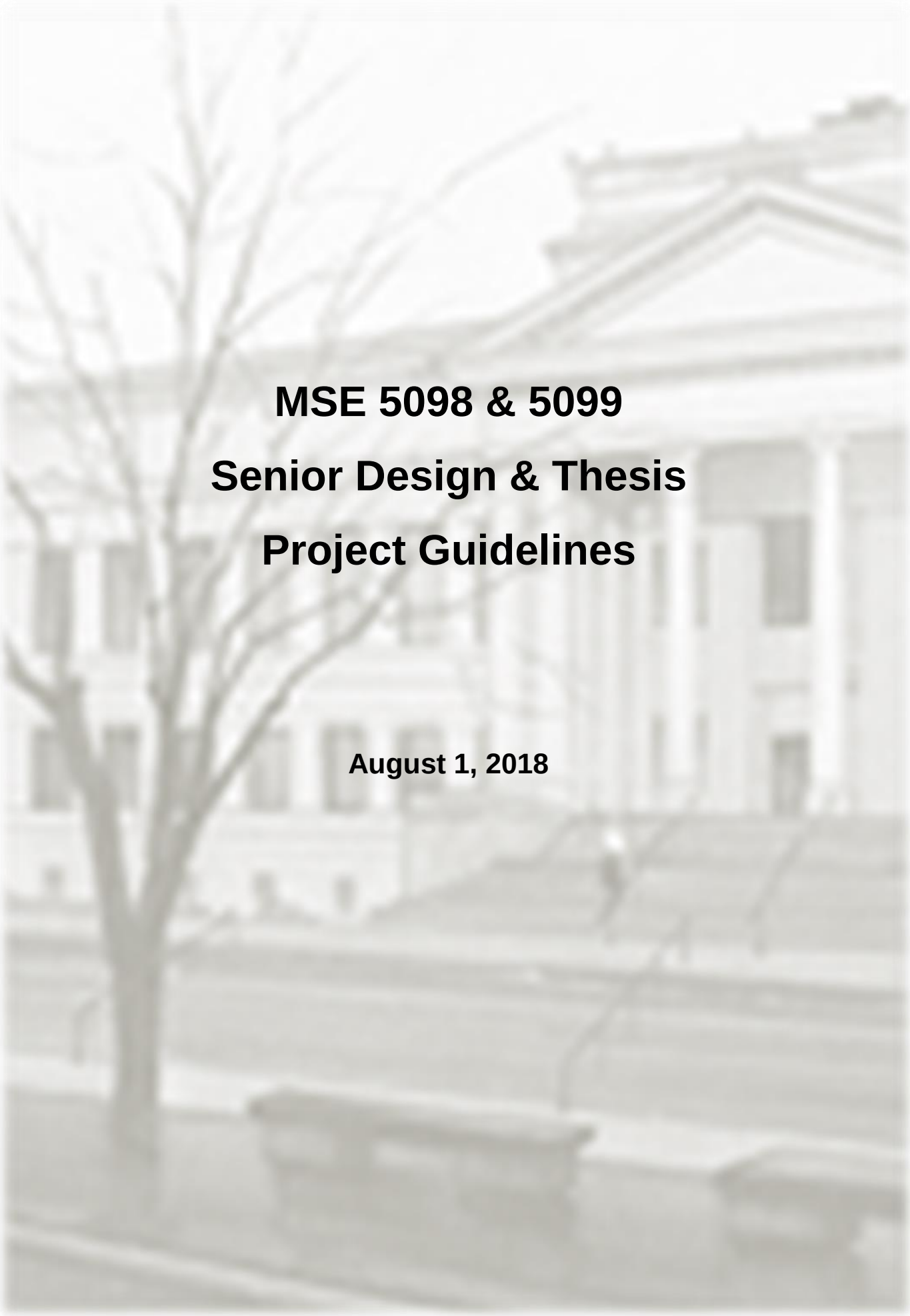

# MSE 5098 & 5099

# Senior Design & Thesis

# Project Guidelines

**August 1, 2018**

# Senior Design Project and Thesis

MSE 5098 and MSE 5099

Graduation requirements for the B.S. degree in the department of Materials Science and Engineering (MSE) include a senior project. The senior project consists of two courses:

