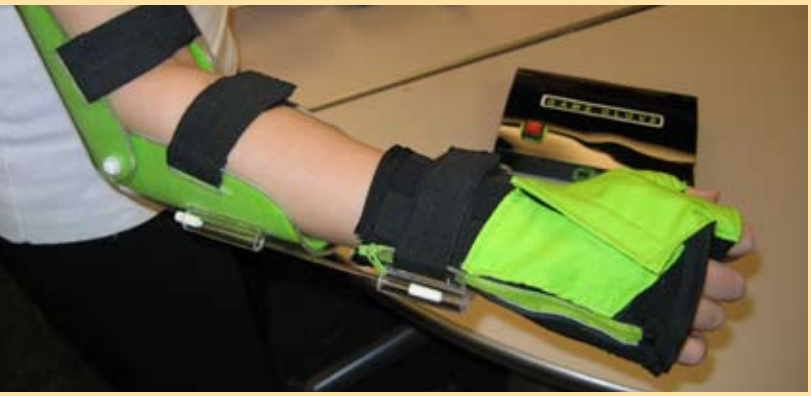
2006
SENIOR DESIGN PROJECTS



MARQUETTE UNIVERSITY
COLLEGE OF ENGINEERING

MARQUETTE
UNIVERSITY

Be The Difference.

FROM THE DEAN

This publication presents the Marquette University College of Engineering Senior Design Projects completed by our students during the 2005-2006 academic year. I am very proud to share this publication with you.

Preparing students for successful careers based on a strong moral and ethical foundation is one of the building blocks of the mission of the College of Engineering. We strive to insure that all of our students leave Marquette prepared to be productive engineers right from the beginning of their career.

Our definition of a productive engineer is comprehensive. A Marquette engineer recognizes the nature of both open-ended and closed problems. He or she envisions multiple correct solutions to any one problem and sees the value in both market-driven and technology-driven solutions. Our engineers work effectively as part of a multi-disciplinary, globally based, team focused on balancing decision making and risk management to reach the best possible solution to a problem.

The Senior Design Project program is one of the important tools we use in this preparation process. Engineering problems in all of the four major engineering disciplines; Biomedical Engineering, Civil and Environmental Engineering, Electrical and Computer Engineering, and Mechanical Engineering are presented by industry. Small groups of senior students are formed to work on these "real world" engineering challenges. Students within each group may be from a variety of engineering majors or all from the same major. Each problem is analyzed. Customer needs are evaluated and a project definition is created. Then the very challenging work of developing a concrete solution begins. Product concepts are generated, including detailed product specifications. Prototypes, oral and written presentations, and periodic peer reviews are also part of the process. The final product is presented to a panel of industry engineers. We strive to create a design project experience that is similar to the design project process in industry.

You are invited to continue your participation or to join us in the important endeavor of preparing our students to be successful engineers. Industry sponsorship of the Senior Design Project program is crucial to its continued success. The College also looks to corporations to be the backbone of our Cooperative Education (Co-op) and internship programs. You know from your own professional experience the benefits of "real world" learning and experience, both to the individual and to their employer. Please help us to continue offering this type of learning and experience to our students.

Congratulations to all of our Senior Design students on the innovative way they met the challenges of their specific project. Again, thank you to our industry sponsors for providing the project opportunities. This cooperative effort and teamwork makes all of us more successful!

Stan Jaskolski, Ph.D., P.E.
OPUS Dean
College of Engineering
Marquette University

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INDUSTRY SPONSORSHIP

Senior Design Course Sequence:

At Marquette University, all senior biomedical, electrical, computer, and mechanical engineering students are required to successfully complete a set of project-based capstone design courses (XXEN 146, Principles of Design, and XXEN 147, Senior Design Project). The objectives of this two-course sequence are to:

- develop students' knowledge of the engineering design process, project management, and the product development process;
- provide students with the opportunity to apply and develop their design, analytical, project management, interpersonal, and communication (oral and written) skills via a team based project experience; and
- prepare students for careers in engineering.

Senior Design Project:

The major component of the course is a design The major component of the course is a design project that is managed by a multidisciplinary team of three to five students for an entire academic year. During the year, project teams identify customer needs, develop potential designs, construct and test prototypes, and deliver a design and/or working prototype to their industry sponsors. Project teams develop project schedules, maintain project notebooks, conduct economic and risk analyses of their design solutions, and develop and present written and oral project proposals and final reports.

Many of the projects are industry sponsored and provide students with an opportunity to learn about the needs of the market and the operations of a company. Experience gained from industry sponsored projects helps prepare students for careers in industry. Teams are advised by a College of Engineering faculty member and a representative from the sponsoring company.

Benefits of Sponsorship:

Benefits to companies sponsoring design projects include:

- Additional resources at little or no cost to company. Three to five senior engineering students will be dedicated to each project for two semesters. The sponsoring company can specify the composition of the project team (biomedical, electrical, computer, and mechanical engineering students). This can be very beneficial to companies with limited engineering resources and can allow companies to focus efforts on those of higher priority.

- Involvement and participation in the training of new engineers and potential employees.

- On-campus advertisement of the sponsoring company. Involvement in the senior design project will provide the company access to and a higher profile among graduating engineers.

Benefits to students of industry sponsored projects:

- Opportunity to work on real-world problems important to industry.
- Exposure to Industry.
- Experience with project management and product development.
- Familiarity with requirements and constraints of product design

INDUSTRY SPONSORSHIP

Requirements for Industry Sponsorship:

Personnel:
Sponsoring companies must identify at least one company representative to act as an industry advisor to the project team. The industry advisor would be the company contact for the project team, advise students on issues involving customer needs, provide technical expertise and advice, and approve design concepts and prototypes. Faculty advisors will be responsible for administrative issues (grading, meeting deadlines, monitoring progress of teams, dealing with team personnel issues, etc.) and providing guidance to the team.

Time:
At a minimum, industry advisors must be available to discuss project requirements, customer needs, and potential designs. Communications can be in-person or by phone, e-mail, or FAX. The advisor determines the frequency of communications.

Travel:
The sponsoring company determines the need for travel.

Funding:
Depending upon the needs and expectations of the sponsor, a fund of $100 to $1000 may be necessary to pay for prototypes and testing.

Other:
Students have access to Marquette University's computer network, libraries, Discovery Learning Center (machine shop), faculty expertise, and engineering laboratories. Sponsors may want to provide additional resources (prototyping facilities and/or personnel, laboratories, etc.) to their project teams if desired.

