IOWA STATE UNIVERSITY
COLLEGE OF ENGINEERING
ME UPDATE
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ME students experience the world

From Long Beach, California, to Mannheim, Germany, ME students immersed themselves in a wide variety of activities this past summer. Some worked, studied, and traveled abroad, while others tried new experiences here in the U.S. No matter how far they traveled from home, the students interviewed for this article returned to school with added insights about themselves and their career aspirations, and an expanded view of the world.

Emily Hoglund, ME senior, expanded her horizons with an internship at Kiewit Industrial in Long Beach, California.

Emily Hoglund wanted to spend her last summer before graduation on the east or west coast. The Eagan, Minnesota, native chose an internship with Kiewit Industrial in Long Beach, California. "I hadn't worked on a construction site before, and this was a great opportunity because it's a unique type of power plant that includes both combustion and steam turbines," Hoglund explains. "I got a very broad exposure, spending half the time working with a project engineer and half with the mechanical superintendent."

Although she's had several other work experiences, Hoglund says this summer was special. "I loved being in California. I worked with a very diverse group of people, and it was a good personal challenge," she observes. In addition, there were the perks—living in Newport Beach, a place everyone recognizes; seeing "The Producers," featuring bona fide Hollywood stars; and learning to surf. As for where she'll end up after graduation, Hoglund says she's leaning toward the Midwest, but will explore all of her options.

Greg Sommer, a senior from Fargo, North Dakota, stayed close to home this summer—he had an internship with 3M in Minnesota. In 2002 he had worked for a start-up company that manufactures small medical devices. With only six employees, he got to do a little bit of everything. This year he chose 3M because he wanted to see how the "other side" operated.

"It was amazing to see how big 3M is and all it takes to keep it going," Sommer says. "They introduce you to all different aspects of the company, plus you apply the engineering skills you've learned." An added bonus was the interactions he had with interns he met from other schools. His roommates, for example, were students at MIT, the University of Indiana, and Michigan Technological University. Sommer will use what he learned from both internships as well as from his on-campus research experiences to assess his options as he prepares to leave Iowa State in May.

Taking classes in Germany introduced Tyler Heithoff, shown here at Neuschwanstein Castle, to the challenges and benefits of study abroad.

Tyler Heithoff, a junior from Ames, hadn't ever been out of the United States—so when the opportunity to spend six weeks in Mannheim, Germany, came up last spring, he jumped at the chance. The study-abroad program included taking courses in plastics manufacturing and introductory German at Fachhochschule Mannheim.

Living and studying in Mannheim gave Heithoff a new appreciation for the conveniences we have in the U.S. as well as the challenges international students face as they interact on a daily basis with people who don't speak their language.

The experience also expanded Heithoff's views of his professional options. As part of the manufacturing class, he toured Daimler Chrysler and the BASF Chemical Production Plant. Currently he's exploring internship options for next summer.

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ME students to get world-class facility

