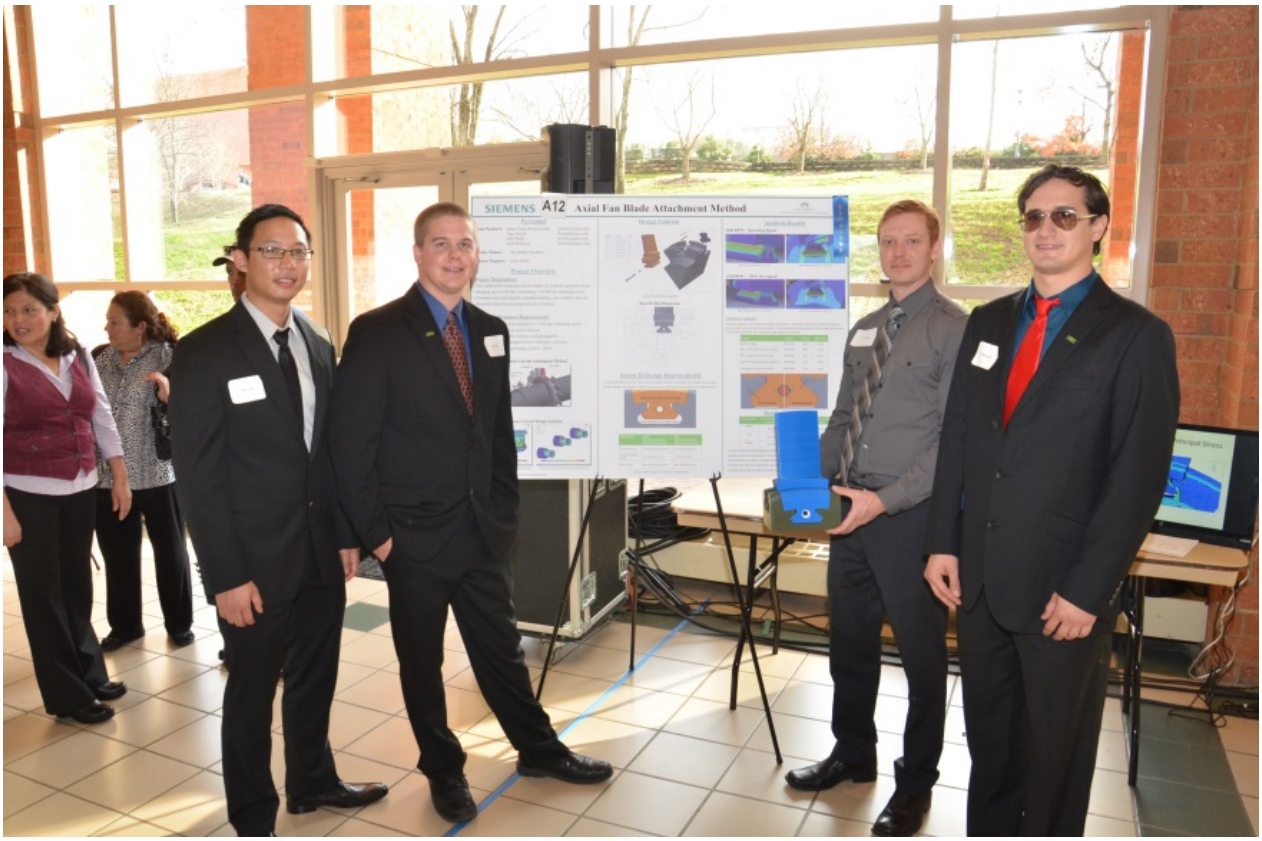
UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Implementing Industry Supported Projects



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1. Overview

1.1 Overview of this Document

Thank you for your interest and support in the Lee College of Engineering Senior Design course. This document is designed to describe the Senior Design Program and the implementation of a senior design project. It also will provide you with an overview of the course and the expectations of students, industry supporter technical representatives and faculty mentors. If you still have questions regarding the course after reviewing this document after reviewing this document, please feel free to contact the Director for the Industrial Solutions Lab at coesrdesign@uncc.edu.

1.2 Overview of the Industry Supported Senior Design Program

The William States Lee College of Engineering (COE) Senior Design program brings together students and external industry supporters in a collaborative research environment. As they tackle real-world engineering projects, the COE students and their industry supporters are afforded unlimited possibilities for learning and achievement.

