

The 2007-2008
Department of Operations Research and Financial Engineering

SENIOR THESIS GUIDE

A Compendium of dates, tips, guidelines and procedures

April 2007

Copies of this guide can be obtained from
Undergraduate Administrative Assistant,
E-218, Engineering Quad

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INTRODUCTION

This guide is to inform students of what to expect when writing a thesis. The guide applies to all students who are satisfying the senior thesis requirement by signing up for ORF 478. This includes ORFE students whose proposals have been accepted by the department in the spring of their junior year, plus some students outside the department in the Engineering and Management Systems certificate program. Students outside the ORFE department in the EMS certificate program who are satisfying the thesis requirement through another course (such as Electrical Engineering independent project course) may find this guide useful but do not fall under the rules and procedures outlined here.

The Senior Thesis *is a full year effort*, and students should budget their efforts accordingly. Students interested in a full-year senior thesis must be willing to spend the appropriate time during both the fall and the spring semesters. Students who are unable to make adequate progress can switch to ORF 479 (one semester project) and be required to take nine departmental electives.

This guide is intended to help develop a schedule that will avoid the typical thesis rush at the end of the year, while at the same time providing tips on how to organize the research and the writing of the thesis. **DO NOT LOSE THIS GUIDE.** It also provides key dates and deadlines and certain rules and procedures governing the preparation of the final document. Failure to abide by these procedures can delay the time at which your thesis is accepted, possibly resulting in a reduction in grade and, in some instances, postponement of graduation. A number of students have not graduated because they failed to satisfactorily complete the department's Senior Thesis requirements. Procedures for obtaining extensions (there is a procedure, but don't bet on getting an extension) and tips on the oral presentation at the end of the year are also provided.

IMPORTANT DATES

The following dates represent the key milestones that must be observed during the year:

Monday, November 12, 2007 FALL TERM PROGRESS REPORT (two copies due)
(see the FALL PROGRESS REPORT for details)

Monday, January 21, 2008 Deadline for the interim report (two copies due)
(see THE INTERIM PROGRESS REPORT for details)

Monday, April 14, 2008 Deadline for SENIOR THESIS (two copies--one bound, one unbound)
(see TURNING IN THE THESIS for details)

Thursday, May 8, 2008 Oral presentations
(see THE ORAL PRESENTATION for details)

All reports and the thesis must be turned in to the Undergraduate Administrative Assistant in E-218 no later than 5:00 p.m. on the date indicated. Late progress reports will be penalized at a rate of one letter grade per day. A late thesis is penalized at a rate of one fifth of a letter grade per day. DO NOT TURN REPORTS IN TO YOUR THESIS ADVISOR.

THE FALL PROGRESS REPORT

The fall progress report is due the second Monday after Fall break, and comprises 15 percent of your thesis grade. It is designed to serve as an initial checkpoint on your progress and provides an early opportunity for feedback.

As with all material you turn in, it will be graded by your advisor and hence you should discuss with him/her what is expected. In general, however, the Fall report is expected to be 10 to 15 pages in length, typed and neatly presented. The basic outline of the report might be as follows:

- Detailed problem description
- Preliminary review of the literature, including a bibliography of major references.
- Description of what you propose to do with the topic.
- Summary of major data requirements, if applicable. Many a thesis has undergone significant changes in emphasis due to an overly optimistic assessment of data availability. If your thesis does depend on a source of data that is not absolutely reliable (such as getting data from a company you worked for over the summer), it is a good idea to have a backup position.
- Summary of project work, if applicable. This includes building components, working with computer hardware or writing major computer programs.
- Schedule of tasks (attempt to estimate major milestones).

Late submissions of reports are penalized at a rate of one letter grade per day. The report must be typed and neatly presented. No extensions will be given under any circumstances.

Keep in mind as you are preparing this report that the university does provide limited funds for thesis research. This is a good time to estimate whether you may need additional resources. See SENIOR THESIS FUNDS on page 6.

