Department of Chemical and Biological Engineering
Senior Thesis Guide

Academic Year 2015-16
Revised: August 2015
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Acknowledgment: This guide has evolved from the senior thesis guide issued by the Department of Civil Engineering and Operations Research to its students and the Class of '92.

I. INTRODUCTION

The senior thesis guide represents an effort to better inform students of what to expect when writing a thesis. Contrary to some popular opinion and past practices, the senior thesis is a full year effort and students should budget their efforts accordingly. 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. It also provides key dates, 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. Extensions will only be granted under rare circumstances. Tips on the oral examination and poster presentation at the end of the year are also provided.
II. COURSE LEARNING OBJECTIVES FOR CBE 454 SENIOR THESIS

The following learning objectives constitute the minimum skills that every student must acquire through the senior thesis experience. These objectives will be used, in part, to evaluate the student's work and in the assignment of a grade.

<table>
<thead>
<tr>
<th>Course Learning Objectives</th>
<th>ABET Program Outcomes</th>
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<tbody>
<tr>
<td>1. Integrate science and engineering principles for analysis and solution of problems in the field of chemical and biological engineering.</td>
<td>a</td>
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<tr>
<td>2. Combine in-depth science/engineering analysis with examination of societal issues related to the thesis topic. Gain broad knowledge about the topic of interest, and appreciate its relevance in modern society.</td>
<td>h, j</td>
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<tr>
<td>3. Formulate the thesis research project. Identify the critical research questions, and define the scope and objectives of the project. Design experiments, analysis, or observation plan.</td>
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<tr>
<td>4. Examine a range of investigative options for approaching the research questions, such as experimentation, simulation, and optimization. Defend the method chosen for approaching the research.</td>
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</tr>
<tr>
<td>5. Know how to use information technology resources to find background information and data pertinent to the thesis topic. As needed, gain the skills to use laboratory techniques and software for data analysis and simulation.</td>
<td>k</td>
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<tr>
<td>6. Apply appropriate paths of inference to interpret the theory, findings, and/or data. Use these interpretations to draw conclusions with regard to the project objectives.</td>
<td>b</td>
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<tr>
<td>7. Behave as a responsible professional engineer with respect to planning and meeting project deadlines, regularly reviewing progress with advisers, and being responsive to feedback from advisers and peers. Become familiar with the ethical standards of technical writing with respect to giving credit: acknowledging other contributors, acknowledging funding sources, citing references.</td>
<td>f</td>
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<tr>
<td>8. Develop writing skills and presentation skills needed to effectively communicate the purpose, scope, and conclusions of the project.</td>
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III. IMPORTANT DATES

The following schedule of due dates have been set for (i) the 1st and 2nd progress reports; (ii) the first draft of the thesis; (iii) the final draft of the thesis; (iv) the oral examination; (v) the final thesis; and (vi) the poster presentation.

Monday, December 7, 2015: 1st Progress Report to the adviser and copy to Julie Sefa (A201).

Monday, February 29, 2016: 2nd Progress Report to the adviser and copy to Julie Sefa (A201).

Monday, April 11, 2016: First draft (nearly final) of thesis to adviser.

Monday, April 25, 2016: Final draft (not bound) of thesis to adviser and second reader.

Monday, May 2, 2016: Poster presentation (Friend Center, Convocation Room).

Friday, May 6, 2016: Oral examinations to be completed.

Friday, May 6, 2016: Adviser and second reader report grade to Professor Link.

Monday, May 9, 2016: Electronic copy of thesis to Julie Sefa.

Monday, May 9, 2016: Title Page and Abstract of thesis to Julie Sefa.

Wednesday, May 18, 2016: Bound thesis to adviser.

Please make a note of these dates. Failure to submit on time may result in a lower grade.
IV. **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
- 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 adviser) 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 here.

<table>
<thead>
<tr>
<th>Month</th>
<th>Problem definition</th>
<th>Doing the work</th>
<th>Writing</th>
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<tbody>
<tr>
<td>September</td>
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<tr>
<td>April</td>
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</table>
Please do not underestimate how long it takes to write the thesis. UNDER NO CIRCUMSTANCES WILL EXTENSIONS BE GIVEN FOR DELAYS DUE TO BROKEN DOWN COMPUTERS. Extensions will only be granted under rare and extenuating circumstances. Even though these may be beyond your immediate control, you still bear the responsibility for getting the thesis in on time. PLAN AHEAD!