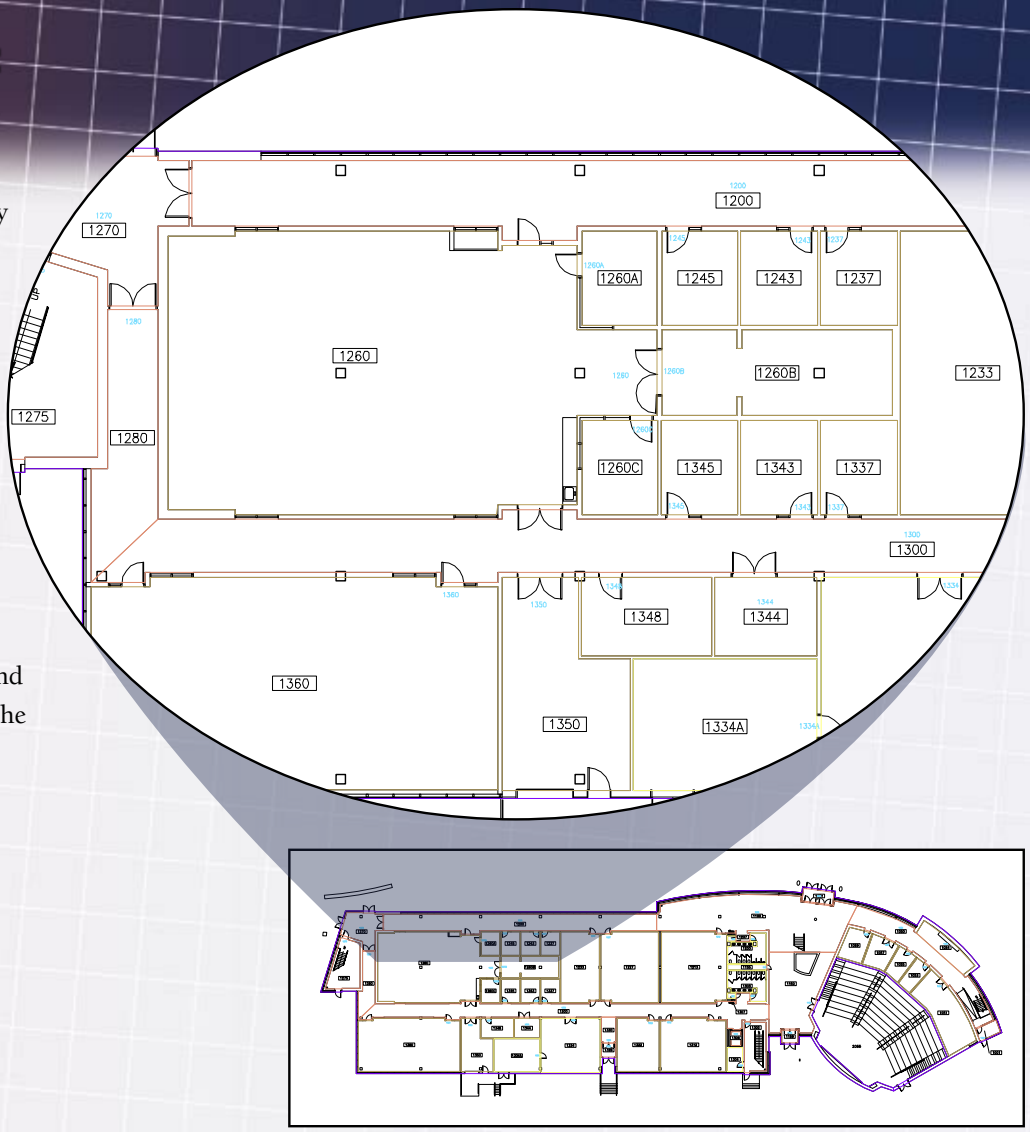
When Gary and Donna Hoover Hall officially opens for classes in January, students taking ME 270, the introductory design class, are in for a real treat, according to **Don Flugrad**, ME associate chair for undergraduate programs.

"It truly will be a world-class facility," says Flugrad, who is coordinating acquisition of the state-of-the-art equipment and furnishings for the Boyd Product Realization Lab, which was created with a gift from **James Boyd**, BSME'38, and his wife **Gayle**. At 2,900 square feet (net), the Boyd lab is the largest lab in Hoover Hall.

Six rooms have been designated as team meeting/design rooms. Equipped with computer workstations and Smart Boards, these areas are specifically designed to facilitate teamwork in the planning and design process. The teams will proceed to the fabrication room, equipped with three machining centers and a CNC-controlled lathe, to manufacture their pieces. "With the parts in hand," Flugrad says, "the students will be able to assess the functionality of their designs and build the prototype."

The final step is to present the results. Room 1233, set up as a classroom, will have the necessary lighting and equipment to digitally capture the students' oral presentations, according to Flugrad. "The students will learn by seeing their own presentations, and, if they want, they can include clips of their presentations on their Web site or resume to illustrate their communication skills."