SENIOR THESIS FUNDS

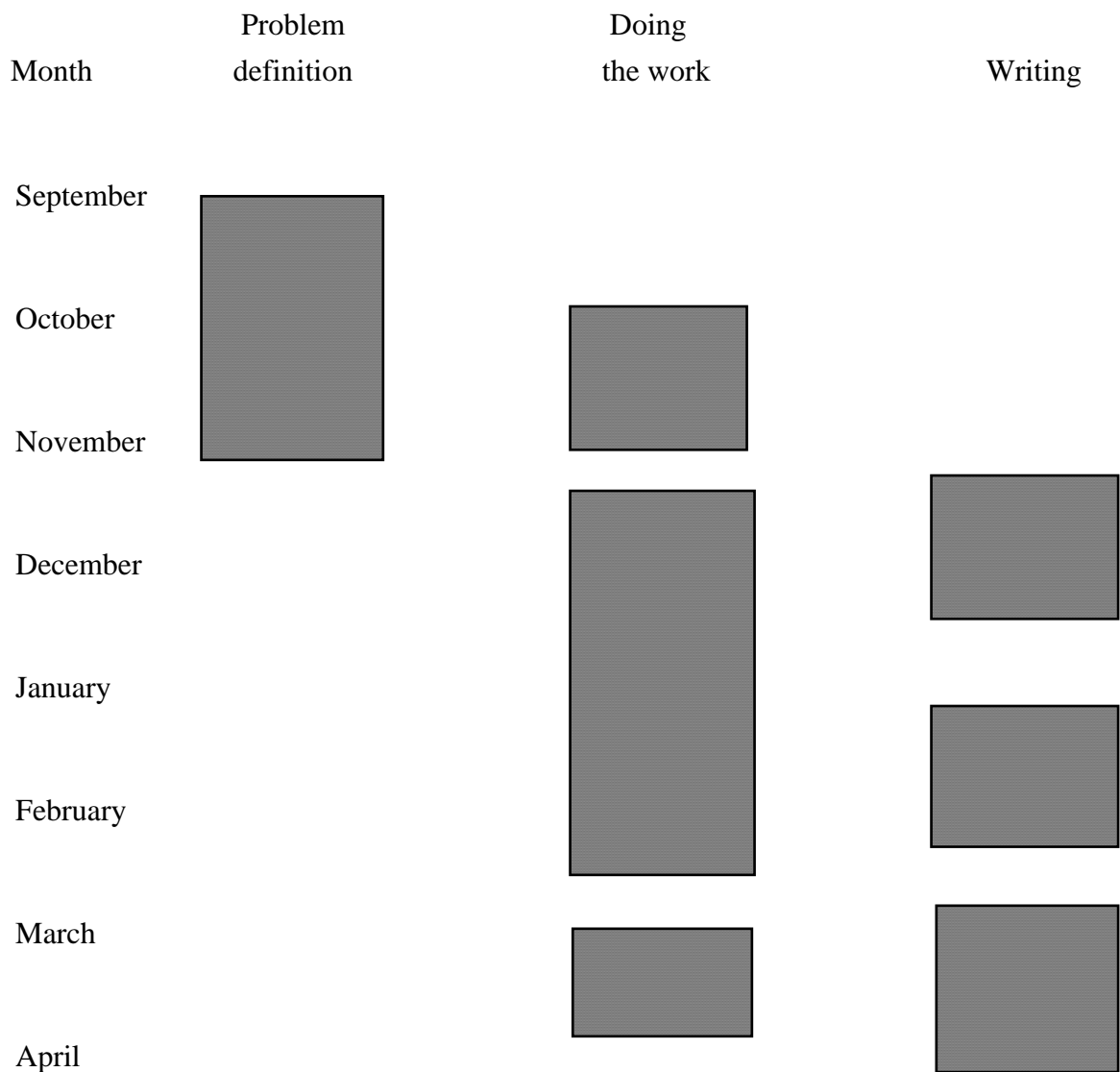
Limited funding is provided by the Dean of the College's office for theses which require financial support for special travel needs, acquisition of data, or other special requirements. Awards are typically around 150 dollars, but not all proposals can be funded. Talk with your advisor if you feel you may qualify for this support. Remember, however, that the deadline is relatively early, implying that you must already have a good idea of what you need, why it requires additional support and how you would use the funds in your thesis. If you would like to apply, you must submit a one or two page proposal, including a budget, to your advisor who must then write a letter of support and pass it on to the Departmental Representative.

ORGANIZING YOUR TIME

One of the most common mistakes made by seniors is underestimating how much time it takes to complete certain tasks, in particular the actual writing of the thesis. It may be helpful to divide the effort into three primary tasks:

- Defining the problem and reviewing the literature
- Doing the work (including experimental work, if applicable)
- Writing the thesis

Depending on the nature of the work, each task can be viewed as requiring approximately the same amount of calendar time (the number of hours spent per day, however, can vary widely). If your research is fairly well defined (usually with the help of your advisor), then the first stage may be reduced somewhat. Naturally, the three tasks will overlap, since you may have to do additional literature review when you finally settle on a specific problem, and it is often useful to begin writing certain sections of the thesis while the actual research is in progress. An approximate time schedule is outlined on page 8.