- Senior Design (MSE 5098) Fall Semester – 2 credits
- Senior Thesis (MSE 5099) Spring Semester – 2 credits

## Overview of the Senior Project Courses

The senior project is a capstone design project for the Department of Materials Science and Engineering undergraduate degree. It provides an avenue for the student to demonstrate the acquisition of an integrated understanding of the scientific and engineering principles in the discipline and their application to an identified problem.

### *Registration for MSE 5098/5099*

MSE 5098 and 5099 are restricted to students in their senior year. Seniors must be registered in consecutive Fall and Spring semesters of the year they graduate. Students must pass both courses to receive credit for either course. Grades for MSE 5098 will be recorded as 'I' until the grade for MSE 5099 is recorded. MSE 5090 is a required prerequisite for MSE 5098 and 5099.

MSE 5098 and 5099 are registered under the name of the ***CLEAR instructor*** assigned to the MSE department.

## Overview of the Senior Project

As a capstone experience, the senior project brings together many aspects of materials science and engineering. Each student's project will demonstrate their knowledge in several areas, including thermodynamics, kinetics, processing, characterization, and materials properties. It also includes an understanding of the structure, properties, processing, and performance of the material. The project will demonstrate the student's ability to apply these concepts to solve applied materials problems rather than perform basic research or operate lab equipment.

### *Selecting a Senior Project*

During the spring semester of the junior year, faculty will offer projects for students to work on with other students. After indicating their preferences, students will be assigned to teams with a faculty adviser by the Senior Thesis Advisor and Academic Advisor with the approval of the faculty adviser. Teams will be selected based on the student's areas of interest and available faculty. Each team will consist of 2 – 4 students, depending on the size of the senior class and the nature of the project. The student's faculty adviser will oversee the design and technical aspects of the student's project. Occasionally, students with well-developed individual projects will be permitted to pursue aspects of those projects as their senior project individually.

If the student is working with a local engineering firm and has a design project that is appropriate as a senior project, an MSE faculty adviser will be assigned to work with the student and the supervisor at the company. Although in most cases, senior projects conducted with local companies will only involve a single student, they are still considered team projects because of the involvement of staff from the local company who will be surveyed regarding the teamwork aspects of the project at the end of the project. The project, presentation and thesis will be completed by the individual student.

### *Scope of a Senior Project*

The senior project must demonstrate the following:

- *Materials System* – An understanding of the underlying structure, properties, processing and performance of a materials system.
- *Engineering Process* – A clearly defined design challenge requiring the development of a material, process or product meeting measurable criteria.

In addition to these technical aspects, the project should assess the proposed solution in the context of relevant engineering standards and applied constraints.

Engineering standards are commonly used in the design and evaluation of engineering products. These standards are commonly created by independent domestic or international organizations, government regulatory agencies, as well as industry sponsored organizations. Standards may relate to topics as diverse as standard

material definitions, characteristics and properties; lab and safety procedures; design methodologies such as finite element analysis (FEA); manufacturing processes; and testing and evaluation procedures.

Among the most well-known standards organizations are the following:

- International Organization for Standardization (ISO) (www.iso.org)
- ASTM International (www.astm.org)
- American National Standards Institute (ANSI) (www.ansi.org)
- National Institute of Standards and Technology (www.nist.gov).

Industry specific standards are often published by industry sponsored organizations as well as international regulatory agencies. Examples include:

- International Atomic Energy Agency (http://www-ns.iaea.org)
- American Petroleum Institute (www.api.org)
- U. S. Food and Drug Administration (www.fda.gov)
- International Electrotechnical Commision (IEC) (www.iec.ch).

As part of the Senior Design Project students are required to determine if there are standards applicable to their projects for all phases of the project. Some standards will create constraints on the possible design solutions while other standards will determine the possible manufacturing or testing processes. When the project deviates from relevant standards the student identify and defend the deviation. This information is documented in Section 3, “Product Design and Specifications,” of the thesis.