The Boyd lab will be well utilized throughout the year with around 110 ME 270 students each semester and another 70–90 students in the senior capstone class.



The Boyd Product Realization Lab (inset of floor plan above) in the new Gary and Donna Hoover Hall will provide ME students state-of-the-art learning experiences. Gary Hoover, BSME'61, and his wife Donna provided the leadership gift for the building that marks the completion of the Engineering Teaching and Research Complex (ETRC). Dedicated on October 4th, Hoover Hall (pictured below) will open for classes in January.

New look for ME leadership

On July 1, **Judy Vance** became the first woman to serve as chair of the Department of Mechanical Engineering. A member of the ME faculty since 1992, Vance was also promoted to the rank of professor in July.

A 1980 Iowa State alum, Vance worked as a mechanical engineer at John Deere Des Moines Works in Ankeny from 1979 to 1984. Returning to Iowa State to pursue her graduate degrees, she completed her M.S. in 1987 and Ph.D. in 1992.

An accomplished researcher, Vance has done extensive work with virtual reality, investigating ways to use this advanced technology to improve product design and development. One current project, funded by John Deere, focuses on developing a virtual reality environment for ergonomic workspace design using a complete 3D anthropometric data set.

Another project, funded by the National Science Foundation (NSF), is for the development of a virtual reality-based tool to be used in the design of products that are subject to critical stress and/or fluid flow constraints. Designers will be able to interactively "push and pull" on a part's shape and investigate the changes this causes to the stress distribution in the part.

Vance has impacted many students at the graduate and undergraduate levels. She was one of the early proponents of active learning in engineering. She helped organize the group that initiated Project LEA/RN, which is now a campus-wide effort. With leadership roles in the American Society of Mechanical Engineers and the Society of Women Engineers, Vance often meets up with her former students at professional meetings around the country.

Dedicated to helping other women achieve leadership roles, Vance heads the Women in Engineering Leadership Institute (WELI). In an NSF-funded project, Vance and Professor **Diane Rover**, Electrical and Computer Engineering, are working with six other institutions to hold leadership conferences for female engineering faculty. "Our focus is on the chair position," Vance says, "because it's a place where you can make a difference."

Due to the large size of the ME department—over 1,000 undergraduates, 165 graduate students, and nearly 45 faculty and staff—**Judy Vance** has named two associate chairs and a director of graduate education to assist with the administrative demands.

Don Flugrad, associate professor, is continuing in the role of associate chair, undergraduate programs. His responsibilities focus on teaching schedules, teaching-assistant appointments, ABET compliance, and curriculum issues.

Professor **Jon Van Gerpen** has been named to the newly created position of associate chair, research and budget. His duties include looking at ways to improve the graduate program and making effective use of limited resources.

The new director of graduate education is **Adin Mann**, associate professor. Working with the graduate student office, Mann's responsibilities include providing services to current and prospective graduate students.

Meet the ME administrative team (from left): Don Flugrad, associate chair, undergraduate programs; Judy Vance, department chair; Jon Van Gerpen, associate chair, research and budget; and Adin Mann, director of graduate education.

It's a small, small world out there . . .

The only thing small about micro/nano systems is their physical size. Microtechnology addresses structures and devices with features in the micron (one-millionth of a meter) domain, while nanotechnology refers to manipulating objects—molecules and atoms—smaller than 1,000 nanometers (one nanometer is one-billionth of a meter).

The impact of micro/nano research, however, is huge. Using specialized instruments, researchers are studying, designing, fabricating, and testing structures with fundamentally new properties and functions. Tremendous advances have already been made in manufacturing, healthcare, national defense, and information technology, and the potential is virtually limitless.

The department is very active in this exciting interdisciplinary area with a number of faculty involved in various aspects of micro/nano systems research. Graduate and undergraduate students also are involved in the research and have the opportunity to take classes that have evolved from these research interests.