Please do not underestimate how long it takes to write the thesis. In particular, allow sufficient time for printing and binding the thesis. **UNDER NO CIRCUMSTANCES WILL EXTENSIONS BE GIVEN FOR DELAYS DUE TO BROKEN DOWN COMPUTERS OR LASER PRINTERS.** Even though these may be beyond your immediate control, you still bear the responsibility for getting the thesis in on time. **PLAN AHEAD!**

THE INTERIM REPORT

The interim report is a summary of progress to date and counts 25 percent of the final thesis grade. Combined with the fall progress report, the work you do in the fall will count a total of 40 percent of the final thesis grade. Poor progress in the Fall, can produce as much as a two grade reduction in your final thesis grade, regardless of the grade given on the thesis itself. Late reports are penalized at a rate of one letter grade per day. The report must be typed and neatly presented. In general 30 – 40 pages are expected. No extensions will be given under any circumstances.

The progress report will be graded by your advisor, and hence you should talk to him/her regarding the contents of the report. The grade you are given will be based on the report as well as other work you have completed by January. It is not unusual, for example, to have a chapter completed in the Fall covering the literature review or an initial experiment. Students are allowed to switch to the one semester senior project, but this will require an extra departmental elective (9 in total).

A suggested format for the report is as follows:

Part I: Review of the progress made to date

The review should include a refined description of your problem with a more detailed summary of exactly what you are doing. Summarize specific tasks already completed, such as the literature review, development of a mathematical model, conceptualization and/or actual design of a component/structure, software, *etc.* List tasks by general titles with short descriptions.

Part II: List of references and sources of data

This list should include a reasonably complete bibliography covering your topic. Also include all sources of data that you have been using or plan to use in the Spring.

Part III: List of tasks to be completed in the Spring with an anticipated time schedule.

List tasks by general titles with short descriptions (a few sentences). Included in this list should be the task of writing (and rewriting) and typing the thesis (this task may be broken down into specific chapters).

Please note: the January interim report **MUST** include your name, your advisor's name **AND** a tentative thesis title. This thesis title will be used to schedule your oral presentation. You may change the title, but it should be as close as possible to your actual thesis title and should adequately describe your work.

WHAT IS A THESIS?

The most frequently asked questions concern what is actually in a thesis (how much detail, how long should it be, should I have a pop-up model of my bridge design inside the thesis? *etc.*). This section of the guide is a strictly informal set of guidelines that a student may use to orient him/herself as to the basic components of a thesis. Since projects differ widely, it is impossible to develop a general outline that applies equally to all students. Regardless of how well you think your own research fits the following guidelines, you should talk to your advisor to determine the most appropriate style of presentation for your own work.

The essence of any scholarly work, which a thesis is supposed to be, is to establish the following:

- Definition of the problem and review of the literature
- Presentation of your particular contribution to this area
- Identification of fruitful areas of further research that others in the field may use to guide their own work

Toward these three goals, the following list of questions may prove useful for organizing both your research effort and the final writing of the thesis.

I. What are you looking at?

You must begin by defining your problem. In the introduction of the thesis, however, you want to do this in a general way that gives the reader a sense of the scope of the project and a basic understanding of your problem area. For example, you may be solving a problem of interest to a particular company, or developing a new approach to a problem that may be of interest to the research community as well.

II. Why are you looking at it?

Motivate your work. Explain to the reader why you will not simply waste his/her time on an uninteresting problem if he/she reads your thesis. Establish who will benefit from your work and why. Note that you do not have to get the whole world interested in your work. Most theses involve the application of existing techniques to particular problems, and hence the only people who will be directly interested may be others working for a particular company, engineers working on a specific project, and so on.

III. Who else looked at it?

Now that we (the readers) have a rough idea of what your problem is, you must firmly establish what the state of the art is in the area. This is particularly critical if you wish to claim that you have a better way of solving/approaching a problem than has appeared previously in the literature. For example, if you are developing a new statistical model for describing the relationship between SAT scores and academic success at Princeton, list others who have worked on the same or similar problems and briefly describe their work. If you are duplicating the approach used by others in the field, but using a different data set that is of particular interest to you, say so and describe why you have chosen this approach over others that may have been used.