Applied constraints relate to various issues, often outside the engineer’s control, but to which the engineer must respond in designing their problem. Examples of applied constraints include:

- *Economic* – The possibility of putting this product or process on the market at a viable cost.
- *Manufacturability* – The ability to manufacture the product with existing manufacturing processes within market constraints.
- *Product life* – Expected length of usefulness of the product or process with consideration of full life cycle costs (from manufacturing through disposal at end of life).
- *Sustainability* – Consider issues such as product or process sustainability given current resource availability, special disposal issues, or “green engineering.”
- *Environmental* – Positive and negative effects of the product or process in light of current environmental concerns such as climate change or waste streams.
- *Social* – The effects of this product or process on society including effects on labor, social structures and global relations.
- *Political* – The consideration of political constraints for this product or process, such as regulatory issues, use of rare materials or other political considerations.
- *Ethical* – The ethical considerations of this product or process that may relate to misuse, disproportionate impact on marginalized groups in society or other issues.

- *Health and Safety* – Health and safety implications of the product or process during manufacturing, use and disposal.

Applied constraints are evaluated at two points during the senior design project. They provide constraints on the design solution, perhaps by specifying the need for sustainable for environmentally friendly materials; accommodating the realities of user preferences expressed in the marketplace or the needs or facilities of the end customer. This evaluation of applied constraints is included in Section 3, "Product Design and Specifications," of the thesis.

Applied constraints are re-evaluated at the conclusion of the project as the understanding of these issues may have changed over the course of the project. Materials projects often undergo design changes in response to process issues or test results. It is, therefore, important to determine if the final product raises new issues in these areas. The re-evaluation of applied constraints occurs in Section 7, "Business, Social and Ethical Considerations," of the thesis.

*What is a design project?*

Materials science and engineering is a broad field, using the knowledge of multiple scientific disciplines. Materials engineers develop new materials, products or processes while others focus on product improvement or quality assurance. Each of these engineering tasks is available as the focus of a senior project, but require the utilization of a design process that involves identifying a problem or challenge, defining options, resolving the problem or challenge, and preparing and implementing efforts to evaluate these options. The purpose and goal of the design project is for each team to work through this design sequence to address an original and applied engineering problem or issue selected by the team with the faculty adviser, and to document the efforts through a written thesis, poster session and public presentation. Completion of this design process is an important indicator that a materials science and engineering graduate is prepared to practice materials engineering as a professional engineer.

Engineering is essentially the art of designing. Design is "the creative process of identifying needs and then devising a product or solution to fill those needs."[1] Design projects must demonstrate that students "attain an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability." [2] Additionally, "students must be prepared for engineering practices through the curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints."[3]

[1] Gassert, John D. and Enderle, John D., "Design versus Research in BME Accreditation," *IEEE Engineering in Medicine and Biology Magazine*, (March/April 2008), p. 81.
[2] Gassert, John D. and Enderle, John D., "Design versus Research in BME Accreditation," *IEEE Engineering in Medicine and Biology Magazine*, (March/April 2008), p. 81.
[3] Engineering Accreditation Commission, ABET, Inc. *Criteria for Accrediting Engineering Programs: Effective for Evaluations during the 2015-2016 Accreditation Cycle*, Baltimore: ABET, 2014, p. 4.

*Distinguishing design from research*

Research is an investigation or study of an open-ended goal. It has no set specification or constraints and does not always result in a tangible product or service. Often research follows the scientific method as part of the discovery process and is scholarly or scientific in nature.

Design does not create knowledge, but rather uses knowledge to complete a task or goal. Design always has a specific goal or specifications in mind. Design considers several solutions to meet that goal and evaluates these solutions to find the one that will best meet the desired needs and development constraints.

Often research and design work together. Many large research projects require the design of a system, component, product or process in order for the research project be successful.

A design project that is carried out in a research lab must still meet the criteria of a design project as defined above. Otherwise, it will not be appropriate as a senior design project.