Pal Molian

Professor **Pal Molian** is investigating tools and processes that will further the advances made through micro/nano research. By studying biomimetic (objects that imitate nature) nanoparticulate surfaces through Coulomb explosion, a process that examines molecular dispersion when exposed to a very short duration of laser pulses, Molian aims to develop practical nanotechnology applications for microelectronics, MEMS (micro-electro-mechanical systems), and tribology. The study of femtosecond pulsed laser-material interactions will increase understanding of mechanisms that will lead to improved nanoprocessing. Molian is also looking at ways to use sub-micron and nanofabrication stereolithography techniques to manufacture better sensors, NEMS (nano-electro-mechanical systems) devices, and compact microcircuits with higher density information storage capacity. In addition, he's working with SiC, a high-temperature, chemically inert semiconductor with a wide bandgap that is useful for next-generation MEMS sensors and actuators. He's also developing novel techniques for nanoparticle additive machining and he's studying a new concept, the liquid lens. It enables a laser to focus at nanoscale dimensions and so has potential to perform nanomachining for medical and other devices.

Abhijit Chandra

Abhijit Chandra, Engel Professor of Mechanical Systems and director of the Engel Manufacturing Lab, is principal investigator for a new NSF grant to improve wafer yield in integrated circuit (IC) manufacturing by enhancing the wafer scale uniformity. **Atul Kelkar** and **Ashraf Bastawros** are collaborators along with faculty from other departments. This grant follows an earlier award to understand the chemical mechanical planarization (CMP) process that is used to flatten out the rough surface of wafers.

To make an IC, a Deep Ultraviolet Stepper is used to pattern the layers, which typically are less than a micron thick. This is a critical component because a rough surface cannot be patterned precisely. Chandra's team is developing a model for determining the exact parameters manufacturers should use to match the characteristics of a particular wafer to get a 2-nm flatness over the entire wafer. "The result will be huge cost savings in the microelectronics industry," Chandra says. "Companies will be able to make maximum use of the wafer, plus they won't have to use trial and error to set the CMP process."

Shyam Bahadur

University Professor **Shyam Bahadur** has focused primarily on tribology and surface engineering throughout his 33-year career at Iowa State. His secondary interests include micro-machining of hard materials and the interrelationships in deformation, structure, and mechanical properties of polymers. In tribology, he investigates the behavior of transfer or thin films with the goal of improving friction and wear properties. As his work has evolved from micro- to nano-sized particles, he's discovered that nano-sized particles are equally effective in reducing the wear rate of polymer composites, and the filler proportion needed for optimum wear resistance of the polymer is much smaller for nano-sized particles than for micro-sized particles.

In a U.S. Civilian Research and Development Foundation project, Bahadur is collaborating with scientists from countries in the former Soviet Union to investigate how surface treatments, reduction of size from micro to nano, and the addition of other compounds could be used to increase the effectiveness of mineral deposits in Armenia for increasing the wear resistance of polymer composites. "It will be highly beneficial for the economy in Armenia if these deposits could be put to effective use," Bahadur says.

Li Cao

Li Cao is developing devices that have tremendous potential for biomedical and biotechnology applications. She is developing a micropump using MEMS technology

that can be implanted in the abdomen or chest to pump drugs, such as insulin, into the body. "Our group is focusing on the mechanical aspects—how to design and fabricate a pump that can deliver the drug in the precise concentrations needed and, at the same time, consume very low power. We are working with experts from other areas to develop the microelectronics," Cao explains.

She is also developing a small, portable device to perform chemical analyses. It will provide quicker, more convenient, and less expensive analyses, she says. The design challenge is to take advantage of surface tension in the microscale world to address issues of pressure created by the small size in order to precisely transport and manipulate fine droplets for analysis.

Michael Olsen

In his research, **Michael Olsen** is searching for an optimal design for microchannels. About the size of a human hair, microchannels are considered the key component for advances in MEMS devices as well as for such novel gadgets as wearable air conditioners. "As a microprocessor, for example, gets faster and smaller, it generates lots of heat. If it gets too fast, the processor overheats and fails," Olsen explains. Fluid flowing through microchannels removes heat, but the smaller the channel the higher the surface-area-to-volume ratio, meaning more force—i.e., a bigger pump—is needed to push the fluid through. Olsen is looking at modifications in the microchannel's geometry that will efficiently transfer heat without requiring a big power source.