Types of Projects Appropriate for a Senior Design Project:

- Lower priority projects for which the company lacks resources
- Projects that can be completed in nine months or less
- New products (hardware or software)
- Product improvements (new features, packaging, materials, etc.)
- Process improvements
- Development of test procedures and/or test equipment

Protection of Proprietary Information:
Sponsors can request that members of their project teams sign non-disclosure agreements to protect confidential and trade secret information.

To Sponsor a Senior Design Project:

If you have any questions about our senior design program or if you are interested in sponsoring a senior design project please contact the appropriate design instructor listed below:

Biomedical Engineering:
Dr. Jay Goldberg
(414) 288-6059
jay.goldberg@mu.edu

Electrical and Computer Engineering:
Dr. Martin Seitz
(414) 288-5659
martin.seitz@mu.edu

Mechanical Engineering:
Dr. Vikram Cariapa
(414) 288-3607
vikram.cariapa@mu.edu

We look forward to working with you.

LETTER TO INDUSTRY SPONSORS

The following pages describe the Biomedical Engineering Senior Design Projects completed during the 2005-2006 academic year at Marquette University.

The Department of Biomedical Engineering at Marquette University is dedicated to preparing students for their professional and personal lives after graduation. Undergraduate students can specialize in biomechanical, bioelectrical, or biocomputer engineering. In addition to courses in engineering, mathematics, and the life sciences, students are required to complete a year long project-based capstone design course. This course is a culmination of their undergraduate education and provides them with the opportunity to apply and develop their design, analytical, project management, interpersonal, and communication skills through a team-based project experience. Students develop their teamwork skills, learn about the product development process used in industry, and are made aware of the unique requirements and constraints of medical device design. Lectures on legal and regulatory issues, standards, economic analysis, packaging, sterilization, and testing are included in the course. Several project deliverables, similar to those used in industry, are required. This capstone design experience provides students with the knowledge base and skill sets needed to be an effective, contributing member of a medical device company, clinical engineering department, or academic research laboratory.

At Marquette University, students may enhance their design experience and preparation for careers in the engineering profession through work experience. At the Les Aspin Center for Government Studies, students can work as interns for the US Food and Drug Administration and learn first-hand how the FDA functions and what is required to market a regulated medical device. Students participating in our highly popular and nationally recognized Cooperative Education Program gain work experience at medical device companies prior to graduation. The experience gained through these programs helps prepare students for careers in biomedical engineering.

As you read through this report and learn of the benefits of industry sponsorship of senior design projects, please consider becoming a sponsor. We recognize the value to our students and program of strong ties to industry, and we are interested in working with additional companies to help us prepare our students for careers in biomedical engineering.

Respectfully,

Jay R. Goldberg, Ph.D., P.E.
Associate Professor of Biomedical Engineering,
Senior Design Course Instructor

Kristina Ropella, Ph.D.
Professor and Chair, Department of Biomedical Engineering
Marquette University

SPONSORS

2005-2006
Medtronic USA Inc., Minneapolis, MN
Guidant Corporation, St. Paul, MN
AKSYS, Ltd., Lincolnshire, IL
U.S. Navy Institute for Dental and Biomedical Research, Great Lakes, IL

2004-2005
Medtronic USA Inc., Minneapolis, MN
DePuy Orthopedics, Inc., Warsaw, IN
Rehabilitation Engineering Research Center,
Milwaukee, WI
Discovery World Museum, Milwaukee, WI
Animark, Inc., Aurora, CO

2003-2004
Siemens Medical Solutions, Hoffmann Estates, IL
Hollister, Inc., Libertyville, IL
DePuy Orthopedics, Inc., Warsaw, IN
Medtronic USA Inc., Minneapolis, MN
GE Medical Systems – Information Technology, Waukesha, WI

2002-2003
GE Medical Systems, Waukesha, WI
DePuy Orthopedics, Inc., Warsaw, IN
Hollister, Inc., Libertyville, IL
Medtronic USA Inc., Minneapolis, MN

2001-2002
Abbott Laboratories, Inc., Abbott Park, IL
DePuy Orthopedics, Inc., Warsaw, IN
Carta Nova, Milwaukee, WI
GE Medical Systems, Waukesha, WI
Milestone Scientific, Inc., Deerfield, IL

2000-2001
Opticon Medical, Inc., Columbus, OH
Baxter Healthcare, Deerfield, IL
Milestone Scientific, Inc., Deerfield, IL

Design and Validation of a Pneumatic Vibrotactile Stimulation Device

Project Team: Tocher Kellom
Michael Poellmann
Melissa Schubert
Anne Yatco

Faculty Advisor: Dr. Brian Schmit

A pneumatic vibrotactile stimulator for the lower extremities was designed for functional magnetic resonance imaging (fMRI) studies. Stimulation of the legs will allow mapping of areas in the brain that correspond to sensory and motor control of the lower body. Areas of the brain corresponding to sensation and control of lower extremity motion can be stimulated by mechanical motion of the legs even in patients paralyzed by stroke or other central nervous system disorders. There is evidence that the brain is capable of functional reorganization after injury. A deeper understanding of this reorganization may lead to improved rehabilitation strategies.

Illusory motion of a limb can be caused by mechanical vibration of a muscle. The use of vibratory stimulation for eliciting a response in the somatosensory cortex of the brain has been shown in PET studies and more recently in fMRI studies. The devices used in fMRI studies have not been well described and were only applied to the upper extremities. The current design of the vibrotactile stimulator is largely based on a device originally designed by Richard W. Briggs.

The device was designed to mechanically stimulate the muscle through the rapid movement of a rubber diaphragm (Theraband) over a plastic cap. The device could be secured to the patient using either a comfortable Velcro strap or medical grade tape. The device was connected to equipment in the control room through low compliance tubing. No metallic components were present that would be placed in the magnet room. In the control room, air was supplied to the device by a compressor and pressurized tank. The diaphragm had two states: resting and distended. The amplitude of distension was controlled by air pressure. Pressure in the diaphragm was modulated with a high speed three way valve (Festo MH2, 2 ms response, 100 l/min flow rate). The entire system was controlled using a LabVIEW interface. A custom circuit boosted the 5 V logic output from LabVIEW to a 24 V DC control signal for the valve.

Validation and optimization testing were conducted to determine whether the prototype met the design specifications. Diaphragms of various sizes and stiffness were tested along with various pressure magnitudes and frequencies. (Previous studies have shown that illusory movement can be achieved in the arm at 70 Hz; the muscles of the leg should require a similar frequency.) Testing revealed that this design produced inadequate high frequency vibration and that the high speed valve was unable to operate at 70 Hz for more than one minute.