*Acceptable Design Projects*

A standard design cycle is shown in Figure 1,[4] beginning with the identification of the need or problem and culminating in the achievement of a solution to that need. The senior design project does not aim to replicate all aspects of the design cycle. The Department permits students to skip the generation of product ideas and does not require successful development. In lieu of the first step of the cycle, the Department allows ideas to be generated by faculty members or commercial operations. Successful development is also not required, although students are required to develop against measureable market-like criteria and identify whether their project makes a reasonable contribution towards marketability.

Available online at http:// www.abet.org/wp-content/uploads/2015/05/E001-15-16-EAC-Criteria-03-10-15.pdf.

[4] LinkEngineering.com, http://linkengineering.org/File.aspx?id=5650, (accessed January 26, 2016).

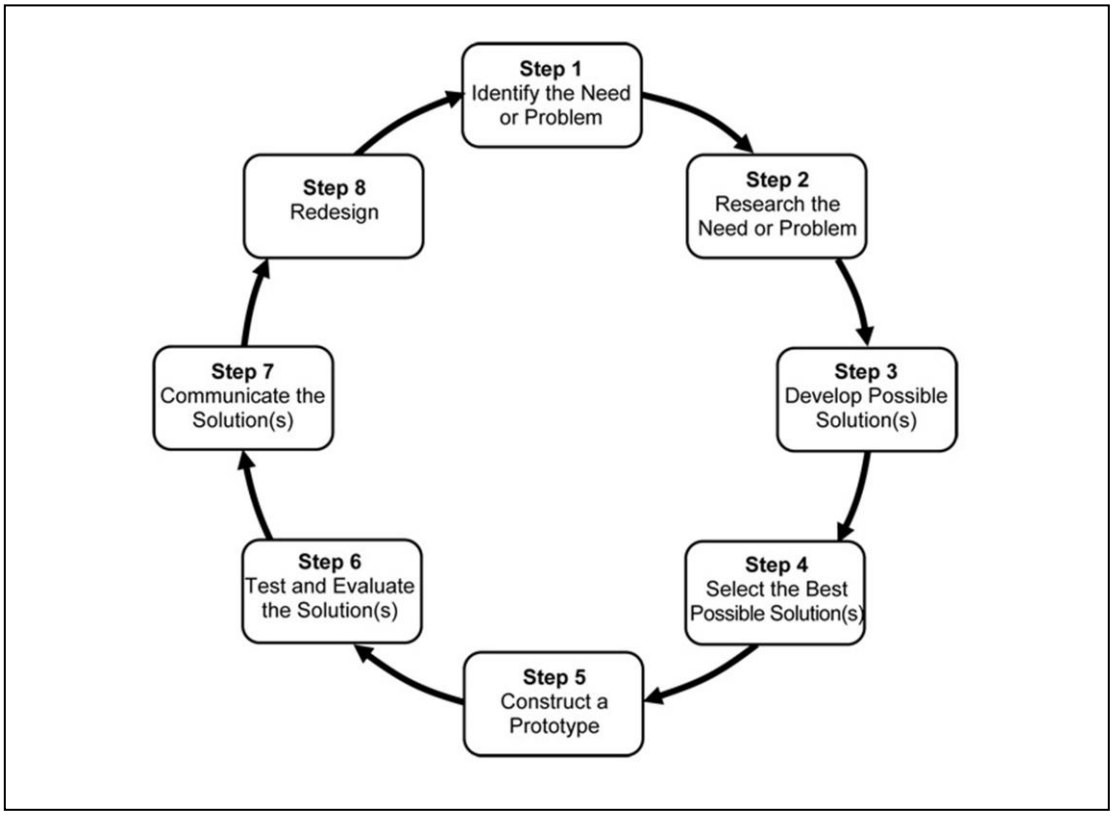


*Figure 1*. Sample engineering design process

An acceptable design project creates a material, process, or device that addresses a clearly applied need. The project must provide measureable criteria by which the material, process or device may be judged as successful in fulfilling the need. Projects do not have to produce market ready products, but must do more than simply implement incremental changes recommended by prior student or faculty projects or research.