His research team devised a microchannel with microfins—bumps added to increase surface area—and is measuring the impact on pressure, temperature, and velocity. "We developed a technique to get a detailed picture of what the fluid looks like inside the microchannel," Olsen says. "Now we can measure the velocity field around a single bump." While pleased with the team's progress, Olsen stresses there is much more to learn.

Both Cao and Olsen, along with Bastawros, whose primary appointment is in aerospace engineering, have received prestigious Faculty Early Career Development Grants from the National Science Foundation to support their micro/nano research.

Bastawros' focus is on the microstructural level of materials, dense materials as well as porous and cellular metal used in multifunctional ultralight structural applications. His main contribution in dense metals is showing how materials deform in that range and then interacting with scientists who develop the modeling framework. The overall goal is to enhance the strength and functionality of the devices' interfaces by reconfiguring materials at the microstructural level.

Francine Battaglia

Francine Battaglia is developing computational models of fluid mixing to see if they can match the results. "We're trying to improve our understanding of the physics of the process," she says. With considerable work in fluid flow on the macroscale, Battaglia describes exploration on the microscale as a natural extension. "In general, fluids behave very differently, and we're trying to understand 'how and why.' We know surface tension is significant due to the large surface area of a microchannel in contrast to the small volume, but what else affects the behavior of a fluid?"

Battaglia also works with multiphase flows, which is important for medical devices like biosensors. "If you're analyzing blood, for example, you need to mix a reagent with the blood, and you have to understand how to maximize the mixing performance on the microscale."

Sriram Sundararajan

Sriram Sundararajan, at ISU since 2002, is addressing issues fundamental to ME—tribology, the science of friction, wear, and lubrication; and mechanics, understanding the mechanical behavior of materials. "Once you've reduced system dimensions to the micro-/nanoscale," Sundararajan says, "the ratio of surface area to volume is more than a thousand times higher than in conventional systems, and this causes large increases in forces you don't want like friction and surface tension. In terms of mechanical behavior, if we can understand what's happening at the molecular level, it might help us predict what will happen on larger systems."

One area of his research focuses on development and testing of new lubricants. "We provide chemists the guidelines to synthesize the molecules. We then apply and test the lubricant to determine if it results in better friction control," he explains. Besides being fundamental research, reducing friction and wear falls under the Department of Energy's goals—and that's for good reason, Sundararajan points out. "More than $25–$30 billion is wasted in energy because machinery has worn out due to neglect or not sufficiently addressing friction and wear."

Interest and accomplishments in micro/nano systems research is continuing to expand in ME. This fall, **Pranav Shrotriya**, who will study mechanics of nano-level structures, joined the faculty.

New faculty members eager to help students learn

ME's two newest assistant professors have diverse backgrounds, but they share a passion for teaching and a commitment to cutting-edge research. And, they've come to Iowa State to do both.

Pranav Shrotriya moved to Ames in August from Providence, Rhode Island. He had spent the past year at Brown University exploring how nanotechnology might be used to develop light weight vehicles.

Although he grew up in India and did his undergraduate work at the Indian Institute of Technology in Bombay, Shrotriya is no stranger to the Midwest. He lived in Champaign-Urbana from 1995 to 2000 while earning his doctorate at the University of Illinois in theoretical and applied mechanics.

As a Ph.D. candidate, Shrotriya won the J. O. Smith Award for Outstanding Young Teacher in Engineering Mechanics. "I love interacting with students and getting their feedback," he observes. "Seeing their eyes light up when they realize they understand the material is the best feeling."

This fall Shrotriya is continuing to develop his instructional skills as part of the faculty team that teaches ME's introduction to design course.