PROJECTS

Grip Handle for Therapy

Project Team: Luqman A-Hamid
Dan Abel
Emily Ballweg
Greg Porter
Carlos Varas

Faculty Advisor: Dr. Brian Schmit

Sponsor: Chris Cayo,
New Berlin Therapies

Children and certain adults with cerebral palsy (CP) have difficulties performing functional tasks due to unbalanced body posture during limb movements. Physical therapists have found that stabilization of one arm in a specific position provides unilateral stability and improves coordinated use of the opposite extremity. One way to provide this benefit is through building a handle on the wheelchair for the patient to grip, allowing them to lock one arm in a position that aligns their back and supports their posture. The patient is then able to concentrate on tasks using the opposite arm.

A local physical therapist with a young patient with cerebral palsy requested a more modern grip handle to replace an existing device which was limited in its range of motion, had sharp edges, and was difficult to adjust. The older device was only adjustable to discrete heights. The purpose of this project was to design and develop a newer, more adjustable and patient-friendly grip handle.

Interviews were conducted with the patient's family and physical therapist to better understand the needs and parameters for the handle. The base of the new handle, a PanaVise, allowed for rotation in all three planes making it highly adjustable and useful for the patient to use in various positions. Also, the clamp on the handle was able to be attached to multiple surfaces such as countertops as well as on either side of the patient's wheelchair tray, making it usable by both arms to practice exercises prescribed by the physical therapist.

A telescoping mechanism was used to for adjusting the height of the grip handle. This mechanism was used so that the excess material from the pole was contained rather than being outside of the pole where it could cause injury and interfere with activities and exercises. Also, telescoping allowed the handle to be adjusted to continuous positions rather than discrete points. A soft grip on the handle provided cushioning and protection for the patient's hand.

Results from the patient trial showed that the goals of the project were met, and the handle will be a useful part of the patient's therapy. The new prototype was a safer, more effective handle than the original device.

PROJECTS

Xerostomia Sleep Aid

Project Team: Christopher Herskovits, Matthew Meyer, Carla Thompson, Maggie Vander Heiden

Student Consultants: (Milwaukee Institute of Art and Design) Bliss Lemmon, Mary Moddrell, Nicole VanLaanen

Faculty Advisor: Dr. Jay Goldberg

Sponsor: Col. Howard Roberts, D.D.S. U.S. Navy Institute for Dental and Biomedical Research

Dry mouth (xerostomia) is an abnormal reduction in saliva production and can be the result of diseases of the salivary glands, radiation therapy of the head and neck, adverse medication effects, and chemotherapy. Dry mouth can affect mouth comfort, oral health, chewing ability, swallowing, speaking, and overall quality of life. Currently patients can chew sugar-free gum, use saliva substitutes, sip water regularly, use medications, or change dietary habits to manage xerostomia symptoms. Unfortunately, these solutions only produce temporary relief, require patient interaction, and may have associated side effects.

The purpose of this project was to provide a passive form of oral hydration for xerostomia patients during sleep. The device was required to function passively, simulate normal salivary function, and provide overall oral comfort. The Xerostomia Sleep Aid contains three components: a water reservoir, an IV pump, and an interface. The use of an IV pump allows for water to be released at a physiological flow rate into the patient's mouth without requiring human interaction. Hydrating a xerostomia patient's mouth relieves the dryness, irritation, and discomfort associated with this condition.

Testing to verify the design indicated that the device provided the desired physiologic flow rate of 0.1ml/min, while improving a patient's oral comfort and quality of sleep. The device was able to be formed into the position that is most comfortable to the patient. Patient studies have not been conducted but will be required for commercialization of the device.

PROJECTS

Mechanical Nebulizer Design

Project Team: Helene Brown
Heather Cross
Kirsten Lecey
Katherine Nelson
Eric Nygaard

Faculty Advisor: Dr. Lars Olson

One of the greatest needs of a people in developing countries is adequate respiratory health care. Poor living conditions including pollution and inadequate ventilation lead to respiratory diseases, such as acute bronchospasms and acute lower respiratory tract infections. Unfortunately, resources are not readily available or affordable, so those suffering from these diseases go untreated. Modern-day respiratory devices need electricity and/or are very expensive.

One solution is to design a mechanical nebulizer that can be built from readily available materials. Through interviews and observations, information was gathered from healthcare providers and workers in rural and urban areas of Guatemala to determine customer needs. The mechanical nebulizer was designed to be compatible with a FDA-approved nebulizer. Instead of an electric compressor, a mechanical pump and pressure chamber delivers air flow to the nebulizer. Flow valves ensure proper pressure and airflow delivered to the nebulizer, while pressure relief valves prevent over pressurization of the chamber. The handheld nebulizer produces a mist from a water/medicine mixture with droplets that are small enough to be breathed deeply into the lungs. The final outcome was a nebulizer that effectively treats respiratory disease and is safe to use for all patients.

To use, the nebulizer must be pumped to a pressure of at least 15 psi. At that pressure a constant flow valve releases the air flow into the MircoMist Hudson nebulizer creating medicine droplets < 5 µm; a particle size recommended for effective drug delivery into the lungs. The healthcare worker continues to pump the nebulizer for the duration of the eight minute treatment. Another safety valve prevents over-pressurizing the system by bleeding off excess pressure at 50 psi.

The pressure chamber is made out of a five galloon utility bucket. Tensile tests were performed to evaluate the strength of the bucket's lid and sides. The results show that the utility bucket can safely withstand pressures of at least 1807 psi. The product received IRB approval for human testing and has been functionally tested. The product has been proven to be safe and satisfies customer needs with an inexpensive, effective, and durable design.

PROJECTS

System to Monitor a Sleeping Patient

Project Team: Meshari Albaqer
Charles Bluett
Ismail Okasha
Timothy Pierce
Tina Thomas

Faculty Advisor: Dr. Dean Jeutter

Sponsor: Dr. Toby Markowitz, Medtronic USA Inc.

Medtronic Inc. is interested in studying sleep-disordered breathing. Using basic principles of physics and sophisticated remote sensing, our system enables the heart rate and respiration signal to be monitored while a patient sleeps with minimal physical attachments. Currently, patients and investigators are frustrated with the inconvenience associated with sleep studies due to multiple electrodes, cables, and leads physically attached to the patient. The system developed is ideal for sleep laboratories and its patients.

To successfully accomplish the project goals, we developed a system which wirelessly monitors the patient's respiration signal and heart rate. The system is small in size, which improves patient comfort during overnight stays in a sleep lab. This is beneficial for sleep labs that need to collect several nights worth of data on their patients.