V. WHAT IS A THESIS?

A thesis is an experimental, computational, and/or theoretical study of an important problem. In order for the thesis to qualify for Chemical and Biological Engineering credit, it is required that there should be significant chemical engineering relevance. Topics are selected by the students from suggestions by the faculty. Written thesis and oral defense are required. The senior thesis is equivalent to a yearlong study and is recorded as a double course in the spring.

A. Senior Thesis Work

Most seniors consider their senior thesis experience - working with a single faculty member on a challenging problem - to be one of the high points of their education. In February the Department circulates to the junior class a list of suggested topics. Students consider these selections or make suggestions of their own. At the end of this period, students submit a rank-ordered list of four topics, each under a different faculty member. The faculty then tries to satisfy student interest and yet maintain a reasonable distribution of students throughout the department. Even with large classes it has been possible to grant each student one of his/her first two choices. No student is ever required to work on a project in which he/she has no interest. For examples of past senior theses titles, please consult the department’s Undergraduate Handbook. We also encourage you to browse through past theses available in the Mudd Library archive.

It is possible to have a primary adviser outside the department. In this case, a departmental liaison will be appointed. This liaison will ensure that the student thesis contains sufficient engineering content to be considered an engineering topic. In addition, the liaison will assist in advising the student, answering questions that may arise about departmental policies, and will receive copies of all evaluation forms, thesis drafts, and the final thesis.
The formal requirements are two progress reports (one submitted after Thanksgiving and one early in the spring term), a written thesis, an oral examination, and a poster presentation.

Students register for CBE 454 in the spring term only. Nothing appears on the transcript for the fall term. CBE 454 automatically carries double credit; that fact is noted on the official transcript.

The most frequently asked questions concern what is actually in a thesis (how much detail, how long should it be, 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 functions 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 adviser 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:

- Defining the problem and reviewing the literature
- Your particular contribution to this area
- 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.

**B. What Are You Looking At?**

Clearly, 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. This should be 1-2 pages in length.
C. 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.

D. 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 studying a catalytic reaction, list others who have worked on the same or similar problems and briefly describe their work. If you are reexamining a problem studied by others in the field, but using a different technique that is of particular interest to you, say so and describe why you have chosen this approach over others that may have been used.

E. 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 was too detailed to put in the introduction. It may be appropriate to introduce at this stage one or more hypotheses which you feel your research will prove (or disprove). After stating the relevant hypotheses, your research would consist of definitive studies to confirm or deny your hypotheses.

Not all work is conducive to initial statements of hypotheses, particularly methodological theses that 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 and which are likely to affect your results but are required for time/budget reasons.

F. 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 taken due to time/budget/data availability constraints. Do not try to claim credit by stating that you feel that your method/model 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 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.

G. 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 very 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, and 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.

H. What Next (or 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 does 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.

VI. 1ST AND 2ND PROGRESS REPORTS

The 1st and 2nd Progress Reports (due December 7, 2015 and February 29, 2016) should be brief and generally should not exceed 3 pages single spaced or 6 pages double spaced unless discussed with your adviser. Each report should contain:

(i) The title of your project and the name(s) of your adviser(s);

(ii) A paragraph that describes the objectives of your work and provides brief background information that places your (forthcoming) investigations in perspective.

(iii) A specific statement of work accomplished to date and a summary of what you have read. If you are doing theoretical or computational work, do summarize the progress in your research in a succinct way. If you have begun to collect data, summarize the results. If you are designing and/or building an apparatus, provide a sketch and the completion schedule; and

(iv) A summary of what you hope to accomplish by the next "deadline", i.e., the next progress report or the thesis first draft.

Please submit an electronic copy or a hard copy of each progress report to your adviser, faculty liaison for those outside the CBE department, and Julie Sefa in Room A-201.

VII. FIRST AND FINAL DRAFTS OF THE THESIS

The first draft (due April 11, 2016) should be in an almost final form, and should be submitted to your thesis adviser. DO NOT BIND THIS DRAFT. Remember that it takes at least two weeks to organize and write a coherent first draft. You are encouraged to draw up an outline of the thesis by early March and discuss it with your adviser before actually writing the thesis. There is often a mistaken notion that once you start writing, the "research" part of your thesis experience is over, i.e. no more experiments, derivations
or computations. This is a myth. It is common to recognize loose ends at the time of thesis writing, and therefore it is almost inevitable that you and/or your adviser will see the need to do additional work. Within a few days after you turn in your first draft to your adviser, he/she will respond to you with his/her comments. Some revisions and perhaps additional research work (such as replotting data, a few more calculations, or one or two quick experiments) may be needed at this stage to finalize the thesis.

