Mechanical Engineering Senior Design Capstone  
Justification for University Studies Designation

Mechanical Engineering Senior Design is comprised of two sequential courses, MNE497 and 498. Students, organized into teams, engage in projects on behalf of outside customers, usually industrial sponsors. Students learn design, delivery, and project management across the two semesters and finish the course with a formal presentation of their work and delivery of a prototype with full documentation to the customer. Because the second semester deliverables intimately depend on the first semester’s specific accomplishments, the two courses cannot be separated. Significant progress milestones are delineated at breakpoints through the semester; at each breakpoint, called “gates,” teams give brief status presentations and deliver executive summary reports in memo format.

5A-1: Senior Design projects generally fall into one of three types:

* Design and fabricate a new product configuration or redesign and upgrade an existing product;
* Design and fabricate a specialized manufacturing apparatus or measurement device for use in the sponsor’s facility in order to improve safety and ergonomics, reduce costs, improve quality, meet specific regulations or requirements, and/or increase throughput;
* Design and demonstrate an improved process and material flow for manufacturing a product, measuring parameters, or accomplishing a defined task.

Team members bring together the needed technical coursework from the prior three years of engineering education in order to solve a technical problem. Because the scope and deliverables for each project are likely to be unique, the technical skills and resource requirements will likewise be unique to each project. Thus, this course does not teach specific technical skills; instead, the course focuses on project management approaches that are applicable to any engineering project, such as communication, personal interactions, professionalism, budgeting, scheduling, and similar.

Students are required to perform thorough secondary research:

* in the technical databases to support their conceptual designs;
* in trade publications to assess the competitive landscape and to glean ideas necessary to develop conceptual design approaches; and
* in the patent databases to examine existing and disclosed ideas that may both offer new ideas and also to avoid the potential for IP interference.

Students are encouraged to perform laboratory experiments (primary research) to explore, develop, and validate new ideas.

5A-2: Students must address aspects of their design that deal with the environment, such as the resistance of components to sea water, acid rain, the weather, or environmental conditions that are unique to the specific application, such as industrial chemicals. Students must also consider the prudent use of materials that will not pollute or contaminate. For this, the students need a firm grasp on the underlying chemistry and physics that characterize the operating and environmental conditions.

Students also address design characteristics that enhance the ability to repair, repurpose, and/or recycle components and materials to lessen the burden on natural resources and the environment.

All projects require interim status reports and a final, formal report, which draw heavily on the expertise developed in ENL266. Likewise, students must deliver brief, concise team presentations (three per semester), one of which is a formal presentation in front of a large and diverse audience. Again, students draw on their public speaking experience and training in Technical Communication.

Part of the final report that is delivered to the sponsor will include a draft “user manual” and maintenance and repair guidelines. Students must be adept at defining the rhetorical situation – audience, context, and content – in order to adequately prepare this type of material, which is likely to differ from the style and tone of the report body.

5A-3: 20%-25% of each student’s final grade is based on the thoroughness, format, content, and continuity of a personal research and engineering design journal. This journal must conform to accepted formatting standards in order to be defensible as credible evidence in court in the event of a challenge or conflict to IP rights.

This research and design journal must demonstrate that the student has mastered two fundamental skills: documentation of appropriate research (both secondary and primary) and documentation of a design process that shows continuity from basic “brainstormed” ideas through to portions of a finished and workable design.

Students are encouraged to research appropriate science and engineering (peer reviewed) databases to search for novel new work that could be productively used. Students are also encouraged to search for related patents to see if (a) their approach is truly novel, and (b) if not, the extent of infringement that might occur. (Students have an ethical responsibility to convey potential patent conflicts to their sponsors.)

Students also learn to research trade and vendor literature seeking materials, components, and supplies needed to fabricate their designs. As part of research, students are expected to interact directly with suppliers in order to learn “real world” constraints, such as delivery times, minimum order sizes, pricing breaks, shipping costs, local sources, and so on. These person-to-person research events are documented in their journals. In addition, summaries of research are appended to the executive summary memos produced as gate reports.