We designed a wireless patient monitor that attaches to the patient via an elastic strap system. The strap contains two electrodes (one located on either side of the chest under an arm) which measure the changing impedance across the chest, thereby obtaining the respiration signal. The heart rate signal is simultaneously taken directly from the two electrodes. Next a frequency division multiplexer combines both respiration and heart rate and these signals are transmitted at 432 MHz to a wireless receiver circuit located at the bedside. Finally, the received signals undergo analog to digital conversion and detection and are processed via a LabVIEW VI (program) that subsequently displays and logs the data. Two 3 V batteries allow at least eight hours of continuous function of the patient part of the system.

PROJECTS

AccuSupport – Patient Positioning System

Project Team: Nancy Anzelc
Christopher Corbeille
Robin Fitzgerald
Catharyn Petitt

Faculty Advisor: Dr. Jack Winters

Project Sponsor: Rehabilitation Engineering Research Center, Marquette University

Imaging technologies such as Magnetic Resonance Imaging (MRI), x-ray, and Computerized Tomography (CT) are extremely important in the diagnosis of diseases. Patients with conditions such as tremors, paralysis, obesity, and weakness cannot benefit from these technologies due to a lack of adequate positioning devices.

Current solutions to patient positioning interfere with imaging, and some are too time-intensive and not used by technologists. Current products also do not stabilize patients and therefore do not eliminate tremor which can cause blurry images. AccuSupport can be attached to MRI, x-ray, and CT beds. It targets a wide variety of patients that were previously unable to receive accurate and timely imaging.

The primary benefits to imaging facilities and their patients who choose to use AccuSupport are:

- proper positioning without image interference,
- patient support to alleviate tremor while assisting patient in maintaining a particular position,
- timely and accurate imaging, and
- a cost-effective solution to patient positioning problems.

Because this device provides a versatile solution to various types of positioning problems, patients who previously could not obtain diagnostic imaging will now be able to do so. Imaging will be quicker and more accurate for these patients.

The positioning devices created ensure that the patient will be secure and stabilized during diagnostic imaging procedures. Customer needs, such as ease of use and cleaning, were met. The shapes of the device ensure proper placement of the limb or body part.

Improved EECP Cuff System

Project Team: Frank Nola
Min Roh
Sarah Schneider
Becky Westcot

Faculty Advisor: Dr. Said Audi

Project Sponsor: Dr. Rodney Salo
Guidant Corporation

Enhanced external counterpulsation (EECP) is a relatively new noninvasive therapeutic approach for treating patients with heart failure. It is used most often as therapy for patients suffering from chronic stable angina, for whom revascularization procedures are shown to be ineffective or cannot be performed due to health risks, or when drug therapy is shown to be ineffective.

Through research and customer needs documentation, we found that the current systems employing EECP therapy use pressure cuffs that are not ideal. These cuffs are available in limited sizes, wrap around a patient's calves, thighs, and buttocks, and require the patient to remain immobile for up to two hours during each of 35 sessions. Existing inconveniences include limited cuff sizes, faulty temporary means of fastening the cuffs around the patients' legs, and minimal padding for boney areas such as shins and the pelvis. These factors coupled with a high cuff cost have created a need for an improved system.

The final proposed design included buckles for fastening, self-adhesive rubber for gripping, foam padding, and length adjustment of the upper thigh cuff via a slit which was secured with buckles. The proposed method of fastening was chosen because buckles offer the most flexibility in terms of diameter adjustment and are more durable, and hence more cost-effective, than existing fastening systems. For the gripping component, self-adhesive rubber was deemed the best solution. Such material would not interfere with the normal cuff operation. Furthermore, the self-adhesive nature of the rubber allows for its replacement at a relatively low cost when it becomes worn. The chosen padding component was foam due to its ability to maintain elasticity over a long period of time without reducing patient comfort.

Product validation tests were conducted at the Wisconsin Heart Hospital and data analysis was performed by Sensor Products LLC. The tests implemented Pressurex® Micro film which detected the pressure distribution in the areas of interest. It was shown that the improved cuff design decreased the direct pressure applied to the patient's boney areas and knees. The gripping feature decreased the patient's slippage on the EECP table by increasing the coefficient of friction of the fabric that composes the thigh cuffs. The decrease in pressure and slippage provided by the proposed design features satisfy the customer needs and project objectives, and are expected to increase patient comfort while maintaining the same quality of therapy.

PROJECTS

Neuromechanical Wrist/Hand Orthosis to Facilitate Grasp in Children with Cerebral Palsy

Project Team: Patricia Gilligan
Paul Hardy
Michael Hartung
Amanda Lauritzen
Carolyn Witkowski

Faculty Advisor: Dr. Michelle Johnson

Cerebral palsy (CP) is caused by permanent insult to the central nervous system during the first two years of development. It is the leading cause of postural and motor impairment in children. Spasticity in one or more of the limbs is often a result of cerebral palsy, and causes a limited range of motion and compromised grasping capabilities. Presently there are no widely marketed devices for upper extremity physical therapy in pediatric CP patients.

The objective of this project was to design an assistive device that can be used in therapy to provide the controlled motion required for grasping. Customer needs were identified after consulting with physicians and observing physical therapy sessions. The orthosis was designed to be lightweight, comfortable, easy to use, adjustable, effective, safe, and able to interface with the Activities of Daily Living Exercise Robot (ADLER) therapy training system.
The design features a control circuit with an electronic air valve that initiates the contraction of a McKibben muscle. The McKibben muscle is a pneumatically activated device designed to mimic actual muscle contraction upon inflation to approximately 50 psi. The McKibben muscle is connected and secured to a wrist splint, and attached to the fingers with Theraband tubing and non-elastic line which run along the tendon lines on the hand. When the control circuit is switched on, the air valve opens, allowing the McKibben muscle to fill and contract. This, in turn, exerts a force on the fingers to open the spastic hand.

Design verification tests confirmed that customer needs and overall project objectives were met.

PROJECTS

Game Glove

Project Team: Zachary Frank, Randy Will, Mirtha Lucas, Heesup Chung, Jon-Eric Morales, Shravan Devanhalli

Student Consultants: (Milwaukee Institute of Art and Design) Megan Gordon, Krystal Lynn Noll, Orson Trudrung

Faculty Advisor: Dr. Michelle Johnson

One of the major symptoms of cerebral palsy is impaired motor function. This often manifests as a reduced range of motion, sustained muscle contraction, and spasticity in the upper and lower limbs. Exercise and stretching routines have been clinically proven to maintain or even increase strength and range of motion. Children with cerebral palsy tend to not enjoy these routines which can lead to a lackluster performance and further reduction in strength and range of motion.

