Learning to Think Like a Mechanical Engineer: The Senior Design Project

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For mechanical engineering students, the senior design project is considered the most challenging component of senior year. In this two-semester course, students must take the knowledge and skills they’ve acquired and tackle a real-life product design problem. I also found that the class requires students to use skills that go beyond what we’ve studied during our years of coursework. Students must adopt a team-oriented mentality as they solve problems, plan their project, manage their progress and write about their work. This multi-faceted education to some degree simulates what we’ll confront later on in our careers.

As I’ve learned, the engineering design process involves decision-making and use of the basic sciences. After establishing the objective and criteria of the client, the engineer must analyze the problem, construct prototypes, test them, and evaluate the system. Engineering standards and constraints such as finances, environmental, safety, reliability, aesthetics, ethics, and social impact are also important factors in the design process.

The engineering design process has seven phases: (1) conceptual design (2) embodiment design (3) design detail (4) planning for manufacture (5) planning for distribution (6) planning for use and (7) planning for product retirement. In our senior design project, we focused on the first two phases of the process: conceptual and embodiment design.

In the senior design course, students work with a course leader and faculty member to find a solution to an open-ended engineering problem. In the first semester, we carry

**Figure 1. The mechanical design process includes a series of cycled sequences.**

out the conceptual design and analysis. Students meet with their advisor to determine their tasks and form teams. Then, the teams generate design concepts and work with the advisor to select the best design. Of course, the design must meet the requirements of the “customer.” In the second semester, students create a functional prototype and present it to their advisor. In addition, the teams must make an oral presentation and write an engineering report.

Here is a brief description of our project. The Split-Hopkinson Pressure Bar (SHPB) is a mechanical device used to measure and characterize the dynamic stress-strain responses of materials experiencing compression or tension. As an example, for the typical SHPB compression test, two long, cylinder bars—called the input and output bars—sandwich a cylindrical test specimen. Utilizing a high-pressure gas gun, a rectangular aluminum bar called the striker bar, is fired at the input bar. This causes a compressive wave to travel through the input bar, to the test specimen, and finally to the output bar. Strain gages are mounted on both the incident and transmitted bars. For tension testing, the setup is almost the same, except the output bar is replaced with the testing apparatus. Here is where our senior design project begins.

The main goal of our project was to design, analyze, manufacture and test a three-point bending test apparatus for determining a material’s dynamic and static fracture toughness. Our course leader was Professor Charles B. Watkins who taught us how the mechanical engineering process works and how to achieve the goal successfully. Our faculty supervisor was Professor Benjamin Liaw, who worked with us on the SHPB project. My team members Eli Worden, Johan Tolosa, Flory Em and Rashal Mahamud and I were each assigned a task.

The in-house SHPB setup that our team used was created by previous members of the senior design project in the mechanical engineering lab. During the first semester, we made accuracy improvements to the SHPB setup, and my individual task was to create computer simulations. During the second semester, we’ve started to transform the existing SHPB compression system into a tension system. In our experiments, we’re trying to get viable readings for the compression and tension testing and compare these results with the computer simulations.

Through weekly meetings with our course leader and by working closely with our faculty supervisor, we’re learning to think like engineers. We’ve successfully created a functional SHPB system and adapted the compression test to a tension test. With this system, our group has recorded data about the material properties of test specimens. Our design allows for simple conversion between system the two testing modes. We’ve also improved our system’s capabilities by adding adjustable alignment and leveling for most components. In addition, we learned to create presentations and written documentation.

Without this senior design course, how could we take what we’ve learned in school and transition to the world ahead of us? As my fellow team member Eli Worden says, “It was a nice experience where we could build and test out our engineering theories on real world phenomena.” Because of this senior design course, we have transformed from students to mechanical engineers.

**Figure 2. Compression Testing for SHPB**