that should be in the thesis but which would break up the flow or bore the reader unbearably, include it as an appendix. Computer programs are often included as appendices, as are data files that are too large to be represented simply in the Results section. (Computer programs should be intelligibly annotated.) Examiners usually read appendices only superficially.

General notes:

How much detail?

More than for a scientific paper. Once your thesis has been marked, and your mum and dad have read the first three pages, the only further readers are likely to be people who are seriously doing research in just that area. For example, a future research student

might be pursuing the same research and be interested to find out exactly what you did. ("Why doesn't the widget that Bloggs built for her honours project work any more? Where's the circuit diagram? I'll look up her thesis." "Nerd's subroutine doesn't converge in my parameter space! I'll have to look up his thesis.") It is traditional to include workshop drawings, circuit diagrams and computer programs, usually as appendices. Ideally, programs should be intelligibly annotated but this practice is as frequent as porcine aviation.
You have probably read the theses of previous students in the lab where you are now working, so you probably know the advantages of a clear, explicit thesis and/or the disadvantages of a vague one.

Make it clear what is yours.

If you use a result, observation or generalisation that is not your own, you must usually state where in the scientific literature that result is reported. The only exceptions are cases where every physicist knows it: dynamics equations need not precede a citation of Newton, circuit analysis doesn't need a reference to Kirchoff. The importance of this practice in science is that it allows the reader to verify your starting position. Physics is said to be a vertical science: results are built upon results which in turn are built upon results... Good referencing allows us to check the foundations of your additions to the structure of physics, or at least to trace them back to a level which we judge to be reliable.
Good referencing also tells the reader which parts of the thesis are descriptions of previous knowledge and which parts are your additions to that knowledge. In a thesis, written for the general reader who has little familiarity with the literature of the field, this should be especially clear.
It may seem tempting to leave out a reference in the hope that the non-specialist reader will think that a nice idea or an nice bit of analysis is yours. I advise against this gamble. The reader will probably think: "What a nice idea - I wonder if it's original?". If the reader has to spend a few hours in the library to find out, then s/he may not be in a great mood to read the rest of the thesis.
The work that is actually yours may be only a small part of the whole thesis, especially in a non-numerical theoretical thesis. Do not feel bad about this: all of us who work in science know that one has to do a lot of work just to get to the boundary between the known and the unknown, and that any small advancement of that boundary is an important achievement.
If you are writing in the passive voice, you must be more careful about attribution than if you are writing in the active voice. "The sample was prepared by heating yttrium..." does not make it clear

whether you did this or whether Acme Yttrium did it. "I prepared the sample..." is clear.

Presentation.

It must be easy to read, so typing is preferable to handwriting. There is no need, however, for the finished product to be a masterpiece of desk-top publishing. Your time can be more productively spent improving the content than the appearance. In many cases, a reasonably neat diagram can be drawn by hand faster than with a graphics package. Either is satisfactory. Don't waste time on fancy drawings - fix up the arguments! Make the explanations clearer! Think more about the significance! Check for errors in the algebra!

There is no strong correlation (either way) between length and mark. Readers will not appreciate large amounts of vague or unnecessary text. There is no need to leave big gaps and empty pages to make it thicker.

The text must be clear. Good grammar and thoughtful writing will make the thesis easier to read. Scientific writing has to be a little formal - more formal than this text. Native English speakers should remember that scientific English is an international language. Slang and informal writing will be harder for a non-native speaker to understand.

One important choice is between the active voice and passive voice. The active voice ("I measured the frequency...") is simpler, and it makes clear what you did and what was done by others. Unless you are schizophrenic or a queen, use the first person singular, not plural. The passive voice ("The frequency was measured...") makes it easier to write ungrammatical or awkward sentences. If you use the passive voice, be especially wary of dangling participles. For example, the sentence "After considering all of these possible materials, plutonium was selected" attributes consciousness to Pu. The advantages claimed for writing in the passive voice is that some other scientists have done so, and that some very polite people do not like using the first person pronouns.

Personal.

In the ideal situation, you will be able to spend a large part - perhaps a majority - of your time writing your thesis. This may be bad for your physical and mental health.

Motivation. The difference between Hons I and Hons IIa, or between Hons IIa and Hons IIb is substantial. If you integrate over the following decade the effect of this difference on your career, it is even more substantial. If extra work put into your thesis (and course work) takes you from one category to another, then that

work is very well compensated. It will be hard work, but it's worth it.

Typing. Set up your chair and computer in the recommended way. The Health Service, departmental typists or perhaps even the safety officer will be able to supply charts showing healthy postures and also exercises that you should do after spending a day at the keyboard. The latter are worthwhile insurance: you don't want to be crippled by back or shoulder pain. Try to intersperse long sessions of typing with other tasks.

Exercise. Don't give up exercise for the interim. You know that lack of exercise makes you feel bad, and you don't need anything else making you feel bad while writing a thesis. 30-60 minutes of exercise per day is probably not time lost from your thesis: I find that if I don't get regular exercise, I sleep less soundly and longer. How about walking to work and home again? (Part of the way if your home is distant.) Many people opine that a walk helps them think, or clears the head. You may find that the occasional perambulation improves your productivity.

Food. Don't forget to eat, and make an effort to eat healthy food. You shouldn't let your body fall apart, or risk illness at this critical time. Exercise is good for keeping up the appetite. I know that you haven't the time to cook much, but get a supply of fresh fruit, vegetables and bread. It takes less time to make a sandwich than to go to the local fast food, and you'll feel better afterwards.

Drugs. Thesis writers have a long tradition of using coffee as a stimulant and alcohol or marijuana as relaxants. (Alcohol and coffee are legal, marijuana is not.) In moderation they doesn't seem to have ill effects on the quality of thesis produced. Excesses however are obviously counter-productive: several short blacks and you will be buzzing too much to sit down and work; several drinks at night will slow you down next day.

Other people will be sympathetic, but don't take them for granted. Spouses, lovers, family and friends shouldn't be undervalued. Spend some time with them and, when you do, have a good time. Don't spend your time together complaining about your thesis: they already resent the thesis because it is keeping you away from them. Finally, we all know that writing a thesis is tough work. It is also a scientific rite of passage, and your colleagues and teachers will sympathize. Good luck with it!

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Some sites with related material

How to write a PhD thesis.
How to survive a thesis defence
Research resources and links supplied by Deakin University
Learning Resources for University Students supplied by Universities of Western Sydney and Melbourne.
"Writing and presenting your thesis or dissertation" by Joseph Levine at Michigan State University, USA
"Postgraduate Student Resources" supplied by University of Canberra
Tufte, E.R. (1983) 'The visual display of quantitative information'. Graphics Press, Cheshire, Conn.
Tufte, E.R. (1990) 'Envisioning information' Graphics Press, Cheshire, Conn.

Further Information

For more information about the Writing a Thesis contact:

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