5A-4: Through both semesters, student teams deliver interim presentations to the class; these presentations are video recorded (specifically for the students’ own critical review). In addition, the teams deliver a two-page executive summary memo with an appendix having as much supporting information as needed. Memos are assessed and graded for organization, information content, and communication effectiveness.

At the end of the course, the final gate report is delivered as a formal presentation to an audience of classmates, faculty, advisers, sponsors, friends, family, and others. For this, students must polish their presentation and content delivery for professionalism, relevance, and timeliness. This requires them to reflect on the rhetorical situation, analyze audience and sponsors’ information needs, and adjust accordingly.

For this day-long final event, student teams must prepare for a poster session walk-through, when visitors talk with the teams to learn about their successes and see demonstrations of their designs working (if safely possible). Students learn to prepare concise graphical and textual presentation materials and address a technically diverse audience face-to-face.

5B-1: The students’ first major task is to meet with their project sponsor and learn the needs that their successful project must satisfy. Students must separate sponsors’ needs from their wants. That is, students must interpret the essential requirements (“needs”) from the desirable-but-nonessential requirements (“wants”) and distill these into genuine user and project requirements; these requirements become the design specifications. Often, high level “wants” (functional characteristics that are nice to have) can be included if the estimated cost and effort is slight or if the aspect provides a genuine advantage, such as ergonomics, safety, sustainability, repair and maintainability, flexibility and adaptability, and so on.

Refining and defining the project design specifications is a reiterative process with the sponsor and usually involves negotiation, because the level of project complexity impacts cost and delivery as well as the breadth/diversity of required engineering talent.

Once the project design requirements are clarified, students perform initial research to learn if similar work has been completed, and if so, then how, where, and by whom. In this way, students can find potential resources within the science, engineering, or manufacturing communities.

5B-2: Students bring their technical expertise from their engineering classes to bear solving the sponsor’s problem. The teams must engage a faculty adviser (sometimes two), so they petition relevant faculty to help them. Almost without exception, the faculty advisers bring the specific technical skills to the team. Often, the best approach to solving a technical problem includes computer modeling, and most faculty advisers have expertise in computer simulations. The results of computer modeling guide and refine the designs; new designs lead to revised computer models, and so on. This reiterative process narrows and sharpens the ultimate design.

5B-3: Students must balance and temper their classroom, textbook lessons with the real-life lessons learned while designing a real system for a real client to perform a real task. In doing this, the students must grapple with the social, environmental, and human (including ergonomic) aspects of their projects and designs. Often, these lessons come from engineering discussions with vendors and suppliers of components but not directly from the sponsor.

Lessons learned by talking with suppliers and end users often have a positive effect on designs, because the sponsor may be interested only in solving cost or performance problems and may be blind to the end user’s interactions with the product or system.

At the conclusion, student teams give a professional presentation in a public forum and publish a thorough engineering project description, including drawings, schematics, and parts lists. This communicates and delivers the project to the sponsor and a wider audience.

Often, students who engage well with their sponsors and others are rewarded with job offers – an ultimate goal for graduating engineering students and a benefit for a project sponsor.

5B-4: The final, formal presentations and reports serve as a vehicle for communicating the depths and details of engagement to a wide audience. And before the final presentation, student teams must make five presentations in front of their peers, where they describe aspects of the design process, including the engagements they have with sponsors and users. It is in these forums where students can explain to their classmates the value of solid interactions with technical and lay people outside the classroom environs. Often, questions from classmates stimulate reflection and reconsideration of approaches.

In their larger engineering communities, students – while still students and later, as professional engineers – remember, articulate, and praise the value of the interactive team experience working as teams and working with others in the community and industry. Often, these alumni return to the University to engage with student and sponsor projects.