The Game Glove is a therapeutic and entertainment device. The general idea behind the Game Glove is to provide incentive for the children to do their exercises. The Game Glove focuses on upper extremity motions including forearm pronation and supination, wrist flexion and extension, elbow flexion and extension, shoulder rotation, and finger flexion and extension. The motions of the Game Glove are interfaced with the controls of a video game such that the "winning moves" correspond to the required exercise maneuvers.

The Game Glove incorporates a glove that covers just the hand and a small area beyond the wrist. The fingers of the glove are completely removed with the exception of the pointer finger and thumb which are removed after the first knuckle. The glove has a series of pores and mesh patches to maximize dexterity and prevent sweat buildup. The remainder of the Game Glove design is comprised of two sections of acrylic that are molded to the contours of the arm. The individual can simply drop their arm into the acrylic shell and strap their arm into place via elastic bands. A bearing connects the two sections at the elbow to maximize maneuverability of the elbow. A glove made out of Neoprene was selected because it provides the necessary flexibility without compromising the required strength. A combination of flex sensors and accelerometers incorporated throughout the apparatus are used to determine the various motions performed by the user. The signals from the flex sensors and accelerometers are then processed and interfaced with a computer to create a game.

Resistance mechanisms are used for wrist extension, forearm supination, and elbow extension via flat springs, acrylic rods, and torsional springs, respectively. All three of these resistance mechanisms are removable to ensure maximum usability as some users may not wish to train with resistance until their range of motion is improved. Removing these components also reduces the overall weight of the device which in turn allows the user to have a more enjoyable gaming and exercise experience.

PROJECTS

Ozone Disinfection of Personal Hemodialysis Machine

Project Team: Christopher Petree
Erin Promersberger
Sarah Rizk
Meghan Tobolski
David Trautschold

Faculty Advisor: Dr. Robert Scheidt

Project Sponsor: AKSYS, Ltd.

Disinfection is a necessary step for hemodialysis machines because the patient's blood comes into direct contact with the machine. Originally, chemicals were used to disinfect these machines, but they were hazardous to patients if not fully removed. Currently, hot water sterilization is the preferred method because it is safe, but it is time-consuming and stresses machine components.

The purpose of this project was to design an ozone disinfection system for use with a hemodialysis machine such as the AKSYS Personal Hemodialysis (PHD) System. Ozone disinfection has been used effectively in other applications, is safe for patients, and can be performed at 30°C, reducing time and stress to components. Research was conducted on the AKSYS PHD system, similar products, materials, methods of integration, and applicable patents and industry standards.

The design was based on three components: the ozone generator, the ozone sensor, and the type of flowpath. The final selection for these concepts was based on cost, reliability, safety, and overall size. Safety and reliability were considered most important and all materials selected for this project were compatible with ozone.

An electrochemical cell was used for ozone generation because cells are reliable, durable, and generate a relatively high concentration of ozone from de-ionized water. This method provides a compact and noise-free solution to ozone generation. Titanium oxide (TiO_2)/ lead oxide (PbO_2) and graphite (C_2) are optimal materials for the anode and cathode from a performance and economic perspective. We chose to use lead oxide for the anode, a proton exchange membrane, and graphite for the cathode.

Product validation tests confirmed that the desired concentration of 40 ppm was attained, no toxic or hazardous byproducts were produced, and the overall effectiveness of the hemodialysis machine was not reduced.

PROJECTS

PACEMAKER EDUCATION PROJECT

Project Team: Dana Fortier
Ann Lee
Jason Malmstadt
Colleen McDonald
Pradnya Vaiti

Faculty Advisor: Dr. Kristina Ropella

Sponsor: Dr. Toby Markowitz
Medtronic USA Inc.

Project Heart is a part of Medtronic's Pacemaker Education Project. The initial goal of this project was to develop instructional tools that bring real-world examples of biomedical engineering to the classroom by showing students the interface between biology and technology. Teaching tools, used in the Pacemaker Education project, have been developed over the past two years as a series of Senior Design projects. The current version of Project Heart is a teaching tool used to demonstrate the basic electrical operations of the heart and the interplay between the heart and an artificial pacemaker. Project Heart is a software-based educational tool that consists of an interactive Java applet that includes a visually appealing heart display, a conduction pathway, pacemaker simulator, and a timing diagram that displays the electrical activity of the heart.

The purpose of this project was to tailor the applet to a wide variety of users ranging from elementary school students to health care professionals, including physicians. Customer needs were identified by interviewing potential users of Project Heart. This helped us obtain changes that needed to be made to the existing version of the Java applet, namely the addition of adjustable Pace Rate and A-V Interval options as well as the correction of a Java loading error. Medtronic also requested that the team develop additional tutorials and quizzes to educate users about the basic functionality of the heart, including electrical conduction and blood flow through the heart. These tutorials and quizzes would compliment the Java applet and enhance the user's learning experience.

The tutorials and quizzes were designed to target a wide variety of users ranging from elementary school students to patients with pacemaker implants. This was accomplished by including a basic information section in the tutorial section targeted towards "beginner users" and in-depth information section to target those users who are interested in learning more about the heart. The quizzes were based off of the information in these tutorials. The quizzes contain questions targeted towards different users as it includes easy questions as well as questions that require advanced understanding of heart function.

Validation and verification tests were carried out on the Java applet. The code was tested extensively to make sure that all aspects were working and that the heart rates for different arrhythmias (tachycardia, bradycardia) were accurate. Testing was conducted for pacemaker firing during these events and proper electrical conduction through the heart during blocks in the conduction pathway. The tutorials and quizzes are flash animations, which capture the user's attention with the colorful graphics display. With these additional components, the project targets a wider range of users and covers a broader range of topics than it did in the past.

PROJECTS

Improved Design of a Baby Bottle with Temperature Indicator

Project Team: Meghan Coffey
Alison Kiser
Katie Laymon
Wai-Hong Leong
Akin Owolabi

Student Consultants: (Milwaukee Institute of Art and Design) Duy Bui
Paul Klitzkie
Mario Minneci

Faculty Advisor: Dr. Jay Goldberg

In the United States alone, nearly 24,000 children are treated in hospital emergency departments every year for scald injuries. Scalds are the number one cause of burn injury to children under age four. Infant children who receive scalding formula not only can injure their mouth at the site of initial contact, but can continue to burn delicate tissue as the hot liquid passes down their throat.

