Senior Design Project Course Guidelines
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Adopted by EE and CSE undergraduate degree program faculties on January 20, 2010

Scope: This document establishes guidelines to facilitate ABET Engineering Criteria compliance and student assessment within the EECS 4000 Senior Design Project course.

Definition “Senior Design Project”

The ABET document on criteria for accrediting engineering and computing programs defines the “design” as follows:

“Engineering design is the process of devising a system, component or process to meet desired needs. It is a decision making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet stated needs.

Students must be prepared for engineering practice 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.”

A senior design project mainly relies on knowledge and skills gained through the past coursework. Accordingly, it is distinct from a research project, where the latter might rely on future learning for success. The senior design project is likely to have little open-endedness, if any, say compared to a research project.

All senior design projects are expected to

- Conceive, design, fabricate, integrate, test and verify a product, device, system or software.
- Develop designs using quantitative, engineering analysis of appropriate complexity, reflecting the academic background expected of electrical or computer engineering seniors.
- Use standard engineering practices, including the development of requirements, specifications, drawings, schematics, verification plans, and test results.
- Use modern engineering tools and methods.
- Use an appropriate set of professional project management tools and practices to ensure project progress, quality and timeliness.

EECS 4000 Course Objectives

The committee formulated the following course objectives (CO) for the EECS 4000 Senior Design Project:
1. Teaches the elements of conceptual and detail design.
2. Facilitates design of complex electrical and electronic devices, software, and systems containing hardware and software components, using modern engineering tools, and incorporating appropriate engineering standards, multiple realistic constraints, and professional and ethical considerations.
3. Provides an opportunity for students to develop expertise in their particular areas of technical interest.
4. Facilitates students to develop hands-on skills and experience in the elements of prototyping/fabrication, integration, and verification and test.
5. Facilitates exposure to standard professional engineering practices in the fields of electrical and computer engineering.
6. Facilitates engineering practices to occur within a team context.
7. Facilitates students to improve technical communication skills.
8. Leverages and integrates knowledge and skills acquired in prior course work.

EECS 4000 Student Learning Objectives (SLO)

Course specific student learning objectives (SLO), which constitute the measurable quantities in direct support of ABET EAC and CAC Criterion 3 outcomes were defined as follows:
1. The student will be able to design a complex system (or component or process) to realistic performance specifications in compliance with applicable engineering standards and multiple realistic constraints, and report the results through a comprehensive and professional technical write-up and oral/poster presentation.
2. The student will be able to build a prototype of a design and demonstrate that it meets performance specifications.
3. The student will be able to list and discuss several possible reasons for deviations between predicted and measured results from an experiment or design, and choose the most likely reason and justify the choice.
4. The student will be able to identify the stages of team development and give examples of team behaviors that are characteristic of each stage.
5. The student will be able to summarize effective strategies for dealing with a variety of interpersonal and communication problems that commonly arise in teamwork, choose the best of several given strategies for a specified problem, and justify the choice.
6. The student will be able to function effectively on a team, with effectiveness being determined by instructor observation, peer ratings, and self-assessment.
7. The student will be able to explain aspects of a project, process, or product related to specified engineering and non-engineering disciplines.
8. Given a job-related scenario that requires a decision with ethical implications, the student will be able to identify possible courses of action and discuss the pros and cons of each one, pick the best course of action and justify the decision.
9. The student will be able to write an effective technical correspondence (i.e. abstract, executive summary, project report) or give an effective oral presentation.
10. The student will be able to propose a solution or critique a proposed solution to an engineering problem, identifying possible negative global or societal consequences and recommending ways to minimize or avoid them.
11. The student will be able to find relevant sources of information about a specified topic in the library and on the World Wide Web (or perform a full literature search).
12. The student will be able to participate effectively in a team project and assess the strengths and weaknesses of the individual team members (including himself/herself) and the team as a unit.
13. The student will be able to identify important contemporary regional, national, or global problems that involve engineering.
14. The student will be able to propose and discuss ways engineers are contributing or might contribute to the solution of specified regional, national, and global problems.

**ABET EAC and CAC Criterion 3 Outcome Support by SLOs**

Following ABET EAC Criterion 3 outcomes were identified to be supported through the 14 SLOs:
- Outcome 3c (design a system, component, or process)
- Outcome 3d (function on multi-disciplinary teams)
- Outcome 3f (understand professional and ethical responsibility)
- Outcome 3g (communicate effectively)
- Outcome 3h (understand the global/societal impact of engineering solutions)
- Outcome 3i (recognize the need for life-long learning and able to engage in it)
- Outcome 3j (know contemporary issues)
- Outcome 3k (Use modern engineering techniques, skills, and tools)