IV. How are you looking at it?

At this point, you may need to review your problem again but at a much higher level of detail, introducing any mathematical notation required and describing any subtle aspects of your problem that may in fact be the central component of your research but which were too detailed to put in the introduction. Empirical research, which involves gathering data to prove some relationship, can often be introduced by citing one or more hypotheses which you feel your research will prove (or disprove). Examples of hypotheses are:

- There is no relationship between a student's math SAT and his/her starting salary on graduation.
- The nation's independent truckers can carry freight for the same or lower cost than rail, with a higher level of service.
- Risks associated with the use of conventional fuels are greater than the risks associated with use and disposal of nuclear fuel.

After stating the relevant hypotheses, your work would consist of collecting and analyzing data to confirm or deny your hypotheses. The most interesting hypotheses are ones that run counter to prevailing public opinion, although these can be very difficult to prove.

Not all work is conducive to initial statements of hypotheses, particularly methodological theses which are aimed at better solutions to existing problems (the implicit hypothesis is that your method is better than others, but this need not be stated as such). In any event, unless your work is purely theoretical, you should describe in detail your experimental design: how you structured your data collection, problems you encountered, and how you conducted your experiments. The description should be sufficiently detailed to allow another researcher to duplicate your efforts. A key part of your description should be a clear list of major assumptions you are making and why you are making them. It is useful at the same time to indicate which assumptions are perfectly reasonable (e.g. other researchers have used the same assumption and have obtained good results) and which are likely to affect your results but are required for time/budget reasons.

V. What are the limitations of your work?

One of the most difficult aspects of research is understanding exactly what you did and what you did not do. If you were limited by your data, explain how you think this might affect the generality of your conclusions. Discuss openly any shortcuts required due to time/budget/data availability constraints. Do not try to claim credit by stating that you feel that your method/model/bridge/pump will work in more general situations if you have done only limited testing. At the same time, do not feel you are getting off the hook by over-qualifying your work (e.g. "Because of such and such restrictions, no valid conclusions can be drawn until more extensive experiments are carried out using so and so's data or equipment."). Clearly drawing the line between what you did and did not do is a central step in the scientific method since it helps define the state of the art.

VI. What are your conclusions?

In view of the limitations above, what conclusions can you draw from your research. Because your conclusions are often inextricably intertwined with the limitations of your research, both questions are often answered simultaneously. It may be useful to discuss limitations of specific aspects of your work while you are describing the work itself, but defer a discussion of how such limitations actually impact your results until later. Your section on conclusions is usually brief, and should specifically and clearly describe your contributions to the field. Frequently, researchers familiar with the field will start by reading your conclusions and, depending on your claims, then decide to read the thesis itself. Again, do not underrate your work, but do not claim to have solved problems that are not firmly substantiated in the body of the thesis.

VII. What next?

Areas for future research. Now that you are an expert in your particular area, you should have both a narrow understanding of a well-defined problem as well as a broader understanding of the field as a whole. As such an authority, it is now your responsibility to guide others in the field who do not have the benefit of your particular experience in directions that you feel will provide the greatest good. Such recommendations are usually based on an evaluation of the major weaknesses in your own work, in which case you might recommend how others (preferably with more time and money than you enjoyed) could overcome these weaknesses. Be sure, however, to specify those weaknesses that you feel would have the greatest impact on your conclusions. Some assumptions that you may have made may be perfectly reasonable, in which case a more accurate model would not improve the final results.

FORMAT OF THE THESIS

There are certain guidelines that must be followed when preparing the copies that will be turned in. These guidelines have been developed as a response to certain legal requirements regarding copyrights as well as administrative needs for processing the thesis.

The requirements for preparing the thesis are as follows:

The front page of the thesis should include title, author, date, advisor(s), and the statement:

Submitted in partial fulfillment
of the requirements for the degree of
Bachelor of Science in Engineering
Department of Operations Research and Financial Engineering
Princeton University

If you are not in the Department of Operations Research and Financial Engineering, but are taking ORF 478 to satisfy the Senior Thesis requirement for the EMS certificate, replace this statement with:

Submitted in partial fulfillment
of the requirements for the certificate in
Engineering and Management Systems
Department of (your department)
Princeton University

The second page should contain the following statements:

I hereby declare that I am the sole author of this thesis.

I authorize Princeton University to lend this thesis to other institutions or individuals for the purpose of scholarly research.

