

# **Department of Chemical and Biological Engineering Senior Thesis Guide**

Academic Year 2020-21

*Revised: September 2020*



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## I. INTRODUCTION

The senior thesis is a defining characteristic of a Princeton undergraduate education. The year-long thesis allows students to work in-depth on cutting-edge research with a faculty adviser. Many alumni find their senior thesis to be the most rewarding academic exercise of their years at Princeton. This guide represents an effort to better inform students of what to expect when writing a thesis. It provides key dates, deadlines, and certain rules and procedures governing the preparation of the final document. Tips on the oral examination and poster presentation at the end of the year are also provided.

### **IMPORTANT: Academic Year 2020-2021 Adjustments**

**For academic year 2020-2021, two specific requirements will be relaxed. Normally, in rare instances a student could replace CBE454 (two term senior thesis) with one term of senior thesis (CBE451 or CBE452) and an additional upper level CBE elective. Given the current situation with COVID-19, this requirement will be relaxed to one term of senior thesis work (CBE451 or CBE452) and an additional upper level engineering topic (ET) course as a substitute for CBE454. The second adjustment concerns honors. Normally, students need to conduct a two-term senior thesis (CBE454) to be considered for honors. Given the current circumstances, this requirement will be suspended for the 2020-2021 academic year.**

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## 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.

<b>Course Learning Objectives</b>	<b>ABET Student Outcomes</b>
1. Integrate science and engineering principles for analysis and solution of problems in the field of chemical and biological engineering.	1
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.	4
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.	1
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.	7
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.	1,2,6
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.	6
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.	4
8. Develop writing skills and presentation skills needed to effectively communicate the purpose, scope, and conclusions of the project.	3

### 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.

Tuesday, November 24, 2020: 1st Progress Report to the adviser and email copy to Julie Sefa.

Monday, March 1, 2021: 2nd Progress Report to the adviser and email copy to Julie Sefa.

Monday, April 19, 2021: First draft (nearly final) of thesis to adviser.

Monday, May 3, 2021: Final draft (*not bound*) of thesis to adviser and second reader.

Thursday, May 6, 2021: Digital poster submission.

Friday, May 14, 2021: Oral examinations to be completed.

Friday, May 14, 2021: Adviser and second reader report grade to Professor Brynildsen.

Monday, May 17, 2021: Electronic copy of thesis to Julie Sefa (**version uploaded to Mudd Library**).

Monday, May 17, 2021: Electronic copy of thesis to adviser.

**Please make a note of these dates.  
Failure to submit on time may result in a lower grade.**

## **IV. WHAT IS A THESIS?**

A thesis is an experimental, computational, and/or theoretical study of an important problem. Students are matched to a faculty adviser who then work together to define a specific research project. In the CBE department, both a written thesis and oral defense are required. The senior thesis is a yearlong study and is recorded as a double course in the spring. In order for the thesis to qualify as an engineering topic course, it should contain significant technical content and engineering relevance. Specifically, theses should include creative application of knowledge from the basic sciences and math to solve engineering problems, which are technical problems that address a societal need. In rare cases, the engineering topic content of a CBE senior thesis can be waived by the CBE Undergraduate Committee if additional engineering topic courses are taken to satisfy the ABET criterion. Importantly, all CBE students still need to conduct a senior thesis; however, this allows for situations where a student desires working with advisers and on topics without engineering content.

### **A. Choosing an adviser**

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 document that summarizes the research of each member of the faculty, as well as the typical engineering topic content of theses performed in their groups. Students read these descriptions and meet with several different faculty members in person. At the end of this period, students submit a rank-ordered list of four advisers. 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 her/his top choices. No student is ever required to work on a project in which she/he has no interest. For examples of past senior thesis' titles, please consult the department's Undergraduate Handbook. Students are encouraged to browse through past theses available in the Mudd Library archive.

It is possible to have a thesis adviser outside the department. In this case, the student in consultation with the external adviser must provide a written statement describing the engineering topic content of the proposed thesis, which will need to be approved by the CBE Undergraduate Committee.

## B. Thesis Requirements

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.

## C. Thesis Research

The matching process between students and thesis advisers is usually complete by early April of the junior year. This allows you to meet with your adviser prior to departing for the summer to discuss your project and get some background reading material. As soon as senior year starts, you should meet with your adviser and get started on your project as soon as possible. The key to senior thesis is sustained effort over the entire academic year rather than trying to rush your work.