Shrotriya's research interest in nanotechnology developed when he was a grad student. He was studying polymer composites and discovered the need to explore issues at the nanoscale level. He continued his research as a postdoctoral fellow in mechanical and aerospace engineering at Princeton University and now is eager to apply nanoscale technology to benefit humankind.

"I work on the mechanics of very small structures developing models to see how they fail under different loads. If we can understand this phenomena at the nano level, the applications are endless," Shrotriya says. "We could make better implants for humans or make engines that last a very long time and are economical. It could bring a whole new paradigm to the engineering field!"

When not preparing for class or doing research, Shrotriya is getting acquainted with Ames by touring the city on his bicycle. His wife will join him here in December.

"Seeing the students' eyes light up when they realize they understand the material is the best feeling."

Eliot Winer, who will move to Ames in November, has spent most of his life in Buffalo, New York. He did live in the Midwest while he earned his bachelor's degree at Ohio State University, but then returned to New York to work.

He went on to earn his M.S. and Ph.D. in mechanical engineering at the University at Buffalo, the State University of New York, where his research focused on visualization, virtual reality, and engineering design.

In 1999, as a postdoctoral fellow, Winer helped write proposals for funding for the New York State Center for Engineering Design and Industrial Innovation (NYSCEDII). Most recently, he served as the center's deputy director with primary responsibilities for the day-to-day operations. He's also taught classes and run a research program as an adjunct professor in mechanical engineering at the University at Buffalo.

The opportunity to devote more time to teaching and advising students helped convince Winer to accept the Iowa State faculty position. He describes teaching as a collaborative process. "It's not me writing lots of notes, and students memorizing everything. I ask questions and allow students to put the concepts together themselves. As they begin to understand, that look on their faces is priceless."

Noting the outstanding facilities at Iowa State, Winer adds that he is anxious to establish his research program. Over the last few years, his research has expanded from basic engineering design to interdisciplinary work that involves developing design methodologies and concepts for using high-end visualization to address specific problems and issues.

In one project, for example, a virtual reality treatment center was designed for people with post-traumatic stress disorder from motor vehicle accidents. "The patients can sit in the cabin, outfitted with steering wheel and foot pedals, and drive. The level of traffic is gradually increased, building their comfort level," Winer explains.

Another project involved working with geoscientists to create an image of past volcanic flows to better predict future ones in order to save lives.

"I never saw myself doing these kinds of things," Winer says, "but I like to get involved in new things and enjoy the challenges they bring."

Winer is moving to Ames with his wife and young daughter. And, although no longer living in Buffalo, he'll continue to support his favorite pro football team, the Buffalo Bills.

What's your favorite professor up to?

The Department of Mechanical Engineering has a comprehensive and dynamic research program. The faculty are a healthy mix of young men and women just beginning their academic careers, those who have begun to establish their reputations in the field, and those who are renowned for their accomplishments. The common denominator is enthusiastic energy for developing and investigating new ideas and finding novel ways to solve problems.

Following is a list of faculty by research area. Please note many are listed in more than one area. To find out more about a faculty member or to contact them, please visit our Web site: www.me.iastate.edu/personnel/index.html.

Thermal Systems

Energy systems
Robert C. Brown
Kenneth "Mark" Bryden
Ron M. Nelson
Howard N. Shapiro

Refrigeration
Gregory M. Maxwell
Michael B. Pate
Howard N. Shapiro

Heat transfer
Francine Battaglia
Kenneth "Mark" Bryden
Theodore J. Heindel
Gregory M. Maxwell
Michael G. Olsen
Michael B. Pate
Richard H. Pletcher

Fluid mechanics and dynamics
Francine Battaglia
Kenneth "Mark" Bryden
William J. Cook
Gerald M. Colver
Theodore J. Heindel
Theodore H. Okiishi
Michael G. Olsen
Michael B. Pate
Richard H. Pletcher
Shankar Subramaniam

Combustion
Francine Battaglia
Robert C. Brown
Kenneth "Mark" Bryden
Gerald M. Colver
Shankar Subramaniam
Jon H. Van Gerpen