The objective of this project was to redesign the baby bottle so that it is safer and easier to use. The number one safety concern about bottle feeding babies is that the milk is sufficiently cooled before giving it to the baby, yet warm enough for easy digestion. Conventional methods of testing the temperature do not provide reliable temperature indication. The major goal of this project is to integrate a temperature indication safety feature into the baby bottle.

Through customer needs analysis, four key needs were identified: (1) a bottle temperature indication system, (2) ease of cleaning, (3) low cost, and (4) ability to withstand repeated microwave exposure; all of which have been considered and implemented throughout the design process.

A low cost temperature indication system that can be integrated into the bottle was selected. The temperature indicator consists of a temperature sensitive color changing ink (leucodye ink) that is printed onto a transparent sticker that is then applied to the exterior of the bottle. Leucodye color changes correspond to temperature fluctuations and are reversible. It takes about a 3ºC temperature change for the ink to change color, which exceeded the sensitivity specification for our design. These inks can be designed to change color over temperatures ranging from as low as -5ºC up to about 60ºC, and are available in a wide range of colors.

To further minimize the manufacturing costs, both volume measurements and the temperature indicator are printed on the sticker to be applied to the bottle. This will avoid the cost of printing directly onto the bottle, which is more expensive than printing onto a plastic sticker.

Other design details that meet customer needs include (1) adjustable flow through the nipple, (2) larger nipple, (3) microwavable plastic, and (4) leakage prevention through a twist-on seal.

The baby bottle design satisfies customer needs established at the beginning of the design process, and accurately incorporates the temperature indication system into a currently manufactured baby bottle.

PROJECT AWARD WINNERS

Marquette University Senior Design Competition

2006

Mechanical Nebulizer Design

Project Team: Helene Brown
Heather Cross
Kirsten Lecey
Katherine Nelson
Eric Nygaard

Faculty Advisor: Dr. Lars Olson

(First Place in the Department of Biomedical Engineering)

2005

Low Cost Nebulizer for Latin America

Faculty Advisor: Dr. Lars Olson
Project Team: Michael Jenders
Adam Hermsen
Amber Jaeger
Jason Schoen
Jennifer Wozniczka
Diane Yabut

(First Place in the Department of Biomedical Engineering, and Third Place in the College of Engineering)

2004

Low Cost, Low Maintenance Wheelchair

Faculty Advisor: Dr. Lars Olson
Project Team: Matthew DesVeaux
Timothy Getschman
Jamaal Jordan
Mary Reiter
Phu Tran

(First Place in the Department of Biomedical Engineering, and Second Place in the College of Engineering)

Respiratory Motion Trigger

Faculty Advisor: Dr. Said Audi
Industry Sponsor: Siemens Medical Solutions, Hoffmann Estates, IL
Project Team: Paul Bergl
Brett Broederdorf
Kevin Clemence
Erin Fallon
Matthew Olson

(Third Place in the College of Engineering)

PROJECT AWARD WINNERS

2003

Magnetic Simulator, Phase II

Faculty Advisor: Dr. Kristina Ropella
Industry Sponsor: GE Medical Systems, Waukesha, WI
Project Team: Yahya Bahlool
Lawrence Baylis
Amanda Gurgone
Jeremy Jones
Allen Joseph
Jennifer Linton

(First Place in the Department of Biomedical Engineering)

Pulmonary Function Tester for Industrial Workers in Latin America

Faculty Advisor: Dr. Brian Schmit
Project Team: Matthew Krauski
Kelly McPhee
Jennifer Moen
Thad Francis Ocampo
John Roeller

(Second Place in the College of Engineering)

Patient Monitoring System

Faculty Advisor: Dr. Dean Jeutter
Industry Sponsor: GE Medical Systems, Milwaukee, WI
Project Team: Sarah Alme
Shana Barry
Carson Ingo
Deborah Jaye
Kelly Miller

(Third Place in the College of Engineering)
2002

Design to Prevent Reuse of a Single Use Dental Handpiece

Faculty Advisor: Dr. Barbara Silver-Thorn
Industry Sponsor: Milestone Scientific, Inc., Deerfield, IL
Project Team: Craig Handwerker
Andrew Meyer
Shadad Al-Mutairi
Michael Kelly
Adam Podbelski
Paul Sherburne

(First Place in the College of Engineering)

Bicycle Ergometer for Hemiplegic Research

Faculty Advisor: Dr. Brian Schmit
Project Team: Shay Balsis
Stephen Brayden
Kelly Heglund
Nicole Miceli
Chad Volk

(First Place in the Department of Biomedical Engineering, and Third Place in the College of Engineering)

Rehabilitation Engineering Research Center on Accessible medical instrumentation National student design competition

2005-2006 First Place

AccuSupport – Patient Positioning System

Project Team: Nancy Anzelc
Christopher Corbeille
Robin Fitzgerald
Catharyn Petitt

Faculty Advisor: Dr. Jack Winters

Project Sponsor: Rehabilitation Engineering Research Center, Marquette University

2004-2005 Second Place

Accessible Syringe Dosing

Project Team: Eric Bertram
Nasseim Bleibel
John Massanisso
Matthew McCormick
Michael Tomkowiak

Project Advisor: Dr. Jack Winters

Project Sponsor: Rehabilitation Engineering Research Center, Marquette University

ABOUT THE DEPARTMENT

Biomedical Engineering is a discipline that advances knowledge in engineering, biology and medicine to improve human health.

Students in biomedical engineering participate in cross-disciplinary activities that integrate the engineering sciences with the biomedical sciences and clinical practice. Biomedical engineers develop strategies to effectively solve challenging problems in medicine and biology. Most graduates secure employment working in the medical device/ biotechnology industry. Some graduates use our "renaissance" training as a stepping stone for careers in fields such as medicine, law, healthcare management, and academics.

Distinctive Features

Marquette's Department of Biomedical Engineering is the largest at a Catholic university, larger than all others combined at both the undergraduate and graduate levels, and one of two such accredited programs. The program has strong linkages with the Medical College of Wisconsin (MCW), and manages a number of Centers including the Orthopaedic Rehabilitation and Engineering Center (OREC), the Falk Neurorehabilitation Engineering Research Center and the Rehabilitation Engineering Research Center on Accessible Medical Instrumentation.

The department has unique laboratory capabilities, including CT microfocal imaging, biotelemetry, implantable devices, telerehabilitation, and neurorehabilitation robots. Marquette's Biomedical Engineering department offers degrees at the bachelors, masters and doctorate levels.