COE students profit from:

- Practical "hands-on" experience.
- An opportunity to learn design philosophies.
- Meeting and working with potential employers.
- The development of team problem-solving skills.
- The use of project management skills and experience in budgeting time and finances.

Industry supporters profit from:

- The opportunity to initiate elective research projects
- Collaboration with UNC Charlotte research faculty.

- The creation of innovative and competitive products at a low cost.
- The development of improved manufacturing or business processes.
- The opportunity to interact with and recruit potential employees.
- Networking at the end-of-semester presentations and competition.
- Corporate name recognition

1.3 Expectations of Students

Students are expected to have the necessary technical knowledge from classes and independent investigations to perform the projects. All pre-requisite coursework through the junior year must be completed prior to enrolling in Senior Design. Each student is expected to work on his/her project outside of class approximately 10 to 15 hours per week as a general rule. Total effort is expected to be approximately 250 hours for each student. This is documented in time sheets that the students are required to submit. This time includes conducting research, generating and maintaining planning documents, writing progress reports, preparing for design reviews, completing formal reports and presentations, and communicating with the industry supporter

technical representative and faculty mentor. Grading rubrics will be used to evaluate student performance across all departments in the college and the disciplines within the departments.

Students are expected to submit all assignments on time, to the designated location and in the proper format. Students must send documents to their faculty mentor and industry supporter technical representative for review at least 24 hours prior to the deadlines posted in the course schedule. The course instructors will assign a grade to each deliverable. The faculty mentor and industry supporter are encouraged to provide additional feedback and requests for enhancements.

It is the responsibility of the student team to establish a weekly or bi-weekly meeting time with the faculty mentor and industry supporter, although the frequency of these meetings should be determined at the mentor and supporter's discretion. (Videoconferencing capabilities exist on campus.) Electronic communications are also strongly encouraged, as needed. The team will identify a Lead Engineer (LE) and this person will be the only team member that corresponds via phone and email with the industry supporter technical representative and faculty mentor. The faculty mentor must be copied on any email correspondence between the LE and industry supporter. The Lead Engineer is expected to correspond with the industry supporter and faculty mentor on a regular basis.

In keeping with the spirit of a first job experience, the team is expected to come prepared to each meeting with an agenda that clearly justifies the meeting's time commitment and includes a report of action items from previous meetings. The team is expected to submit meeting minutes to the industry supporter technical representative and faculty mentor within 48 hours of all meetings.

1.4 Expectations of Industry Supporters

Industry supporters of senior design projects must have a product or project in mind with well-defined requirements and constraints. The scope of projects must be suitable for teams of 3-6 students (typical team size that can be adjusted depending the work required to complete the project) working steadily over a 28 week period spanning the two academic semesters. In most cases, the supporter will provide an $8,000 contribution for prototype parts and materials, student travel costs for site visits, and UNC Charlotte senior design shop and laboratory consumables. Since the COE senior design program is fully self-supporting, a portion of these monies will also be used to provide the venue and meals that occur during events where student work is showcased (e.g. expositions).

The supporting company must identify a technical representative that will act as the liaison between the company and the student team/faculty mentor. The company technical representative should be accessible for approximately one hour per week during the school year to meet and/or correspond with the project team, so that important design issues can be resolved satisfactorily and promptly. The involvement of the technical representative will begin at the Senior Design Kickoff Breakfast. This breakfast serves as a kickoff meeting at which the formal Statement of Work and project scope will be finalized between the technical representative, the faculty mentor, and the team. While the technical representative is not expected to do any of the student work, the success of the student team and supported project is often strongly linked to technical representative's involvement and accessibility. The technical representative should

provide timely and constructive feedback to ensure that the team's final solution meets specified requirements.

The technical representative will be asked to use provided rubrics to grade certain student team deliverables and the overall project. The Conceptual Design Review and Preliminary Design Review in Semester 1 and the Prototype Status Review and Prototype Review in Semester 2 will be reviewed and graded by the technical representative to ensure the team remains on schedule and the project is developing in a manner satisfactory to the supporter. The technical representative will assist the team in resolving design, development, and test issues. The technical representative should review the posters prepared for the Exposition at the end of both semesters and all submitted reports to verify that no materials include any confidential or proprietary information provided by the industry supporter. Should the industry supporter require the report delivered to them to include any shared proprietary information, the student team should be directed to compose two reports: one proprietary and marked as such for the industry supporter, and one non-proprietary report for academic evaluation and public display as in the case of project posters.