This final draft (due April 25, 2016) should be submitted to your adviser and second reader. Every student will be assigned a second reader in March. DO NOT BIND THIS DRAFT. This draft should be in FINAL FORM. You will be graded on the basis of this draft.

VIII. THE THESIS

An electronic copy, preferably a .pdf, of the thesis must be turned in to Julie Sefa on or before Monday, May 9, 2016. Extensions beyond this date can only be granted with the approval of the Department Representative and will only be considered under rare circumstances. This electronic copy is for the Mudd Library and will be used as an archival copy. A hardbound copy must be turned into your adviser by May 18, 2016. If your project is supervised by more than one professor, please give each one a copy. You do not have to give a copy to the second reader. If you received funding for senior thesis research through the Lidow fund, etc., remember to acknowledge these sources in your thesis.

To recap the number of copies:

- one (1) hardbound copy for each adviser
- one (1) .pdf copy for the Mudd Library archive and for departmental records (to be emailed to Julie Sefa).
- one (1) softbound copy for each funding source (other than the usual university funds)
- one (1) .pdf copy of the title page and abstract to be emailed to Julie Sefa at jsefa@princeton.edu.
IX. Thesis Requirements

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.

A. Length

Your thesis should not be more than 40 pages, double-spaced, 12 point font size. You should be able to succinctly convey all the above information within the page limitation. Indeed, proposals are limited to much fewer pages at many funding agencies, so it is important that you are able to convey your findings concisely and succinctly. Of the 40 pages, no more than half of the length should be dedicated to introduction and background. You should spend the majority of your thesis discussing your results.

B. Format

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

Submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Engineering

Department of Chemical and Biological Engineering
Princeton University
If you are using this thesis to fulfill the requirements of any certificate program, state that as well. eg: Department of Chemical and Biological Engineering and Engineering Biology Certificate Program.

(2) The second page (page ii) should contain the following statements:

This paper represents my own work in accordance with University regulations.

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)

(3) The third page (page iii) helps to provide a record of who has used the thesis, and should be blank except for the following statement at the top of the page:

Princeton University requires the signatures of all persons using or photocopying this thesis. Please sign below, and give address and date.

(4) It is not uncommon for authors of manuscripts to dedicate their works to loved ones. This is page (iv).

(5) Page (v) is Acknowledgments. This is voluntary. It is common practice to thank funding agencies who supported your research through the senior thesis research fund.

(6) Page (vi) is Abstract. Occasionally, more than one page may be needed for the abstract.

(7) Page (vii) etc. are for Table of Contents, List of Tables and List of Figures. The List of Tables and List of Figures should include table or figure number, the caption and the page number where it appears.

(8) Then starts the text of the thesis. Start numbering the pages 1, 2, 3 etc. from here on.

(9) Citation of literature referenced in the text and in bibliography should correspond to a commonly accepted format. For the sake of uniformity, it is suggested that everyone follow the guidelines recommended by the American Chemical Society. Please review The ACS Style Guide: A Manual for Authors and Editors by Janet S. Dowd, for guidance. Literature citation is not included within the 40 page limit.
Other requirements that must be observed when preparing the thesis:

- General requirements regarding figures, tables, nomenclature are described in the ACS Style Guide.
- The thesis must be typed double-spaced, with the exception of footnotes and bibliography. Fonts should be 12 point, with the exception of figure and table captions.
- 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.
- Each thesis must have the title and author inscribed on the cover or typed on a white label placed on the front of the thesis.

C. Printing and Binding

The following places are recommended by prior senior classes:

- Pequod Copy & Print Center- Princeton  [www.pequodcampus.com](http://www.pequodcampus.com)
- Smith-Shattuck Bookbinding  [www.thesisbookbinding.com](http://www.thesisbookbinding.com)
- Triangle Repro Center  [www.princetonprinter.com](http://www.princetonprinter.com)