Mechanical Systems

Machine design (CAD)
Donald R. Flugrad
Adin Mann
James H. Oliver
Abir Qamhiyah
Judy M. Vance
Eliot Winer

System dynamics, controls, and robotics
James E. Bernard
Donald R. Flugrad
Atul G. Kelkar
Greg Luecke
Adin Mann

Manufacturing and materials
Shyam Bahadur
Ashraf F. Bastawros
Daniel B. Bullen
Li Cao
Abhijit Chandra
Warren R. DeVries
Martin C. Edelson
Palaniappa A. Molian
Abir Qamhiyah
Pranav Shrotriya
Sriram Sundararajan

Virtual Reality Applications

James E. Bernard
Kenneth "Mark" Bryden
Atul G. Kelkar
Greg Luecke
James H. Oliver
Judy M. Vance
Eliot Winer

Micro/nano Systems

Shyam Bahadur
Ashraf F. Bastawros
Francine Battaglia
Li Cao
Abhijit Chandra
Palaniappa A. Molian
Michael G. Olsen
Pranav Shrotriya
Sriram Sundararajan

Bethany Noyes, BSME'03, was one of 21 Iowa State spring graduates employed in Iowa who were featured on life-size cutouts at the university's exhibit during the Iowa State Fair in August. Noyes, a mechanical engineer at John Deere Dubuque Works, says the senior design class was the highlight of her ISU studies. "It made the design process come alive in the sense of meeting the customer requirements, developing specifications, ordering parts, and actually fabricating the product. Our group designed a desk for a 3-year-old girl who had mobility limitations . . . Seeing her utilize our final product was a reward within itself."

ME students continued from **page 1**

Andrew Schumacher at BMW in Munich.

For another student, **Andrew Schumacher** from Schaumburg, Illinois, his three-month internship at BMW's Research and Innovation Center in Munich confirmed his career interest in international business management and allowed him to develop his German language skills. Schumacher, who had previously participated in the internship/study program at John Deere in Mannheim, wanted experience in the international automotive industry.

"BMW is an international market-leader that engineers cars successfully combining sport, luxury, and quality. I wanted to see how this was done," he explains. "The experience gave me the ability to evaluate things from an engineering perspective as well as from an international business experience."

In Lyon, France, **Jesse Bernstein**, a senior from Columbus, Nebraska, lived with a family and studied French for seven weeks as part of the Iowa Regents' Program. Introduced to the European manufacturing industry as a high school student, Bernstein had decided she would like to work in Europe.

A chance encounter with an ME professor from Arizona State University in Grenoble introduced her to another aspect of ME research. "He bumped into me, and we were both surprised to find someone else who spoke English," Bernstein recalls. The professor and his wife gave Bernstein a tour of the lab where he is studying fluid flow. Although Bernstein's interests focus on the technological aspects of manufacturing, she notes the value of making professional connections throughout the world, especially as she explores options for graduate school.

A small group of ME students studied in France. **Kris Lineberry**, a senior from Clive, Iowa, was one of three to take the computer-aided design course coordinated by Iowa State ME Assistant Professor **Abir Qamhiyah**. The class was taught at the University of Technology of Compiegne (UTC) in Compiegne.

Jesse Bernstein at the Colosseum in Rome, Italy

"The purpose is to prepare students to work in teams with engineers from other cultures and from different engineering educational systems," Qamhiyah says.

ME students (from left) Peter Gaylord, Nolan Walton, and Kris Lineberry at Normandy Beach.

"Total immersion in another culture is the best way to prepare them for the global marketplace."

For Lineberry a highlight was going to the Paris Air Show, the world's largest air exhibition. A two-week international perspectives course introduced him to students from 13 countries. After the class, he and another ME student explored Europe. "We did a whirlwind tour—Italy, Austria, Germany, Czech Republic, France, and England—just with the packs on our backs," Lineberry says. "This summer was an adventure I will never forget! I learned a lot about other cultures, and that has given me a new appreciation of the United States."

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