An outline of the tasks required by the technical representative is listed below:

Semester 1

1. Attend the kickoff breakfast to discuss the project with the student team and faculty mentor and adjust the project description and project deliverables as required.
2. Meet and/or correspond with the team, ideally on a weekly basis.
3. Attend and grade the Conceptual Design Review.
4. Attend and grade the Preliminary (80% complete) Design Review.
5. Provide comments and input throughout the design process, including comments to the poster for the Senior Design Exposition.
6. Review and comment on the final design report at the end of the semester.
7. Attend the Senior Design Exposition at the end of the semester.
8. Complete a short on line survey of the project at the end of the semester.

Semester 2

1. Meet and/or correspond with the team, ideally on a weekly basis.
2. Attend and grade the Prototype Status Review.
3. Attend and grade the Prototype Review.
4. Provide comments and input throughout the design process, including comments to the presentation for the Senior Design Exposition.
5. Attend the Senior Design Exposition at the end of the semester and grade the technical design aspect of the project.
6. Complete a short on line survey at the end of the semester.

Any time the technical representative has concerns about the team's performance the technical representative should immediately contact the faculty mentor or one of the course instructors.

1.5 Expectations of Faculty Mentors

The goal of the senior design course is to emulate a first job experience. Therefore, the faculty mentor should not do any of the research, technical calculations, design, construction, or testing required for the project. Although it is helpful if the faculty mentor has technical expertise associated with the project, it is not necessary. The faculty mentor is expected to be an effective manager and process facilitator who will promote good team skills, disciplined use of the engineering design process, and effective project management skills. The faculty mentor's role is to provide sufficient direction and support to the team so that they can be self-motivated, independent problem solvers. The faculty mentor will help the team members identify appropriate questions, resources to obtain answers, and strategies for overcoming obstacles. The faculty mentor will hold the team accountable for completing project deliverables on schedule and satisfying all design requirements and performance capabilities required in the Statement of Work. The faculty mentor will ensure that the team explores all viable design and fabrication methods or strategies. Consequently, the team, and not the faculty mentor, is ultimately responsible for decisions that enhance or limit the success of the team.

Micromanaging the team is discouraged. However, weekly or bi-weekly in-person meetings are strongly suggested as are electronic communications, as needed. The deliverables (course assignments) of the team will be graded by a course instructor. However, the faculty mentor's participation in the grading process is strongly encouraged since the faculty mentor often has the most insight into the team's performance. If a faculty mentor wishes to participate in the grading of their team, please contact one of the course instructors listed on the cover page of this document for more information.

Most projects will have a design, build, and test requirement and funds will be made available for the development and testing of a prototype. (A maximum limit of $3,000 has been set for all industry supported projects.) The faculty mentor should verify that the design process includes an analysis of material and fabrication costs. Additional funds may be available, as needed, at the discretion of the Senior Design Committee. However, there is no guarantee of additional funds and a formal request must be made for committee deliberation.

The faculty mentor is expected to participate in the Senior Design Kickoff Breakfast to meet the team members and industry supporter technical representative. During breakfast, the mentor should facilitate a discussion between the team and industry supporter to ensure that requirements and capabilities are clearly articulated. If not, the project description needs to be adjusted until the description is clear and the industry supporter indicates satisfaction. The faculty mentor must monitor the team's progress and deliverables to ensure that the final solution achieves supporter requirements. The faculty mentor will review the poster prior to the poster display at the end of both semesters. The poster should not include any proprietary information provided by the industry supporter. Additionally, the faculty mentor is expected to track the development of the prototype product for the exposition at the end of semester two and resolve any development and test issues in a timely manner.

An outline of the tasks required by the faculty mentor for the two-semester course sequence is listed below:

Semester 1

1. Attend the kickoff breakfast to discuss the project with the student team and industry supporter and facilitate the adjustment of the project description as required.