X. Poster Presentation

The poster presentation will take place on Monday, May 2, 2016 at the Friend Center Convocation Room. The purpose of the poster session is for the faculty to see what the students have done and also for the students to see what their classmates have done. Each student will be asked to stay next to his/her poster until the faculty assigned to their poster has completed his/her examination of the poster. During the remainder of the time, he/she can wander around the room and look at the other posters. Julie Sefa will make the arrangements. The poster typically consists of visual aids stating the research objective(s), approach, typical/key result(s), and conclusions. It takes a fair amount of planning to put together a good poster. Use a good balance of text and visual aids (figures/graphs/tables). If a faculty member or a fellow student from your class stops by your poster and asks you to explain your work, you ought to be able to do that within five minutes. Place on the poster
only those visual aids that will help you in this explanation. The top of your poster should include the title of your thesis, your name, and your adviser's name. **It is recommended you read “Tips for Effective Poster Presentations”** by K. Barbara Schowen in *The ACS Style Guide* J.S. Dodd, ed. American Chemical Society, Washington D.C. 1997. to get a sense of what constitutes a good poster presentation.

**For additional advice on preparing for a poster presentation:**

http://www.kumc.edu/SAH/OTEd/jradel/Poster_Presentations/110.html
Tutorial from University of Kansas

http://www.osti.gov/em52/workshop/tips-exhibits.html
Department of Energy Tips for Poster Preparation

http://www.pitt.edu/~etbell/nsurg/PosterGuide.html
University of Pittsburgh Poster Presentation Guidelines

http://www.ncsu.edu/project/posters/
Creating Effective Poster Presentations, North Carolina State University

**XI. ORAL EXAMINATION**

The oral examinations must be **completed by Friday, May 6, 2016.** The student should arrange the oral examination with their second reader and adviser at the time of submission of the final draft of thesis. The oral examination may take place in the second reader’s office, the adviser’s office or another location reserved by the student. Please confer with your second reader and adviser regarding location. If you need help with these arrangements please contact Julie Sefa. The purpose of this examination is to give the second reader a chance to probe the extent of independent thinking done by the student. The exam should last approximately 1 hour. You should prepare to speak no more than 10-15 minutes about the project you worked on and your key results. Consult with your second reader whether he/she prefers a formal presentation or whether you can present from your poster. The faculty will then follow up with some questions. You can be asked questions about the relevant literature, your research, and your thoughts about future directions of fruitful research, etc. The atmosphere is generally informal. However, do not take the oral examination lightly. Remember that it is an examination of the student and not of the
adviser. So, do not expect your adviser to answer the questions if you do not know the answers. Also, do not get upset with your adviser if he/she fails to bail you out of tough questions! Once the question period is done, you will be excused so the faculty can confer and discuss the thesis and exam.

XII. EVALUATION

A. 1st and 2nd Progress Report Grade Sheets

You will receive feedback on your first and second progress reports with the focus of the evaluation being work ethic, understanding of the thesis project, and progress on the research. Grade sheets can be found in Appendices I and II.

B. Final Grade

Your final grade in CBE 454 will be based on your performance over the course of the year. You will be evaluated based on your two progress reports, your senior thesis adviser report, your second reader’s report as well as your poster grade. For details on the criteria used in evaluating your senior thesis, poster presentation, and oral defense, please consult Appendices III, IV, and V. These individual grades serve as guidelines during a meeting at which the faculty members convene to assign final grades; external thesis advisers will be invited to this meeting. Opinions and evaluations will be solicited from faculty members (internal and external) in advance if they cannot attend the meeting. The Chemical and Biological Engineering Department historically awards A grades on thesis at a level comparable to other engineering and natural science departments.

XIII. ADDITIONAL RESOURCES

A. Senior Thesis Funding

Seniors in the School of Engineering and Applied Science may apply for support for senior thesis and independent work research from funds administered by the SEAS Dean’s Office. These funds are normally restricted to consumable supplies, software, small equipment and parts, and travel for field experiments. They do not cover conference travel, books and journals, copying and thesis preparation costs, or capital equipment. Funding per project varies, but will normally not exceed $600; requests above that amount will be considered
only if accompanied by a special request letter from your adviser. All awards are contingent on the availability of funds.

The SEAS Undergraduate Affairs Office will send out information, via email, to students explaining how and when to apply for funding for senior thesis or independent work projects. Generally, two requests are sent out, one each semester.

Application materials must be submitted, according to the deadline, to Dean Peter Bogucki.