Your thesis research can be thought of as having three phases:

- **Background and literature search:** since a thesis is meant to be a piece of original work, it is critical to know what prior work has been done in your field. Thus it is important to read the literature both broadly and deeply. This background reading will help you in formulating the introduction to your progress reports and your thesis. The rubrics for grading the progress reports and thesis (see Appendices I to IV) include
- **Doing the research:** the faculty of the CBE department have diverse research interests. Theses that are based entirely in theory and computation are possible, as are theses that are completely experimental. CBE faculty work in energy, materials, and the life sciences. Because of this diversity in research disciplines, each student's thesis experience will be unique. Rather than provide a set of strict guidelines, what follows are broad suggestions to be followed by all students, regardless of research area.
  - **Start early and work consistently.** Get started on your thesis research in September before job interviews, grad school applications, and other commitments become more daunting. If you set up a schedule early in the fall

and get used to working on your thesis regularly, it will be easier to keep up your work throughout the year.

- **Talk to your adviser frequently.** Scientific research is rarely done in isolation. You can often get past roadblocks in your research by having discussions with your adviser. Some advisers have senior thesis students attend group meetings while others will prefer one-on-one meetings with students.
- **Talk to your group members.** Much like the adviser, other thesis students as well as grad students and postdocs in your thesis lab can help you past challenges in your own work.
- **Keep reading.** Though you will likely focus more on your background reading early on in the semester, it is a good idea to keep reading the literature in your field throughout all year long.
- **Writing the thesis:** another critical aspect of research is being able to convey your results in a concise and compelling fashion. Your thesis document has a page limit of 40 pages double-spaced including display items such as figures and tables. Additional information can be placed in appendices, but these sections are likely not to be read in the same depth as the main text.
  - Your thesis should start with a background section that describes the state of the art of the field. This section should include the bulk of the referenced works in your thesis.
  - Move next to the specific question you are answering or hypothesis you are testing with your research.
  - The bulk of the thesis should be your results and discussion of how these results address the question or hypothesis.
  - Finally, include some closing remarks and suggestions for further study.
  - Please note that separate sections describing the engineering topic content and societal impact of the research contained in the thesis are required.



## V. 1ST AND 2ND PROGRESS REPORTS

The 1st and 2nd Progress Reports (**due November 24, 2020 and March 1, 2021**) 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.
- (v) A written description of the engineering topic content of the thesis.

Please submit an electronic copy of each progress report to your adviser, faculty liaison for those outside the CBE department, and Julie Sefa.

## VI. FIRST AND FINAL DRAFTS OF THE THESIS

The first draft (**due April 19, 2021**) 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 May 3, 2021)** 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.

## VII. THE THESIS

An electronic copy, preferably a .pdf, of the thesis must be turned in to Julie Sefa on or before **Monday, May 17, 2021**. Extensions beyond this date can only be granted with the approval of the Director of Undergraduate Studies and will only be considered under rare circumstances. This electronic copy is for the Mudd Library and will be used as an archival copy. **An electronic copy must be turned into your adviser by May 17, 2021.** 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) electronic copy for each adviser.
- one (1) .pdf copy for the Mudd Library archive and for departmental records (to be emailed to Julie Sefa at [jsefa@princeton.edu](mailto:jsefa@princeton.edu)).
- one (1) .pdf copy for each funding source (other than the usual University funds).

## VIII. 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 including display items such as figures and tables. 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.
- (10) 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 1½ 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.
- ❖ Each thesis must include separate sections describing the engineering topic content and societal impact of the research performed.

### 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)

## IX. POSTER PRESENTATION

The poster presentation will take place on **Thursday, May 6, 2021 in a digital format for the spring 2021 term**. Details of the digital poster session will follow in an email to students at a later date. 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. 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:

[https://urc.ucdavis.edu/local\\_resources/documents/pdf\\_documents/How\\_To\\_Make\\_a\\_n\\_Effective\\_Poster2.pdf](https://urc.ucdavis.edu/local_resources/documents/pdf_documents/How_To_Make_a_n_Effective_Poster2.pdf)

University of California at Davis Undergraduate Research Center Poster Presentation Guidelines

<https://guides.nyu.edu/posters>

NYU Poster Guidelines

<http://www1.udel.edu/research/presenting/posters.html>

University of Delaware Poster Guidelines

## X. ORAL EXAMINATION

The oral examinations must be **completed by Friday, May 14, 2021**. 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, another reasonable location, or by Zoom if needed. Please confer with your second reader and adviser regarding location. It is the responsibility of the student to arrange the meeting (date, time, 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.

## **XI. EVALUATION**

### **A. 1<sup>st</sup> and 2<sup>nd</sup> 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 evaluations. The adviser assigns scores for the progress reports and the final thesis, while the second reader assigns a score based on the thesis document and defense. Two more faculty will grade your poster presentation, so a total of four different faculty will evaluate your work. 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 are weighted as follows: 10% each for the first and second progress reports, 45% for the adviser final thesis score, 20% for the second reader score, and 15% for the combined poster scores. These scores 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. During this meeting each thesis is discussed individually and the faculty vote on the final letter grades. The Chemical and Biological Engineering Department historically awards "A" grades on thesis at a level comparable to other engineering and natural science departments.