An unacceptable design project is one in which there is no clear applied need or in which there are no measurable criteria by which the project may be judged as successful. Examples of unacceptable design projects include projects in which there is only characterization of existing materials, projects which only build new materials in accordance with faculty recommendations, or which do not include significant elements of the design cycle.

*What is a significant design experience?*

The Senior Project is intended to provide a significant design experience. To ensure that a project provides this experience, each team, in conjunction with the faculty adviser, should answer the following questions:

1. What is the need or problem that the project will resolve? Is it clearly defined?
2. What design process will be used in addressing this need or problem?

3. What are the product or process specifications, and are they testable?
4. What are the relevant standards and applied constraints that require consideration?
5. What are the alternative approaches and why was the selected design approach chosen over the alternatives?
6. Does the design process lead to an implemented product or process?
7. Does the design experience utilize the knowledge and skills acquired in earlier course work and incorporate appropriate engineering standards?

Each student must be able to answer each of these questions and describe the relevant aspects of the project that fulfill each question for the project to be considered a significant design experience. An inability to answer these questions indicates that the student is not yet ready to begin the project or that the project may be unacceptable as a senior project. Any such deficiencies should be addressed early in the project.

## Roles in the Senior Project

*The Role of the Senior Design Student*

Attendance at MSE 5098/5099 class meetings is mandatory. Students are expected to participate in class discussion and expected to complete all course assignments. Students are expected to work with their peers to review one another's work and maintain detailed laboratory notebooks for their project.

Additionally, students are required to review and reflect on input and feedback from their Faculty Advisor, Thesis Advisor, and CLEAR Instructor regarding their project. Although the Senior Design Project is a yearlong effort, there are deadlines for various portions of the written and oral project. Adherence to the assignment deadlines is expected so that the student may progress through their project in a timely manner.

*The Role of the Senior Thesis Advisor*

The Senior Thesis Advisor oversees the senior project degree requirement for the department. The primary responsibility of the Advisor is to ensure that each senior project fulfills the requirements as established by the department. This advising role includes:

1. Provide guidance to the students to ensure their project meets the Senior Project criteria.
2. Ensure faculty advisers are fully informed regarding the senior design requirements.
3. Ensure that faculty advisers are supporting and assisting students in the design project as required to facilitate the educational aspects of the senior project.
4. Review and sign all completed senior theses.

*The Role of the Faculty Advisor*

The Faculty Advisor[5] provides the primary technical (scientific and engineering) guidance and oversight to the senior project. In many cases the adviser also provides access to laboratory facilities and materials resources. This advising role includes:

1. Provide oversight and guidance to students on a regular basis.
2. Provide technical expertise to the project as required.
3. Provide mentoring on effective communication as required.
4. Work with the students to achieve effective time management.
5. Help the students define and manage a schedule for the different stages of the design process.

[5] In some cases, the Faculty Advisor will assign routine supervision of the senior project to a doctoral student or post-doctoral researcher. In these cases, students will work closely with the assigned supervisor, although the Faculty Advisor retains overall responsibility for the supervision of the project.

*The Role of the CLEAR Instructor*

The CLEAR instructor provides course oversight and detailed instruction and guidance in producing documentation and presentation materials for the Senior Project course sequence. This role is both instructional and advising and includes:

1. Work with the Senior Thesis Advisor, the Faculty Advisor and the students to ensure that all projects meet the requirements of the Senior Project requirement.
2. Provide instruction and guidance on effective communication.
3. Provide detailed review on all course assignments.
4. Assist students with the resolution of problems encountered during the project.
5. Help students prepare for the Senior Banquet, including developing their posters and public presentations.
6. Help students prepare their Senior Thesis.
7. Work with the students to achieve effective time management.
8. Help the students define and manage a schedule for the different stages of the design process and assignments for the Senior Project course sequence.