For additional information please consult the School of Engineering and Applied Science website at: http://engineering.princeton.edu/undergraduate/

B. Writing Program

The Writing Program, home of your freshman writing seminar, offers support and guidance to complement your working relationship with your adviser and help you find collaborators while you conduct your independent work. Housed in Whitman College, the Writing Center offers free one-on-one conferences with experienced fellow writers trained to consult on assignments in any discipline. Special 80-minute conferences are available for JP and senior thesis writers, who may sign up to work with a graduate student fellow from the department of their choice. Many of these writing groups schedule occasional boot camps, where you and your fellow students set writing goals and commit yourselves to blocks of distraction-free writing time.
APPENDIX I SENIOR THESIS ADVISER’S 1ST INTERIM GRADING SHEET

Department of Chemical and Biological Engineering

By the time of the first progress report, students should have 1) learned techniques relevant to their project, 2) read literature sources relevant to their project, and 3) made tangible progress toward completing the goals of the thesis project.

There are two criteria to guide an interim evaluation: Work Ethic and Thesis Scholarship. Students will be evaluated on both criteria on a numerical scale of 1 to 5. A grade of 5 represents truly distinguished work and thus must include a brief narrative comparable to an A+ statement provided for coursework.

1. Work Ethic
   5 Truly exceptional, a “once in every several years” performance. Works daily on the project with sustained effort over the semester.
   4 Worked on the project enthusiastically and with diligence. Has learned most of the techniques needed for carrying out the project.
   3 Working at an above average level. Comes to lab each week, several times a week.
   2 Performing acceptably, but at average level. Has initiated project but work is sporadic.
   1 Has not devoted enough time to thesis this semester, project has barely been initiated.

2. Thesis Scholarship
   5 Truly exceptional; a “once in several years” performance. Student has already augmented a project suggested by the advisor with her or his own ideas.
   4 Shows superior scholarship. Has shown mastery of most of the literature and skills needed for the thesis.
   3 Has carried out a competent review of the literature. However, the student does not go much beyond the material recommended by the adviser.
   2 Shows average scholarship. The student has only begun to read the literature suggested by the advisor.
   1 Minimal understanding of the project. Lack of effort with regard to reading literature sources.
3. **Overall Evaluation:**

5  Among the top 5% of performances initiating senior independent work I have seen.
4  This student is doing really well.
3  This student is making good progress.
2  This student is making satisfactory progress.
1  This student has been a slow starter and needs to improve effort. An academic warning slip may be issued.

Assigned Score______
Your score can be the arithmetic average of the three scores above or you may use a different weighting.

**Grading guidelines**

5  A+
4  A
3  A- to B+
2  B to B-
1  C+ or below
APPENDIX II SENIOR THESIS ADVISER’S 2\textsuperscript{ND} INTERIM GRADING SHEET

Department of Chemical and Biological Engineering

By the time of the second progress report, students should have 1) mastered techniques relevant to their project, 2) have carried out a significant body of independent research and 3) begun writing sections of the thesis.

There are two criteria to guide an interim evaluation: Work Ethic and Thesis Scholarship. Students will be evaluated on both criteria on a numerical scale of 1 to 5. A grade of 5 represents truly distinguished work and thus must include a brief narrative comparable to an A+ statement previously required for A+ grades in coursework.

1. Work Ethic
5  Truly exceptional, a “once in every several years” performance. Works daily on the project with sustained effort over the semester.
4  Worked on the project enthusiastically and with diligence. Works nearly every day.
3  Working at an above average level. Comes to lab each week, several times a week.
2  Performing acceptably, but at average level. Work is somewhat sporadic.
1  Has not devoted enough time to thesis this semester, project has barely been initiated.

2. Thesis Scholarship
5  Truly exceptional; a “once in several years” performance. Student has gone well beyond the project suggested by the advisor. A clear path to thesis publication is apparent.
4  Shows superior scholarship. Has shown mastery of most of the literature and skills needed for the thesis.
3  Has carried out a competent review of the literature. However, the student does not go much beyond the material recommended by the adviser.
2  Shows average scholarship. The student has only begun to read the literature suggested by the advisor.
1  Minimal understanding of the project. Lack of effort with regard to reading literature sources.
3. **Overall Evaluation:**

5  Among the top 5% of performances initiating senior independent work I have seen.
4  This student is doing really well.
3  This student is making good progress.
2  This student is making satisfactory process.
1  This student has been a slow starter and needs to improve effort. An academic warning slip may be issued.

Assigned Score______

Your score can be the arithmetic average of the three scores above or you may use a different weighting.