Following ABET CAC Criterion 3 outcomes were identified to be supported by the 14 SLOs:
- Outcome c (design, implement, and evaluate a computer-based system, process, component, or program)
- Outcome d (function effectively on teams)
- Outcome e (understand professional, ethical, legal, security and social issues and responsibilities)
- Outcome f (communicate effectively with a range of audiences)
- Outcome g (analyze the local and global impact of computing on individuals, organizations, and society)
- Outcome i (use current techniques, skills, and tools necessary for computing practice)
Outcome j (apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoff involved in design choice)

Outcome k (apply design and development principles in the construction of software systems of varying complexity)

Course Requirements

Course Topics
Following topical or activity coverage (in the form of seminar talks or workshops) should be included in the course in sufficient detail to satisfy the student learning objectives SLO-1 through SLO-14:

- Literature Search
- Technical Writing
- Design Process
- Design Review
- Engineering Design Teams
- Engineering & Business Standards (IEEE, ANSI, ISO9002 etc.)
- Professional and Engineering Ethics
- Intellectual Property

Definition & Scope of Design Project
Engineering design is the process of devising a system, component or process to meet desired needs. It is a decision making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet stated needs.

Students must be prepared for engineering practice 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.

A senior design project mainly relies on knowledge and skills gained through the past coursework. Accordingly, it is distinct from a research project, where the latter might rely on future learning for success. The senior design project is likely to have little open-endedness, if any, say compared to a research project. A design project is deemed to be incomplete until it has been implemented, tested and evaluated in terms of how well it satisfies the original problem requirements.

Course Instructor
An EECS faculty member is assigned to instruct the Senior Design Class for a given semester and is responsible for directing the course. The instructor conveys course requirements information to the students, provides for lectures (may be given by guest speakers), and directs the students to resources. The instructor enforces deadlines, evaluates student performance through input from faculty advisors, and issues a grade for each enrolled student at the end of the semester.

Student Participation
Each student is responsible for serving as a contributing member of a design team and for attending lectures, team meetings, presentations, and meetings of the team with the instructor, faculty advisor, and the sponsor.

Engineering Team Notebooks
Each team member will maintain a daily log of his/her activities pertaining to the project effort in this course. This notebook will be utilized to self-document each team member’s contribution on a daily basis to the overall project effort. Recording will commence with the first day of semester and conclude upon fulfillment of all requirements of the project. This is a bound and professional quality notebook appropriate for documenting engineering sketches, drawings etc. The engineering notebook is to be turned in at the end of the semester and must be available throughout the course for inspection upon request. It is advisable to make backup copies against damage or loss.
Each team leader, in addition to the daily log, will maintain a team notebook to record all events related to team interaction, communications, meetings, and dynamics. The team leader will compile the attendance record for each team member throughout the semester and present in a tabular form in the team notebook.

Team Experience
Each design team will consist of 2 – 4 team members. “Teams” of one student are not permitted and groups of 5 or more must be divided. Each design team will designate one member as “leader.”

Individual Contributions
Each team member must make substantial, significant and relevant contribution to the overall engineering effort. The distribution of the engineering work must be to facilitate every member to receive a balanced and equitable opportunity. As an example, assigning a team member to only manage and author technical documentation would not be acceptable.

Project Selection
The idea for the project may come from a design team member or members, a faculty member, or a sponsor, i.e. an “industrial partner” outside the university. “Projects” already completed through co-op or previous work experiences are not acceptable. The project idea is subject to approval by the faculty advisor and the course instructor.

Honors Credit Requirement
Students taking the EECS 4000 for honors credit are expected to make a notable “intellectual contribution” beyond what is typical and average. Often, such an intellectual contribution may be facilitated through an additional design component with increased complexity or engineering/mathematical rigor. Simply increasing the student’s workload is not appropriate for a claim of satisfaction of this requirement. The honors student will be the sole author of their “honors thesis” in the format required by the University Honors Program, as a document separate from the team’s final report.

Faculty Advisor
Each design team is required to select an EECS faculty advisor. The faculty advisor serves in the capacity of “technical consultant” and “evaluator” for the project. The faculty member is approached by the leader of the team and is designated “faculty advisor” for the team by mutual agreement between the design team and the faculty member. Faculty who agrees to serve as an advisor is expected to offer technical guidance to the student team, conduct design reviews, evaluate the project proposal, progress reports, design review documents, and final deliverables including the project report, presentation, and exposition. Complex projects with a wide scope might require expertise well beyond what a single faculty member might possess. In those cases, it is advisable to designate multiple faculty co-advisors for a given design project.

Multi-disciplinary Design Teams
An EECS student may elect to work with a senior design project team from another engineering department, provided that the contribution of the EECS student is appropriate to the project. The EECS student must obtain an EECS faculty advisor who will coordinate with the faculty advisor from the other department working with the project team. The project must be approved by the other department project advisor as well as the EECS faculty advisor. The EECS student will register for the Senior Design course, EECS 4000.

