

Hands-On Design Curriculum Teaches Problem-Solving

Hands-on experience is a hallmark of the ME department's design science curriculum. In ME350: Design and Manufacturing II, students in Professor Sridhar Kota's class were recently given two springs and asked to design — and demonstrate — a novel catapult mechanism. After a lengthy analysis of spring forces, they built their prototypes and tested them in the field. Kota assigned grades based on how far the mechanism launched a tennis ball and with consistent accuracy.

"In all of my other classes, the situations are scripted in a textbook," said Claire Carpenter, a junior, who took the course in her sophomore year. "In ME350, it was real-world. As we prototyped our design, it became clear that what we thought was an ideal solution on paper was not going to give optimal results. It was up to the students to figure out the best way to solve the problem."

Kota says the course emphasizes mechanical system design rather than simply component design in order to provide students with context. "If all that students learn is how to design parts, they just end up doing end-of-chapter problems, rather than creative system design."

This year Kota added a second major design project — in addition to weekly homework assignments and exams. He gave each student team an orbital jigsaw, which students had to take apart, model and analyze. Then they had to suggest improvements and develop a new motor shaft bearing. Kota's goal was for the class to understand "why products are designed the way they are — not only to understand the calculations but the tradeoffs that have to be made."

"My favorite project of the semester was definitely modeling the orbital jigsaw in MSC.ADAMS software," said Andrew Mansfield, a junior who took the class in his second year. "We ran tests on the model to determine cutting power and forces felt by the user, which was quite amazing to me," he said.

Students submitted papers and, at the end of the project, had to verify that they'd reassembled the jigsaw properly. The entire class was successful. Teaching assistants



(Above and opposite) Students in Professor Sridhar Kota's ME350 class learn about design by disassembling orbital jigsaws, suggesting improvements and designing new parts.

Michael Cherry and Brian Trease "really made it possible for the class to complete a project like this," Kota said.

ME452: Design for Manufacturing

Kota also teaches ME452, Design for Manufacturing, which covers manufacturing processes and engineering design guidelines for optimal performance. The highlight of this course is students' dissection of common objects — from egg beaters and dishwashers to weed whippers. They analyze the components and how they're made, review patent materials, conduct customer surveys and analyze the competition. "There's a pretty extensive analysis we go through," said Kota. Then students design an improved version, ideally with fewer parts and a shorter assembly time as well. They build a prototype, test it and write a business plan. The project is "intensive," he said. And yet enrollment is consistently high.

The course is offered to working professionals off-campus too, thanks to the work of Adjunct Assistant Professor Donald Malen.

ME450: Capstone Design and Manufacturing

When Associate Professor Steven Skerlos joined the U-M faculty in 2000, he got involved with the department's capstone design and manufacturing course right away. "The program at U-M just blew me away in terms of what it tries to achieve — and does achieve. It really impressed me."

Skerlos wasn't alone. During its on-site visit, ABET reviewers found that the course provides students "an outstanding major design experience....The attention to the details in the lectures and the projects, including the quality of the guidance provided by the instructors, plus the quality of the interim and final reports prepared by the students, are excellent."

Students work in four-person teams. Seven instructors assign each team one of 35 sponsored projects. About half the projects are sponsored by industry, and half by faculty. Each project involves a design challenge, "a challenge that, coming into it, there's no obvious solution," said Skerlos. And that's the goal.

“We’re trying to teach design by process. Students have to solve the problem. That’s the lesson: design is a creative process, but there are real-world trade-offs, such as time pressure or cost constraints.” Students have 14 weeks to develop, analyze and model a concept, build a prototype and demonstrate that it works.

This year course instructors introduced a new theme-based approach, with each instructor teaching analysis methods focused in his or her thematic area, including sustainable energy and conservation systems and compliant systems design.

“We’re trying to teach design by process. That’s the lesson: design is a creative process, but there are real-world trade-offs, such as time pressure or cost constraints.”

The themed approach will give students additional opportunities to learn design analysis approaches. It will also engage a broader swath of faculty members. “Why not leverage the passions faculty have for their area of ME and let them develop themes within 450 to take it to the next level?” Skerlos said.

Finally the theme-based approach will allow richer engagement with sponsors since projects will be able to evolve from previous work. “Rather than a shotgun approach where we find new projects each year, we will be able to have deeper relationships with specific companies,” he said. “No one company will ever own a large number of projects, but if they can sponsor a theme and allow creativity, everyone wins. Whatever skill set they’re interested in, they’ve got an obvious pool of talent not trained the same way anywhere else in the country.”