2. Meet and/or correspond with the team on a weekly or bi-weekly basis.

3. Attend and grade the Conceptual Design Review Presentation.

4. Attend and grade the Preliminary (80% complete) Design Review.

5. Monitor the team's progress and process to ensure project requirements and capabilities are satisfied.

6. Provide timely and constructive feedback to the team.

7. Review and comment on the final design report at the end of the semester.

8. Attend the Senior Design Exposition at the end of semester one.

Semester 2

1. Meet or correspond with the team on a weekly or bi-weekly basis.

2. Attend and grade the Prototype Review Presentation.

3. Monitor the team's progress and process to ensure project requirements and capabilities are satisfied.

4. Provide timely and constructive feedback to the team.

5. Attend the Senior Design Exposition at the end of semester two and grade the technical design aspect of the project with a provided rubric.

At all times, the faculty mentor should immediately contact one of the course instructors if there are concerns about the team's performance.

2. Overview of Senior Design Projects

Projects may address the design of hardware, processes, or analysis. In all cases it is necessary that the project be oriented towards design. But the object of that design can vary considerably, just as fields of engineering vary substantially. The primary engineering results delivered in Senior Design will be a set of rational decisions, with the rationality of those decisions supported by appropriate analysis and testing. The quality of the design will usually, but not always, be reflected in a prototype of either the hardware or software system. In some cases (particularly large industrial systems) the end point will be a finished detail design with supporting analysis. In the case of process design the result may be a detailed process description coupled to a demonstration which verifies the design.

2. 1 Major Criteria for a Senior Design Project

1. The project should provide an opportunity to integrate and apply the academic material previously covered in the B.S. program

To meet the first criterion, the project needs to have significant engineering content. If the project can be carried out without recourse to engineering calculations, it is unlikely that the project will serve well. One should critically examine potential projects that are comprised of interesting and challenging fabrication and assembly of known designs. In many cases such projects lack sufficient engineering content to be suitable.

2. The project should provide the opportunity to practice the professional disciplines of engineering and engineering technology.

Most projects will meet the second criterion if the scope of the project lies within the control of the student. But care must be taken when senior projects are carried out in conjunction with an outside entity. In these cases it is important to establish that there is sufficient discretion in the student team to actually drive the execution of the project. If insufficient progress on the part of a student team would lead to intervention on the part of the outside entity, the project is probably not suitable. While we strongly discourage project failure, it is important that project failure is understood to be at least a theoretical possibility.

3. There should be a reasonable expectation that the project can be executed successfully.

The third criterion relates to the availability of sufficient resources to complete the project. The primary resources to consider are student time (is the scope sized to match the available time of the students for the design?), student knowledge (can the engineering be done by someone with B.S.-level skills?), availability of prerequisites (are mating parts, interface specifications, necessary personnel for interviews, company-supplied equipment or facilities, etc. available?), and financial support for required activity of the project team. Where resources will be supplied from the outside, it is particularly important to have a realistic understanding of the magnitude of the required resources and the reliability of the source for the full length (two semesters) of the project.

2. 2 Potential Risks

The most common sources of problems (outside of student performance) relating to senior projects are inappropriate technical scope (both too much and too little) and unrealistic support expectations (both internal and external). It is important that students not place their successful progression to a bachelor's degree at risk by taking unnecessary risks with their senior project.

2. 3 Team Structure

The following list describes the preferred makeup of Senior Design teams based on best practices:

1. The ideal senior design project would be one identified, supported, and funded by an Industry Supporter. Therefore, the technical representative from the supporting company must be identified at the start of the project and be available for consultation throughout the two semester life of the project.

2. All projects must have a faculty mentor, and preferably a stakeholder outside of the university if the project is not supported by industry.

3. Ideally teams should be multidisciplinary.

4. Team size should be a minimum of 3.

5. Single person projects are discouraged and, in the limited case where they are warranted, managed outside of the Senior Design Program.

3. Overview of Project Staffing

An electronic copy of each project description is made available to the students on the course website http://www.srdesign.uncc.edu on the first day of class during the first semester of the senior design course sequence. The students are asked to review all of the project descriptions that pertain to their discipline and choose the top three projects that are of most interest to them. A company profile is usually included with the project description to provide the students more insight into the industry supporter. On the second week of class each student submits a resume and indicates their top three project choices via an online survey. The course instructors review all resumes and place students on project teams. In keeping with the overall philosophy of senior design, placements are made with the same kind of approach that would be taken by a business. The primary criterion for the placements is maximizing the likelihood of success on all projects. While an attempt is made to assign students to projects of their own choice, student choice is not a primary consideration, and is optimized within the constraint of likely project success. While it would be possible to maximize staffing resources for a particular project, or project choice for a particular student, the data set makes it manifestly impossible to do so for either all students or all projects.

