



Operations Research &
Financial Engineering

2021-2022
Senior Thesis Guide

A Compendium of dates, tips, guidelines and procedures

Class of 2022

PRINCETON
School of Engineering and Applied Science

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INTRODUCTION

This guide informs members of the ORFE class of 2022 of what to expect when writing a Senior Thesis. The guide applies to all students who are satisfying the graduation requirement of writing a Senior Thesis based on two semesters of independent research conducted throughout their Senior year rather than a single semester of Senior Independent Research conducted in the Spring semester of their Senior year.

The Senior Thesis is a full year, 12 month, effort which really starts during the end of the junior spring semester. Be prepared to devote at least the amount of time that would be needed to attend and satisfy all of the requirements of a normal advanced course in both the Fall and the Spring semester. Administratively you are required to register for ORF 478 in the **Spring** of your senior year. The grade for the Fall version of ORF 478 will be deferred until the Spring at which time your Senior Thesis grade will be applied to both courses.

This guide is intended to help develop a schedule that will assist you to budget your time and gauge your progress so as to avoid the dreaded 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. Tips on the formal oral presentation at the end of the year are provided. Key dates and deadlines and certain rules and procedures governing the preparation of the final document are also contained herein. Failure to abide by these procedures and/or the meeting of deadlines can cause a substantial reduction in the Senior Thesis grade and, in some instances, postponement of graduation. Procedures for obtaining extensions are contained herein; however, it is not an easy process.

If you have chosen an advisor from another department and that person is a regular member of the Princeton faculty, you are not required to have a second reader. Advisors outside the department must follow each of the requirements and deadlines in this guide.

Students who are unable to make adequate progress during the fall can switch to ORF 479 (One Semester Project) by September 24, 2021 and will be required to take eleven department electives instead of the ten taken when doing a Senior Thesis.

IMPORTANT DATES

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

Wednesday, September 15, 2021 SENIOR THESIS PROSPECTUS
(see the *SENIOR THESIS PROSPECTUS* for details)

(Friday, September 24, 2021-Last day to drop ORF 478 and switch to take ORF 479 One-Semester independent Research in the Spring Semester if you feel you have are not making adequate progress on your Senior Thesis)

Monday, November 1, 2021 FALL TERM PROGRESS REPORT
(see the *FALL PROGRESS REPORT* for details)

Monday, January 24, 2022 Deadline for the INTERIM PROGRESS REPORT
(see *THE INTERIM PROGRESS REPORT* for details)

Tuesday, April 5, 2022 Deadline for SENIOR THESIS (three copies—two bound, one electronic)
(see *TURNING IN THE THESIS* for details)

Tuesday, April 26, 2022 Oral presentations
(see *THE THESIS SYMPOSIUM* for details)

All reports, except for the final thesis, must be turned in using Blackboard by 4:30 p.m. on the date indicated. Failure to meet any of these deadlines is severe! Your final grade which is applied to two courses (ORF 478 twice) will be reduced by 1/3 of a letter grade for EACH day or part thereof that you are late for meeting any of these deadlines. This means that if you turn it in at 4:31 PM, of any of the deadline dates, you forfeit one third of the final letter grade for two courses. EMAILS AND/OR ITEMS TURNED IN TO YOUR ADVISOR DO NOT SATISFY THESE DEADLINES.

SENIOR THESIS FUNDS

Limited funding is provided by the School of Engineering and Applied Science for theses which require financial support for special travel needs, acquisition of data, or other special requirements. Awards are typically around 250 to 500 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. You will receive an email application from Dean Bogucki in early October and then again in February.

CHANGING TO A ONE SEMESTER PROJECT

Friday, September 24, 2021- Last day to drop ORF 478 and switch to take ORF 479 One Semester Independent Research in the Spring semester if you feel you are not making adequate progress on your Senior Thesis.

In order to switch out of ORF 478- Senior Thesis and into ORF 479- One Semester Independent Project you must notify your advisor and the undergraduate affairs office in writing (email) of your intentions to switch. You are required to take eleven department electives instead of the ten required by taking ORF 478.

Also, if you are taking only 3 other courses you may not be granted permission to drop this “4th course” because you would no longer be considered a “full time” student. The University may require you to take a complete leave of absence.

SENIOR THESIS WRITERS GROUP

To help guide and assist you, the department offers a Senior Thesis Writers Group. The STWG is comprised of two graduate students that offer meetings, resources, and workshops to help you during your senior year. For current STWG activities visit <https://orfe.princeton.edu/undergraduate/stwg>

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 7.

Month	Problem Definition	Doing the work	Writing
Summer & September			
October			
November			
December			
January			
February			
March			
April			

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. Even though these may be beyond your immediate control, you still bear the responsibility for getting the thesis in on time. PLAN AHEAD!