## Format of the Senior Project

The senior project consists of several components: the design project, written thesis, professional conference poster and oral presentation of the thesis. Although the design portion of the project does not result in an independent written report, the design process and results are incorporated into the written thesis. Students will be expected to maintain proper documentation of the design process in order to ensure the accuracy of the thesis, poster and presentation. As part of MSE 5098 students will be expected to report on the progress of the design project.

*Written Thesis Format*

The thesis documents the engineering problem, the design and development process, the results of the project and assesses the project in a social context. Among the fundamental elements of the design process is the establishment of the objective and criteria of the design project, supported by a comprehensive literature review.

The thesis must report the following elements:

Title-Signature Page

Abstract Page – States the problem, briefly describes the design and design process, and summarizes the results and significance of the project.

1. *Introduction* – Describes the problem domain and the specific problem to be resolved, reviews existing solutions and their inadequacies, and how the design project, by the use of modern design theory and methodology, adequately resolves the specific problem.

2. *Literature Review* – Describes prior research on the materials and problems related to the project and serves as justification for the particular focus of the senior project. The literature review demonstrates why the project is the next step in development or can be expected to solve the identified problem.

3. *Product Specifications* – Describes the needs of the end user and translates those needs into technical requirements for the solution to the engineering problem adequate for the solution's realization. These requirements are expressed as measurable specifications using explicit metrics and values adequate for testing. The specification discussion must address the standards and applied constraints applicable to the problem domain and proposed solution. The section shall also explain how each specification and its value was determined.

4. *Product Design* – Describes the technical design of the solution to the engineering problem, including the identification of systems and subsystems, and interfaces between subsystems. All specifications shall be assigned to the system, one or more of the subsystems and/or interfaces. This process

ensures that all specifications are addressed and tested in an appropriate manner. A discussion of alternative solutions and their rejection must be included.

5. *Project Plan and Procedure* – Describes in detail the development of the proposed engineering solution and provides details of the development process and relevant testing procedures in adequate detail to allow duplication by others. This discussion must identify standards applicable to lab and testing procedures and any deviations from the relevant standards due to cost, equipment availability, schedule or other issues. Step by step procedures for manufacturing or testing will be recorded in the Appendix.

6. *Results and Discussions* – Presents the data generated in the project relative to the design specifications and objectives defined for the project in order to enable an assessment of the success of the project. An assessment of the project's success, with justification, shall be made. Known limitations and issues with the design project should be discussed in this section. Significant challenges encountered and deviations from the original plan should be included.

7. *Future Work* – Based upon the results obtained, recommended future work related to the process or product should be discussed.

8. *Business, Social and Ethical Considerations* – Discusses the applied constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact, related to the completed product. Comparison of the understanding of applied constraints at the conclusion of the project to those that were considered during the design aspects of the project shall be included.

9. *Summary and Conclusions* – A restatement of the objectives of the project and an assessment of the outcome of the project relevant to the objectives, including the significance of the work in the design context.

10. *References* – A list of the resources cited in the thesis.

11. *Appendix* – If applicable, large data sets, collections of photos, and step by step procedures for manufacturing materials or conducting tests will be included here. Material shall be organized into multiple appendices as necessary, using an uppercase alphabetic identifier (e.g., Appendix A). If an appendix is not required, the section shall be deleted.

There is no required length for the thesis, although typically theses range from 15 to 45 pages, including figures, data, and tables. The thesis should adhere to general academic writing standards, project specified formatting standards (1" margins, double-spaced, Arial or Times New Roman fonts, 12 pt font). All pages must be consecutively

numbered, with the page number centered in the footer, except the title page which has no page number. Templates with these features are available from the course website.

All material drawn from other sources shall be documented using the standard citation method of either the American Chemical Society (available online at http://pubs.acs.org/isbn/9780841239999 when on campus) or IEEE (available online at http://www.ieee.org/documents/ieeecitationref.pdf ). Alternate citation methods may be used at the discretion of the Faculty Advisor.

The written thesis is a team paper, with all members of the team contributing to the final paper. Multi-authored papers must maintain the same voice and style throughout the paper. Students should work with the CLEAR instructor on ensuring this is accomplished in their thesis.