As in industry, job satisfaction can vary. In many regards that is a personal choice, and most of us who have been in the business for a while have learned how to choose to be satisfied and even enthusiastic about jobs that were not our first choice. The leadership of the faculty mentor and industry supporter can make a tremendous difference in how students view and execute these projects.

4. Explanation of Deliverables

Templates and rubrics for all deliverables are made available to students, and will be available upon request to industry supporters and faculty mentors. (Rubrics are given to industry supporters and faculty mentors to use when grading presentations.)

4. 1 Resume – Semester 1

Resumes of all students, regardless of major, are available to any industry supporter for the asking. The industry supporter may specify which major(s) they are interested in and corresponding resumes will be delivered on a CD. Options are: Civil Engineering, Mechanical Engineering, Mechanical Engineering Technology, Electrical Engineering, Electrical Engineering Technology, Electrical and Computer Engineering and Systems Engineering. Send an e-mail to coesrdesign@uncc.edu with your request.

4. 2 Statement of Work and Capabilities and Requirements – Semester 1

Using the project description supplied, independent research and interaction with the industry supporter and faculty mentor, each team will generate a Statement of Work (SOW) that describes exactly what work will be accomplish during the course of the project, who will perform the work, what specific work product will be delivered, the expected performance and verification of the deliverables and a budget that includes all sources of funding and a not-to-exceed value. The SOW needs the approval of the industry supporter.

The Requirements and Capabilities section of the SOW is developed at the start of the first semester based on the project requirements and expected outcomes provided by the industry supporter. This section is used to reinforce the disciplined application of scientific principles and techniques for developing, communicating, and managing the specific details of the project.

The Requirements and Capabilities also serve as the rubric with which the industry supporter can verify that the end product has all of the desired functionality. To generate this section, students are instructed to first identify all relevant sources of requirements (capabilities, project description provided by the industry supporter, proposals, etc.). Next, they determine what information is needed and analyze the gathered information looking for implications, inconsistencies and unresolved issues. Finally, they synthesize appropriate statements of the requirements and confirm their understanding of the underlying issues with the industry supporter. The requirements of the project may change as development continues, but the original Requirements and Capabilities section remains intact. If alterations are required, the request must receive approval of the industry supporter and faculty mentor.

The document is assessed by the course instructors based on a system of grading rubrics. Input from the industry supporters and faculty mentors will be valuable and is encouraged. This rubric is provided to the students before the assignment is due so that they may ensure their document meets the high-level of standards the supporter will expect.

4. 3 Project Plan – Semester 1

This document consists of the Work Breakdown Structure of the project and Project Schedule.

4.3. 1 Work Breakdown Structure

Students use the Work Breakdown Structure document to identify as many individual tasks as possible that need to be done for the entire project. An initial list is usually produced during a team brainstorming session, and a time estimate for each task is assigned. The team then groups the tasks by precedence, that is, similar tasks that may depend on each other. Finally, the individual tasks are assigned to the various team members.

4.3. 2 Project Schedule

The students are required to enter all of the information outlined in the Work Breakdown Structure into a project schedule and produce an appropriate timeline. The project schedule will be continually maintained and updated throughout the life of the project.

4. 4 Progress Report – Semester 1 and 2

Progress reports outline the team's accomplishments related to the Requirements and Capabilities documents, updates to the timeline and any shortcomings. The format of the progress report is similar to the Capability and Requirements document.

4. 5 Time Recording

Each student will record the date and amount of time spent on each task, and list how that work was documented. The team's LE will be responsible for compiling this information into an Excel spreadsheet template provided by the course instructors and submit this document according to the class schedule. The time reported by each student carries the full weight and responsibility of any assignment for the class and therefore the rules of Academic Integrity apply (The UNC Charlotte Code of Student Academic Integrity).

4. 6 Peer Evaluation

Each student will assess their project teammates and their effort twice each semester. The results of the evaluations may lead to adjustment of the final course grade of a student at the course instructor's discretion. Results of the evaluations will remain anonymous, but will be provided to the faculty mentor. Students that do not submit a peer evaluation for each teammate before the deadline posted will receive a 0 for their evaluation and a reduction in their final grade.