Reporting
Each design team will be required to submit written reports in compliance with technical writing requirements that will be stated in appropriate assignment documents. The set of reports is envisioned to include, but not necessarily be limited to, the following:

- Project Proposal Document
- Progress Reports
- Design Review Report
- Final Project Report
Presentations
Each design team is expected to hold formal presentations in compliance with the requirements to be detailed in appropriate assignment documents. These presentations will include, but not necessarily be limited to, the following:

- Project Proposal
- Design Review
- Final Project Oral Presentation
- Senior Design Exposition Poster Presentation

Course Grade
Weights for grade components in the following table may be utilized.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Grade Component</th>
</tr>
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<tbody>
<tr>
<td>45%</td>
<td>Technical Quality</td>
</tr>
<tr>
<td>25%</td>
<td>Written Reports, Documentation and Assignments</td>
</tr>
<tr>
<td>10%</td>
<td>Design Review</td>
</tr>
<tr>
<td>10%</td>
<td>Tests and quizzes and</td>
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<tr>
<td>5%</td>
<td>Project Oral Presentation</td>
</tr>
<tr>
<td>5%</td>
<td>Senior Design Poster Presentation</td>
</tr>
<tr>
<td>±%</td>
<td>Individual Contribution</td>
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Grading standards based on project attributes are established as follows:

Letter Grade A: The project implements a mature process. It demonstrates solid engineering practices, reasoning and judgment. It draws upon a variety of coursework while extending the knowledge in a multitude of areas through self-learning. Creativity and novelty are clearly observable. The project presents the best possible accomplishments given the difficulty level, and experience level of the student team. Design documentation is high quality. The amount of effort invested is substantial.

Letter Grade B: The project shows strong awareness of an appropriate engineering process and reasoning while falling short in a few areas. Although, in general, solid engineering practices, reasoning and judgment are exercised, there may be a number of exceptions. Traces of creativity and novelty are observable. It draws upon advanced coverage of coursework yet no noteworthy extension of knowledge might be readily observable. There are potential (but not necessarily substantial) improvements to the project accomplishments and the end product. Design documentation is good. The amount of effort invested is noteworthy but could be increased.

Letter Grade C: Engineering work is minimally acceptable. Design fails to materialize through a refined process. Questionable design decisions are noted. Design rationale is not well-documented or simply not credible or not sound from a technical perspective. Documentation and reporting are barely acceptable. The project is below expectations with respect to a number of criteria; however it does score some successes which suggest promise for the future. Students appear to be minimally prepared to undertake such endeavors unless significant refinement is implemented.

Letter Grade D: The engineering process, practices, reasoning and judgment are questionable. Most deliverables and documentation are substandard. The project draws upon shallow and limited knowledge base. Given the difficulty level, accomplishments are minor although promising in certain aspects. There is potential that a fully functional prototype could be delivered if additional time is allotted. Students should consider retaking this course to improve design skills.

Letter Grade F: Project could not possibly be classified in any of the above categories.
Appendices

Elaborations on Written and Oral Communications

Project Proposal
Each design team submits one project proposal document. Proposals will be about 8 – 12 pages in length. The proposal will include the following parts (additional parts may be specified by the instructor), clearly identified as separate sections in the document:

i. Title page—include the name of the project, the names of the students on the team, and the names of the faculty advisor and course instructor.

ii. Abstract

iii. Problem Definition/Purpose of the Project—What is needed? What will be supplied at the completion of the project?

iv. Goals of the project. What qualities should the final product have? What needs does the project aim to satisfy?

v. General Design Alternatives—What are some alternative solutions to this problem?

vi. Method Selection Criteria—How will the solution method be chosen?

vii. Ethical Considerations and Societal Impact—What are the ethical issues involved (with the project and/or with the solution) and what are the potential benefits/risks to society?

viii. Project Schedule—give a realistic timetable for completion of the project including acquiring resources, implementation, testing and evaluation.

ix. Division of Labor—give a list of general assignments for the team members, by name, including the team leader.

Progress Reports
Each design team is required to submit at least two progress reports. The progress reports will generally be brief (3 – 5 pages in length) and include the following (additional parts may be specified by the instructor):

i. Title page as stated above.

ii. Brief statement and description of the project.

iii. Design process to date: steps to project definition, solution alternatives considered and their evaluations, assignments to each member of the team and their accomplishments to date, current overall status of the project, revised timetable to completion.