Co-op and Internship Program

Marquette University has developed one of the leading co-op/internship programs among Biomedical Engineering Departments in the nation. Seventy percent of the undergraduate biomedical engineers gain co-op or internship experience before graduation. The Biomedical Engineering department has forged partnerships with many major medical device companies in the Midwest who rely on the excellent reputation established by our students as co-ops, interns and permanent employees. The Co-op and Internship Program offers students the opportunity to gain meaningful practical and professional experiences in the health care industry, in addition to their on-campus educational experiences.

Marquette University began its Engineering Co-op Program in 1919. Students usually enter the Co-op program at the end of their sophomore year and complete 3 to 4 terms of off-campus employment. The employment experience is alternated with semesters of on-campus study, extending graduation by only one year. Internships, in comparison, are summer only engineering experiences.

Les Aspin Center for Government (FDA Internships)

The Les Aspin Center for Government at Marquette University and the Department of Biomedical Engineering offer internships on biomedical research and regulatory issues. The Les Aspin/Biomedical Engineering Internships began in 1997 with Biomedical Engineering undergraduates participating in this innovative program in Washington, D.C. To date, over 85 biomedical engineers have completed Les Aspin Biomedical Internships. The internships are completed at the Food and Drug Administration, Office of Science and Technology in Rockville, MD.

Undergraduate Offerings

Choose from Three Specializations

The Biomedical Engineering Program at Marquette offers a strong undergraduate education. There are three tracks in the Biomedical Engineering curriculum:

- Bioelectronics
- Biomechanics
- Biocomputing

All undergraduate tracks in Biomedical Engineering are compatible with other programs offered by the College of Engineering. Each track contains the requisite humanities courses, and requires 134 credit hours for graduation. Students automatically earn a minor in biology, and can earn an optional minors in areas such as mathematics, electrical, mechanical, or computer engineering. In addition, all tracks retain most of the core courses of the initial year, which allows the student flexibility to transfer to other curricula if so desired.

The Biomedical Engineering curriculum is interdisciplinary in nature, incorporating courses in biology, chemistry, physics, mathematics, computer science and engineering. We provide a solid foundation in the mathematical, physical, and life sciences necessary for the engineer to function effectively in a medically or biologically oriented problem-solving environment. In addition, we prepare biomedical engineers to communicate with life scientists, physicians and other health care providers to describe and model complex biological systems, collect and analyze experimental or clinical data, understand the capabilities and limitations of sophisticated instrumentation, and understand the principles of design.

Five Year B.S./M.S. Program

This program allows qualified students to receive a Bachelor of Science Degree and a Master of Science Degree in Biomedical Engineering in just five years. Students with qualifying grade point averages apply to the program during their Junior year. They begin their thesis research the summer between their Junior and Senior years, and continue their research during the summer between their Senior and fifth years and throughout their fifth year, culminating in the preparation of a written thesis and defense.

Research

BIEN faculty and students at Marquette are engaged in a wide range of research activities, with many opportunties available for students at both the gradaute and undergradaute levels. areas of research, two areas of excellence stand out: Functional Imaging and Rehabilitative Bioengineering

Research-oriented Faculty

More than 50 faculty who are active in research have primary (11), secondary (10) or adjunct (30) appointments in our department, and are available for supervision or co-supervision of students.

Research Labs and Centers

The number of research laboratories and centers within our department has been growing dramatically, with the BIEN department now housing ten research laboratories and three centers.

Externally Funded Research

More than $2 million/year in externally funded research, the largest of any department on campus, flows through the Department of Biomedical Engineering (BIEN). Research and training grants are managed by BIEN core faculty and support research projects for roughly 35 graduate students. Additionally, other graduate students are funded through projects led by BIEN adjunct faculty whose primary appointment is at the Medical College of Wisconsin (MCW) or the Zablocki Veterans Affairs Medical Center.

Strong Partners

MCW is one of the two fasest growing medical centers in the U.S. in terms of externally funded research, and its Department of Physiology receives more NIH funds than any in the country. Marquette biomedical engineers helped create several physiology research labs at the Zablocki VAMC, and these continue to be a source for many student research projects.

FACULTY

Ropella, Kristina M., Ph.D.
Professor and Chair. Signal processing, cardiac and neuro-electrophysiology, functional magnetic resonance imaging

Audi, Said H., Ph.D.
Pulmonary mass transfer, tracer kinetics, pulmonary hemodynamics

Beardsley, Scott, Ph.D.
Neuroengineering, computational modeling, perceptual learning, functional imaging

Gilat-Schmidt, Tal, Ph.D.
Medical imaging, image processing and reconstruction, systems engineering

Goldberg, Jay R., Ph.D., P.E.
Director, Healthcare Technologies Management Program

Harris, Gerald F., Ph.D.
Quantitative assessment of neuromuscular function, human motion analysis, orthopedic biomechanics, data acquisition and control, real time analysis

Hendee, William R., Ph.D.
Senior Associate Dean & Vice President, Technology, Medical College of Wisconsin

Jeutter, Dean C., Ph.D., P.E.
Implantable transcutaneous radio frequency power transfer, biotelemetry, biomedical instrumentation, radio frequency circuit design and development

Olson, Lars E., Ph.D.
Optical instrumentation, tissue engineering, biological transport and circulation physiology, mathematical modeling of physiological systems, biosensors

Scheidt, Robert A., Ph.D.
Human motor control, systems identification, rehabilitation engineering, embedded systems, product development

Schmit, Brian D., Ph.D.
Spinal cord injury, human neurophysiology, neurorehabilitation, instrumentation, biomechanics

Silver-Thorn, M. Barbara, Ph.D.
Prosthetic limbs, soft tissue mechanics, rehabilitation engineering, orthopaedic and dental biomechanics

Winters, Jack M., Ph.D.
Neuromuscular control systems, movement and tissue biomechanics, rehabilitation engineering, telehealth, neurofuzzy computing

Research Faculty

Johnson, Michelle, Ph.D.
Rehabilitation Engineering, Rehabilitation Robotics

Associate Faculty

Brower, William, Ph.D.
Cryobiology

Cariapa, Vikram, Ph.D.
Rapid prototyping, process controls, neural networks, design of experiments

Clough, Anne V., Ph.D.
Mathemetical and computer modelling of biomedical systems, image processing and analysis, modeling of pulmonary hemodynamics, integral equations

Josse, Fabien J., Ph.D.
Biochemical sensors, acoustics, acousto-electronic devices

Krenz, Gary S., Ph.D.
Mathematical modeling of hemodynamic properties of the lung, microangiographic measurements, pulmonary vascular morphogenesis

Marklin, Richard W., Ph.D.
Ergonomics in office and industrial settings, human factors, cumulative trauma disorders

Nagurka, Mark L., Ph.D., P.E.
Biomechanics, vehicle dynamics and controls, and control system design

Riedel, Susan, M.S.
Mathematical and system level models of physiological systems, computer languages and compilers, operating systems, architecture

Seitz, Martin A., Ph.D., P.E.
Electronic materials and devices, biological materials

LETTER TO INDUSTRY SPONSORS

The mission of the Department of Civil and Environmental Engineering is to educate students in the Jesuit tradition of ethics based education who are competent in their technical field, appreciate the moral and ethical impact of their professional work and continue their professional development throughout their careers, to advance the state of technical and scientific knowledge through research and to provide service to the civic and professional communities.