(your signature)

(your name)

I further authorize Princeton University to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

(your signature)

(your name)

Each thesis must have the title and author on the front of the thesis engraved by the binder (bound copy only).

Other requirements that must be observed when preparing the thesis:

- The thesis may be typed one and one half spaced or double spaced, with the exception of footnotes and bibliography
- The font size should be between 10 and 12 point
- The left hand margin should be 1 1/2 inches to allow for binding; all other margins should be approximately 1 inch.
- All material in the thesis (tables, figures and exhibits) must be photo reproducible. Photographs may be included, but should be clear, glossy, and high contrast.

Finally, you must turn in a "Senior Thesis Information Sheet". The information you provide on this sheet must be reported to Mudd Library with the submission of your thesis. The form will be sent to you as an e-mail attachment.

TURNING IN THE THESIS

Two copies (one **must** be bound and one **must** be unbound) of the thesis must be submitted to **the Undergraduate Administrative Assistant in E-218 no later than 5:00 p.m. on Monday, April 16, 2007.** (*Please provide the appropriate amount of extra copies if being advised by more than one advisor*). The unbound copy may be printed on regular bond paper.

ALL STUDENTS MUST DELIVER THE THESIS IN PERSON. There are several forms that must be signed before the thesis can be accepted. The thesis cannot be accepted unless it follows the guidelines described in **FORMAT OF THE THESIS** and the appropriate forms are signed. Late theses are penalized at a rate of one fifth of a letter grade per day or any part thereof. This rule is rigidly enforced, so allow plenty of time for copying and binding. Remember that many other students are trying to meet the same deadline, and that copying and binding services may require more time than you think.

Note that your advisor does not get to keep the copy he/she grades. As a courtesy, permanent copies should be given to your advisor(s). Ask them if they would like a copy of their own.

EXTENSIONS

Extensions for turning in the thesis will be granted only in the case of illness (or family emergencies) and only when such illness or emergency makes it impossible to complete the thesis on time. All extensions must be requested in writing and turned in to the Departmental Representative at least one week prior to the deadline for the thesis. Each request must be approved first by the student's advisor and then by the Departmental Representative. Extensions will not be granted for unexpected delays due to problems in printing, photocopying, or binding the thesis.

No extensions will be allowed for the thesis progress reports. If for some reason you must be away from campus when one of these reports is due, turn the report in early.

THE ORAL PRESENTATION

Capping the thesis effort is a day of oral presentations where Seniors have a chance to stand up and describe their work. Attendance is required. Failure to make an oral presentation will result in a one letter grade penalty. If you have other commitments on the day of the presentation, contact the Departmental Representative at least one week in advance, and it may be possible to schedule around these commitments. In case of conflict, however, the oral presentation takes precedence. The schedule of presentations will be available before the presentations and will be posted or may be obtained in E-218.

The format of the presentation provides **NO MORE THAN 12 MINUTES** for describing your work, followed by 3 minutes for question and answer. As it is very easy to run over this time limit, it is a good idea to practice your presentation the day before. The content of your talk should generally accomplish the following:

- Briefly explain your problem
- Describe what you did and briefly how you did it
- Summarize your most important and interesting conclusions

A good rule to follow is just to present the highlights of each aspect of your work. Do not try to impress people with how much work you did; if you did a lot of work, you will not be able to describe it all, and invariably you will simply be cut short (the time limits are rigidly enforced). A few tips on how to make your presentation are the following:

- Sound interested in your work - enthusiasm spreads
- Emphasize the easy to communicate ideas that others will enjoy the most
- DO NOT read your presentation (if you want to know why, just listen to someone else reading his/her presentation - it's boring)
- Use a powepoint presentation or slides to help structure the presentation; keep it simple and prepare in a manner suitable for a professional presentation (i.e. don't scribble out a few slides the night before). Also, do not photocopy pages out of your thesis. Avoid complex expressions unless they are central to your work.
- This is a formal presentation, so dress accordingly (coat and tie/dress or blouse and skirt). There will be a Class photograph taken during the lunch break.

GRADING

Operations Research and Financial Engineering theses are normally graded by your advisor only; there are no second readers. However, if your advisor cannot provide a grade in time (due, for example, to a sabbatical leave out of the country where there is insufficient time to transfer the thesis through the mail) a second reader may be assigned. Talk to your advisor if you think this may be a problem. If there is a problem, it is helpful if you arrange your own second reader. If necessary, a grade will be assigned by a second reader, and then changed after the advisor turns in a grade.