SENIOR THESIS PROSPECTUS

In preparation for doing two semesters of focused research during your senior year you are required to prepare an initial report that serves as a prospectus or guide for your Senior Thesis research. This Senior Thesis Prospectus is due on Wednesday, September 15, 2021. It serves the purpose of ensuring that you have a clear vision of the work that lies ahead for you and your faculty advisor. You have had all summer to think about your Senior Thesis research. You should return to campus organized and prepared to begin conducting your research. The Senior Thesis Prospectus should include a Title, a one page Abstract, and initial Table of Contents.

The Table of Contents should include Chapter, Sub Chapter, Sub-Sub Chapter,, titles that serve to describe the problem your intended approaches, and findings that you anticipate. It serves as a road map/work plan for your research. The Table of Contents can be duplicated in the body of the Prospectus and should contain the beginnings of a concise problem statement, literature review, approaching data sources, expected findings, and key references. You can then leverage this initial Prospectus through editing to have it evolve into your final thesis document in April. You should easily produce 5 or more substantive pages of the beginning of content.

Entries are due by 4:30 pm to the ORF 478 Blackboard site. Note that emailed copies are not accepted, nor printed copies turned in to your advisor. The Senior Thesis Prospectus will be graded and will account for 5% of the final course grade. Severe final grade penalties of 1/3 of a grade per day of **your final senior thesis grade** will be assessed for failure to meet this deadline (as is assessed for failure to meet any of the other deadlines during the year).

FALL TERM 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. It should be a substantial update and expansion of the Senior Thesis Prospectus with expanded references, detailed description of data sources, if appropriate, and include an initial draft of at least some sections contained in the Table of Contents.

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 substantive 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).
- Update of Prospectus including Title, Abstract, Table of Contents and updated chapter content as they exist.

Late submissions of reports are penalized at a rate of **1/3 of a letter grade per day of your final thesis grade**. The report must be typed and neatly presented. No extensions will be given under any circumstances. You are free to submit any time in advance of the deadline. Entries are due by 4:30 pm to the ORF 478 Blackboard site. Note that emailed copies are not accepted, nor printed copies turned in to your advisor. Severe final grade penalties of **1/3 of a grade per day of your final senior thesis** will be assessed for failure to meet this deadline.

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 5.

THE INTERIM REPORT

The Interim Report is a summary of progress to date and counts 20 percent of the final thesis grade. Combined with the Prospectus and 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 **1/3 of the final letter grade per day, or part thereof, of your senior thesis.** 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 introduction, problem statement, and some preliminary results or their expectations.

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 interim report MUST include your name, your advisor's name AND a tentative thesis title. You may change the title, but it should be as close as possible to your actual thesis title and should adequately describe your work.

Part IV: Boiler Plate: The thesis as it exists at that time: A boiler plate version of the final thesis including: title, abstract, table of contents, rough draft of some chapters (especially introduction), literature review, preliminary formulation, references, data sources, *etc.*

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 that 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 (June 2022), 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 gold stamped or engraved by the binder (hard bound copies only).

Other requirements that must be observed when preparing the thesis:

- Must include title page.
- 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 (10 Point Recommended)
- 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.

Four copies of your thesis will need to be submitted as follows:

- Two Hard Bound Copies, one to be graded and returned to you, the other for your advisor to keep
- One Electronic Copy submitted through Blackboard in PDF
- One Electronic Copy submitted through Thesis Central (MuddLibrary)

All items below must be handed in when you turn in your Thesis.

- Resume—Your resume will be used by the School of Engineering in the event we are contacted on your behalf for information.
- White Form---filled out completely for all courses you have taken
- Thesis Satisfaction Survey

A Thesis will not be accepted unless ALL above forms are completed.

TURNING IN THE THESIS

Three thesis copies:

- two **must** be hard bound, one to be graded and returned to you, the other for your advisor
- one electronic copy submitted through Blackboard

must be submitted to **the Undergraduate Administrative Assistant no later than 4:30 p.m. on Tuesday, April 5, 2022.** *(Please provide the appropriate amount of extra bound copies if being advised by more than one advisor).*

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 third 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.

EXTENSIONS

Extensions for turning in the thesis will be granted only in the case of **extreme** illness (or **extreme** 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. To make it perfectly clear, over the past 5 years **no** extension has been granted.

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 THESIS SYMPOSIUM

Capping the thesis effort is a day of oral presentations where Seniors have the opportunity to stand up and describe their work. The Oral Presentation represents 10% of your final thesis grade. Attendance is required. Failure to make an oral presentation will result in a one third letter grade penalty. 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 the undergraduate office.

Please bring your own personal laptop or a memory stick with your presentation. Each room will be equipped with a laptop and projector.

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 PowerPoint 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, business attire. A class photograph will be taken.