4. 7 Conceptual Design Review – Semester 1

In the middle of the first semester each team will present their conceptual design to a panel of faculty and industry supporters. This will give all teams a chance to receive input and feedback

from the industry supporter, faculty mentor, and instructors. The conceptual design should demonstrate that the team understands the project requirements and has made feasible decisions based on sound engineering.

4. 8 Preliminary Design Review – Semester 1

Near the end of the first semester each team will present their preliminary design to a panel of faculty and industry supporters. By this time the detailed design should be complete. Models and drawings are expected to be at least 80 % complete. Fabrication costs should be estimated.

4. 9 Senior Design Exposition – Semester 1

Each team will produce a poster to be displayed at an end of the semester Senior Design Exposition where they showcase their efforts to students, faculty, alumni and industry members. The poster should provide an overview of the project, the Requirements and Capabilities, a description of the design, the plans for the second semester, and the expected final results.

4. 10 Final Design Package – Semester 1

A Final Design Package is required by each group at the end of the first semester. It is to be given to the industry supporter technical representative and faculty mentor for their review. The document outlines the group's accomplishments to date and their ability to adhere to the requirements, capabilities, and proposed time line for the remainder of the project. The format of this document is similar to the Capability and Requirements document.

4. 11 Revised Final Design Package – Semester 2

The Revised Final Design Package is an update of the first semester's Final Design Package and the starting point for the second semester. Deficiencies in the first semester's report should be corrected in this version. This is a go/no-go assignment from the design perspective. It must be approved by both the faculty mentor and the team's grading instructor. Project teams will rework this document until the mentor and instructors are satisfied. This then becomes the benchmark for progress and grading in Semester 2.

4. 12 Prototype Status Review – Semester 2

A 20 minute PowerPoint presentation will be given by each group describing the project status and outstanding milestones that need to be reached. Evidence of progress towards developing a prototype is expected.

4. 13 Prototype Review – Semester 2

In the middle of the second semester each team will present to a panel of faculty and industry supporters the preliminary prototype of the project (the design should be frozen by then). This

will give all teams a chance to receive input and feedback from the industry supporter, faculty mentor, and instructors.

4. 14 Senior Design Exposition – Semester 2

Each team will produce a poster to be displayed at the Senior Design Exposition where again they showcase their efforts to students, faculty, alumni, and industry members. Students with a physical end product or prototype will also display their deliverable device. The poster will display the final design as well as the project results.

4. 15 Final Report and Comprehensive Document Submission – Semester 2

A final project report is required outlining the final design, cost, and testing performed to verify that the end product conforms to the specified requirements and capabilities. The format of this document is similar to the Capability and Requirements document. Additionally, each team will submit a comprehensive document submission electronically that includes all supporting documents, design calculations, etc. generated over the life of the project.

4. 16 Technical Design – Semester 2

The merit of the technical design of the project is also evaluated at the end of the second semester. This assessment looks at the overall project including identifying the problem, executing the plan, communications with the industry supporter and faculty mentor as well as the technical level and suitability of the final solution in solving the problem.

5. Grade Distribution

The course grade for both semesters will be calculated as outlined in the following tables:

5. 1 Grade Distribution for Semester 1

Graded Item	Total
Summary of Project Description, Initial Capability and Requirements	**2%**
Time Sheets	**5%**
Statement of Work (SOW)/Final Requirements and Capabilities	**5%**
Project Performance Specification Document	**5%**
Project Plan (and required updates)	**5%**
Progress Report (2x)	**10%**
Conceptual Design Review	**10%**
Preliminary Design Review (PDR)	**10%**
Final Design Package	**18%**
Expo Presentation	**6%**
Technical Evaluation	**18%**
Peer Evaluation (2x)	**6%**
	100%

SD1 Instructor / Mentor evaluation +/- 10%

5. 2 Grade Distribution for Semester 2

Graded Item	Total
Revised Final Design Package	**4%**
Timesheets	**5%**
Progress Reports (2x)	**10%**
Prototype Status Review	**5%**
Prototype Review	**15%**
Final Project Report	**20%**
Expo Presentation	**6%**
Technical Evaluation	**25%**
Peer Evaluations (2x)	**10%**
	100%

SDII Instructor/mentor evaluation +/- 10%