## **XII. 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 [Senior Thesis/Independent Work Funding](#).

## **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 1<sup>ST</sup> 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) started to become independent in their research.

There are three criteria to guide an interim evaluation: Work Ethic, Thesis Scholarship, and Independence. Students will be evaluated on each criterion on a numerical scale of 1 to 5. Your score need not be an integer. A score above 4 represents truly distinguished work and thus must include a brief narrative comparable to an A+ statement provided for coursework. Scores above 4 without a narrative will be reduced to 4.

#### **1. Work Ethic: how much effort is the student putting into the project?**

- 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: how well does the student understand the field?**

- 5 Truly exceptional; a “once in several years” performance. Student has already augmented a project suggested by the adviser 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 adviser.
- 1 Minimal understanding of the project. Lack of effort with regard to reading literature sources.

3. **Independence**: to what extent has the student taken ownership of the project?

- 5 The student has already taught me and my group members new things
- 4 Student has starting working on her/his own, plans and executes experiments on her/his own
- 3 Student needs frequent input from adviser or grad students/postdocs
- 2 Student still works closely with grad student/postdoc
- 1 Student has taken no ownership of project, requires constant input from adviser or grad student/postdoc

4. **Engineering Topic Content**: does this progress report describe the engineering topic content of the thesis?  
*According to ABET, engineering content refers to the creative application of knowledge from the basic sciences and math to solve engineering problems. Engineering problems are technical problems that address a societal need.*

Please circle one:      Yes   /   No

5. **Overall Evaluation**: you may average your scores or use a different weighting

- 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.

**Grade Scale**

- 5 A+
- 4 A
- 3 A- to B+
- 2 B to B-
- 1 C+ or below

## APPENDIX II SENIOR THESIS ADVISER'S 2<sup>ND</sup> 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 three criteria to guide an interim evaluation: Work Ethic, Thesis Scholarship, and Independence. Students will be evaluated on both criteria on a numerical scale of 1 to 5. Your score need not be an integer. A grade of 5 represents truly distinguished work and thus must include a brief narrative comparable to an A+ statement required for A+ grades in coursework. Scores above 4 without a narrative will be reduced to 4.

#### 1. **Work Ethic**: *how much effort is the student putting into the project?*

- 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**: *does the student have a good grasp of prior art and challenges in the field of the thesis research?*

- 5 Truly exceptional; a “once in several years” performance. Student has gone well beyond the project suggested by the adviser. 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 adviser.
- 1 Minimal understanding of the project. Lack of effort with regard to reading literature sources.

3. **Independence**: to what extent has the student taken ownership of the project?

- 5 The student has already taught me and my group members new things
- 4 Student has been working on her/his own, plans and executes experiments on her/his own
- 3 Student needs frequent input from adviser or grad students/postdocs
- 2 Student still works closely with grad student/postdoc
- 1 Student has taken no ownership of project, requires constant input from adviser or grad student/postdoc

4. **Engineering Topic Content**: does this progress report describe the engineering topic content of the thesis?  
*According to ABET, engineering content refers to the creative application of knowledge from the basic sciences and math to solve engineering problems. Engineering problems are technical problems that address a societal need.*

Please circle one:      Yes / No

5. **Overall Evaluation**: you may average your scores or use a different weighting

- 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.

**Grade Scale**

- 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 to 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):

**Engineering topic content:** Has the engineering topic content of the research been described suitably in the thesis document? According to ABET, engineering content refers to the creative application of knowledge from the basic sciences and math to solve engineering problems. Engineering problems are technical problems that address a societal need.

Engineering topic content (please indicate Yes or No):

**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    5: A+            4: A            3: A- to B+            2: B to B-            1: C+ or below

## **APPENDIX IV SENIOR THESIS 2<sup>ND</sup> READER'S GRADING SHEET**

### **Department of Chemical and Biological Engineering**

The grade for the 2<sup>nd</sup> 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):

**Engineering topic content:** Has the engineering topic content of the research been described suitably in the thesis document? According to ABET, engineering content refers to the creative application of knowledge from the basic sciences and math to solve engineering problems. Engineering problems are technical problems that address a societal need.

Engineering topic content (please indicate Yes or No):

**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

## **APPENDIX V SENIOR THESIS POSTER EVALUATOR'S GRADING SHEET**

### **Department of Chemical and Biological Engineering**

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:  
[https://cbe.princeton.edu/sites/cbe/files/undergrad\\_thesis\\_guide.pdf](https://cbe.princeton.edu/sites/cbe/files/undergrad_thesis_guide.pdf)

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