Honors students must complete an individual Senior Thesis in order to comply with the Honors College requirements for graduation, regardless of whether they worked on a team project or not. It is the responsibility of the Honors Student to fulfill this additional requirement.

*Poster Format*

Each team will produce a project poster suitable for display at a professional conference. The poster must accomplish the following:

- Introduce the goal of the project with an overview of the importance of the project to society.
    - What problem am I solving?
    - Why is this problem important?

- Describe the project design
    - What did I develop?
    - What does it do or what is it used for?
    - What key decisions were made in developing the solution?

- Describe the results of the project
    - What test results do I have?
    - Does the product fulfill the objectives?
    - Was I successful?

This information should be given in logical scientific order rather than a chronological order. This requires the student to synthesize the information and present it as an integrated whole.

In addition to the information listed above the poster is required to contain the following details:

- Author line, including project title, all team members and faculty adviser
- Acknowledgments
- Important references

The poster must fit within a 36” (h) x 48” (w) space constraint. The content and design of the poster is up to the student team and the faculty adviser. The content should reflect the nature of the project and present the project accurately and efficiently. The text on the poster must be readable and serve as a useful communication tool. Each team will work with the CLEAR instructor on the best format and proper communication style for their poster.

*Presentation Format*

In addition to the requirement of the written senior thesis, all teams are required to present a 5-10 minute summary of their team project during the Senior Banquet. Each team member is required to present at the banquet.

The purpose of the presentation is to introduce the project to a general audience and entice the audience to examine the poster and to hear more about the project during the question and answer session. The presentation should be geared to a mixed audience of technical and non-technical members. The Senior Banquet is attended by faculty, students, spouses, family members and other guests.

The CLEAR instructor will assist the students on developing their presentation for the appropriate audience and formatting the presentation materials. Students are encouraged, whenever possible, to include relevant props in their presentations.

*Faculty Assessment*

Each team will present their design project as a team. It is important that all members of the team be prepared on all aspects of the project, not just the aspects they present. The poster and presentation grading will be a group grade.

All faculty attending the Senior Banquet will judge the presentations and posters for the following items:

- Design of project – The selected design is effective and efficient in meeting project objectives within realistic market constraints.
- Content of presentation – The presentation and poster effectively communicate the reason for the project (including background information necessary to understand the project), specific objectives, project design, discussion of results, and conclusions.
- Effectiveness of presentation – The presentation was smooth, clear, enthusiastic, and appropriate to the audience.
- Quality of Slides – The slides were well constructed, containing a unified theme, easy to read, animated to support audience focus and without errors.

- Quality of poster – The poster contains the required information, is visually appealing (layout and color) and easy to read.
- Defense of project – Students were able to respond adequately to questions and demonstrate a thorough understanding of the project topic.

Presentations will be videotaped for the department record archive. The graduating seniors are required, as part of MSE 5099, to evaluate their presentations.

*Senior Project Deadline*

The completed thesis is due the last day of classes of the Spring Semester the student is enrolled in MSE 5099, regardless if the student has classes to take in subsequent semesters. There are no exceptions.

*Grading*

The CLEAR Instructor will assign the grade for MSE 5098 (Senior Design) and MSE 5099 (Senior Thesis) in consultation with the Senior Thesis Advisor and the Academic Advisor. Attendance will be considered when determining the final grade for both MSE 5098 and MSE 5099. Grades will not be given for MSE 5098 and MSE 5099 until the senior design and thesis project have been completed and accepted by the Department, as indicated by a complete signature page.

(Sample of Title-Signature Page)

"Title"

By
"Authors"

A design thesis submitted as a partial fulfillment of the requirements for the degree of Bachelor of Science in Materials Science and Engineering

University of Utah

"Date"

Approved:

_____
J X. Doe, Faculty Advisor, MSE

_____
Ashutosh Tiwari, Senior Thesis Advisor, MSE

_____
Russell W. Askren, CLEAR Instructor

_____
Feng Liu, Department Chair, MSE