Final Report
Each design team submits one final report. The number of pages in the final report will be usually in the range of 25 – 40 pages. The final report will include the following parts (additional parts may be specified by the instructor) clearly identified as separate sections in the document:

iv. Title page—Give the name of the project. State the following:

- EECS Department Senior Design Project Final Report
- Names of the students on the design team
- Name of the faculty advisor
- Name of the instructor
- Date of the report

v. Abstract—limit this to 100 words. Briefly cover the nature of the project, its purpose, and summarize the results.

vi. Introduction/Background—inform the reader of the problem addressed by the project. Give a short history of the general area, if appropriate. Consider that your reader is generally technically literate but not necessarily a specialist in the area.

vii. Goals of the project—clearly state the team’s goals for this project (by which the resulting project may be judged).

viii. Solution method—cover the design process, any alternatives that the team considered or attempted. You may recount the decision process experienced by the team, the choices made at
different points in the process. Describe any mistakes, “dead-ends,” or “blind alleys” encountered. Describe the methods used in implementing and testing the final product.

ix. Description and Evaluation of Project—describe the implemented project resulting from the team effort. Evaluate the project by how closely the project satisfies the goals.

x. Summary with Ethical/Societal Considerations—Summarize the success of the project, work that remains, and possible future directions. Evaluate any ethical/societal concerns with this project regarding its use (or abuse) for the complete life cycle of the project (examples: recycling, reuse, obsolescence, disposal, need for continuing maintenance and upgrades, personal safety, and the secure collection, storage, and deletion of protected data).

**Oral Presentation**

Each design team will give a 10 – 15 minute oral presentation summarizing the project, describing the methods used, and emphasizing the result. Each member of the design team will be present for the presentation, dressed in professional/business attire, and have a speaking part. At the end of the presentation, the members of the design team will address any questions presented by members of the audience.
Engineering Design References in ABET Accreditation Documentation

Engineering Design in ABET Engineering Accreditation Criteria

The ABET document entitled “Criteria for Accrediting Engineering Programs” effective for evaluations during the 2011-2012 evaluation cycle mentions, discusses or elaborates on the engineering “design” in three separate sections. Specifically, the discussion on “design” takes place under Criterion 4, Criterion 3, and Program Criteria for Electrical and Computer Engineering Program. Following more specific observations can be made on requirements and specification on “design”:

a) Under Criterion 4, incorporation of appropriate engineering standards and multiple realistic constraints is explicitly mentioned as requirements for a major design experience.

b) Several outcomes under Criterion 3 are applicable for a senior design activity.

c) “Design of complex systems” is explicitly mentioned under the program criteria for electrical, computer or similarly named engineering programs.

All three references to “design” are excerpted below for the ease of reference.

Criterion 4. Professional Component

b) …Engineering design is the process of devising a system, component or process to meet desired needs. It is a decision making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet stated needs.

Students must be prepared for engineering practice 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.

Criterion 3. Program Outcomes and Assessment

…

Engineering programs must demonstrate that their students attain:

a) an ability to apply knowledge of mathematics, science, and engineering

b) an ability to design and conduct experiments, as well as to analyze and interpret data

c) 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

d) an ability to function on multi-disciplinary teams

e) an ability to identify, formulate, and solve engineering problems

f) an understanding of professional and ethical responsibility

g) an ability to communicate effectively

h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

i) a recognition of the need for, and an ability to engage in life-long learning

j) a knowledge of contemporary issues

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

PROGRAM CRITERIA FOR
ELECTRICAL, COMPUTER,
AND SIMILARLY NAMED ENGINEERING PROGRAMS
Lead Society: Institute of Electrical and Electronics Engineers
Cooperating Society for Computer Engineering Programs: CSAB
These program criteria apply to engineering programs that include electrical, electronic, computer, or similar modifiers in their titles.

1. Curriculum

... The program must demonstrate that graduates have: knowledge of probability and statistics, including applications appropriate to the program name and objectives; and knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives.

Engineering Design in ABET Criteria for Accrediting Computing Programs

Criterion 3. Program Outcomes

The program has documented, measurable outcomes that are based on the needs of the program’s constituencies.

The program enables students to achieve, by the time of graduation:

a) An ability to apply knowledge of computing and mathematics appropriate to the discipline
b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution
c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs
d) An ability to function effectively on teams to accomplish a common goal
e) An understanding of professional, ethical, legal, security and social issues and responsibilities
f) An ability to communicate effectively with a range of audiences
g) An ability to analyze the local and global impact of computing on individuals, organizations, and society
h) Recognition of the need for and an ability to engage in continuing professional development
i) An ability to use current techniques, skills, and tools necessary for computing practice.

PROGRAM CRITERIA FOR
COMPUTER SCIENCE
AND SIMILARLY NAMED COMPUTING PROGRAMS
Lead Society: CSAB

These program criteria apply to computing programs using computer science or similar terms in their titles.

3. Student Outcomes

The program must enable students to attain, by the time of graduation:

j) An ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices.
k) An ability to apply design and development principles in the construction of software systems of varying complexity.