**Grading guidelines**

5  A+
4  A
3  A- to B+
2  B to B-
1  C+ or below
APPENDIX III SENIOR THESIS ADVISER’S GRADING SHEET
Department of Chemical and Biological Engineering

The grade from the thesis adviser is based on 6 criteria: originality, independence, work ethic, quality of the written document, knowledge of the field, and societal impact. Grades for each section range from 1 to 5 according the scale below. A grade of 5 should be reserved for truly exceptional work, and thus should not be given regularly.

Originality: Did the student contribute to the design of the project or did the student simply follow suggestions from the adviser? Did the student find creative solutions to research problems? Was the thesis project a new direction of research within the adviser’s group?

Originality score (1-5):

Independence: Did the student work on her/his own or did the student need constant supervision from a senior grad student or postdoc? Did the student identify literature sources relating to her/his project or did the student only read what the adviser suggested?

Independence score (1-5):

Work ethic: Did the student put in enough time in the lab to generate meaningful data? Was there sustained effort throughout the year, or was everything rushed in the spring semester?

Work ethic score (1-5):

Writing: Was the thesis document well-written? Is it easy to read and understand? Is it well-organized? Is the balance between text and display items appropriate? Has the student mastered principles of scientific writing?

Writing score (1-5):

Knowledge of the field: Does the student understand the context of her/his work? How well-versed is the student in prior work in the research area? Has the student become engaged with the thesis topic such that she/he will continue to learn about it after graduation?
Knowledge of the field/life-long learning score (1-5):

**Societal impact:** Has the societal impact of the research been addressed suitably in the thesis document and/or in the oral defense?

**Societal impact score (1-5):**

**Overall score:** Please provide an overall score as the thesis adviser. You may simply average your scores from above or use a different weighting if you prefer.

**Overall numerical score (1-5):**

**Grade scale**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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<tbody>
<tr>
<td>5</td>
<td>A+</td>
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<tr>
<td>4</td>
<td>A</td>
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<td>3</td>
<td>A- to B+</td>
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<td>2</td>
<td>B to B-</td>
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<tr>
<td>1</td>
<td>C+ or below</td>
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</tbody>
</table>
APPENDIX IV SENIOR THESIS 2ND READER’S GRADING SHEET

Department of Chemical and Biological Engineering

The grade for the 2nd reader is based on 3 criteria: quality of the written document, scientific content or scholarship, and the quality of the oral defense. Grades for each section range from 1 to 5 according the scale below. A grade of 5 should be reserved for truly exceptional work, and thus should not be given regularly.

Writing: Is the thesis easy to read? Is it organized in a logical fashion? Are formatting and length requirements obeyed? Is the balance between text and figures/other display items appropriate? Are the references appropriate? Has the student demonstrated competence or even excellence in scientific writing?

Writing score (1-5):

Scientific content: Has the student contributed something new to the field? Were proper control experiments carried out? Were statistical analyses properly carried out? Does the student clearly place the work in context of previous work?

Content score (1-5):

Oral defense: Was the oral defense well-organized? Did the student concisely state the major conclusions of the thesis? Did the student respond well to questions without help from the adviser?

Defense score (1-5):

Overall score: Please provide an overall score as the second reader. You may simply average your scores from above or use a different weighting if you prefer.

Overall numerical score (1-5):

Grade scale
5 A+
4 A
3 A- to B+
2 B to B-
1 C+ or below
The grade for senior thesis poster presentations is based on 3 criteria: poster aesthetics, scientific content, and the quality of the poster defense. Grades for each section range from 1 to 5 according the scale below. A grade of 5 should be reserved for truly exceptional work, and thus should not be given regularly.

Aesthetics: Is the poster well-organized and easy to follow? Is there balance between text and figures? Are there obvious spelling mistakes or other issues?

Aesthetics score (1-5):

Poster content: Does the amount of work presented on the poster reflect a year-long thesis project? Has the student clearly learned something new?

Content score (1-5):

Poster defense: Is the student able to explain the work clearly and concisely? Is the student able to answer questions about the work?

Defense score (1-5):

Overall score: Please provide an overall score for the poster. You may simply average your scores from above or use a different weighting if you prefer.

Overall numerical score (1-5):

Grade scale
5   A+
4   A
3   A- to B+
2   B to B-
1   C+ or below
Additional copies of the Senior Thesis Guide can be obtained from the Chemical and Biological Engineering Undergraduate Office, EQuad Room A201, as well the website: http://www.princeton.edu/cbe/undergrad/Undergrad_Thesis_Guide.pdf