A key component of the undergraduate program is our capstone design course. Capstone design courses offer engineering students a culminating design experience on an applied engineering project. With a longstanding history reinforced by support from the Accreditation Board for Engineering and Technology (ABET), these courses have become common in engineering departments across the United States. At Marquette, the Department of Civil and Environmental Engineering offers one of the best capstone design courses in the United States – CEEN 189 Civil Engineering Design.

In our senior design course, students generally work in groups of three or four and design a civil engineering project. These are real-life projects which have been designed or are in some phase of the design process by consulting engineers in and outside of the Milwaukee area. The design engineer of record on the project serves as the client and meets with the student group on several occasions during the semester. Students are required to consider environmental requirements and cost in the design process. In addition, each student group completes a written report, a set of drawings and makes an oral presentation to a general audience including the engineer of record and other engineers and/or faculty members and one peer group. During the course of the design process, the student groups are required to make presentations in their laboratory section on the status of their project. These sessions occur three times during the semester and the person making the presentation is rotated among members of the design team. This course also covers topics on technical writing, professionalism and ethics.

The success of our course is highly dependent on collaboration with practitioners who supply new design projects and our willing to work with our students. We have been blessed over the years with strong practitioner support, but we are always looking for additional projects and mentors.

Sincerely,

Clifford Crandall, PhD, PE
Associate Professor of Civil and Environmental Engineering
Senior Design Course Instructor

Michael S. Switzenbaum, PhD
Professor and Chair, Department of Civil and Environmental Engineering

INDUSTRY SPONSORS

2006

R.A. Smith and Associates, Inc.
CH2M Hill, Inc.
Graef, Anhalt, Schloemer and Associates, Inc.
Earth Tech
Cowhey, Gudmundson
Leder, Ltd.
Bloom Consultants, LLC
The Sigma Group
Thornton-Tomasetti Group
Marquette University
R.A. Smith and Associates, Inc.
THe Sigma Group
Wisconsin Department of Transportation
Kapur and Associates, Inc.
Waukesha County Department of Public Works
Pierce Engineers, Inc.
Ruekert and Mielke, Inc.

2005

CH2M Hill, Inc.
City of Milwaukee
Earth Tech
Tetra Tech MPS
R.A. Smith & Associates, Inc.
Triad Engineering, Inc.
Pierce Engineers, Inc.
Ruekert and Mielke, Inc.
Kapur and Associates, Inc.
Waukesha County DPW
Earth Tech, Inc.
Cowhey Gudmundson Leder, Ltd.
Patrick Engineering, Inc.
Wagner Komurka
Geotechnical Group, Inc.
Kantley & Templar Consulting
Marquette University

2004

Waukesha County Dept of Public Works
Ruekert & Mielke, Inc.
R.A. Smith and Associates
Pierce Engineers, Inc.
MSI General Corp.
Cowhey Gudmundson Leder, Ltd
Kapur & Associates, Inc.
CH2M Hill, Inc.
Milwaukee Transportation Partners
Marquette University

2003

MSI General Corporation
Kapur & Associates, Inc.
Applied Technologies, Inc.
Wisconsin Department of Transportation
Waukesha County Dept. of Transportation
Pierce Engineers, Inc.
Janesville Engineering Dept.
Cowhey Gudmundson Leder, Ltd
Patrick Engineering, Inc.
Earth Tech, Inc.
Ruekert & Mielke, Inc.
Marquette University
R.A. Smith & Associates
CH2M Hill, Inc.

PROJECTS

Golf Road Improvements

Project Team:	Elizabeth Norton
	Michael Adamo
	Morgan Grocholski
Mentors:	Pat Hawley, P.E., P.T.O.E.
	John Bruggeman, E.I.T.
Sponsor:	R.A. Smith
	and Associates, Inc.

Rio Suliya Bridge Department of Chimaltenango Guatemala

Project Team:	Jackie Martinez
	Marty McDonnell
	Matt Feller
	Matt Neenan
	Jessie Lindseth
Mentors:	Michael Paddock, P.E.
	Erika Powell, P.E.
	Kevin Hagen, P.E.
	Jaren Hiller
Sponsors:	CH2M Hill, Inc.
	Graef, Anhalt, Schloemer
	and Associates, Inc.
	Earth Tech

Ridgefield Meadows Residental Development Kane County, IL

Project Team:	Daniel Caceres
	Anne Kuehl
	Jerad Protaskey
Mentor :	Kevin J. Micheli, P.E.
Sponsor:	Cowhey, Gudmundson,
	Leder, Ltd.

1D CTH ES Bridge Design New Berlin, WI

Project Team:	Anthony Filleti
	Brian Zimmerman
	Eric Witt
Mentors:	Jeff M. Reedy, P.E.
	Darrell J. Berry, P.E.S.E.
Sponsor:	Bloom Consultants, LLC

Menomonee River Debris Problem/Public River Access

Project Team:	Jack Sbertoli
	Brian Black
	Linda Rawlins
	Brian Greskey
Mentors:	Kenneth E. Kaszubowski,
	P.E.
	Natalie Behne, P.E.
Sponsor:	The Sigma Group

Canal Street Bridge Project

Project Team:	Chris Kadera
	Bernida Egging
	Brad Blanchette
Mentors:	Steve Miller, P.E.
	Thad Kosmicki, P.E.
Sponsor:	CH2M Hill, Inc.

PROJECTS

77 West Wacker Commercial Office Building Design Chicago, IL

Project Team:	Mary Collins Dan Schug Kevin Ryan
Mentors:	John L. Peronto, M.S.M.E. Christopher Foley, P.E., Ph.D.
Sponsors:	Thornton-Tomasetti Group Marquette University

Water Distribution System Design Village of Sanic Ya, Guatemala

Project Team:	James Mullen Pat McNamara Ryan Carr
Mentors:	Paul Johnson, P.E. Michael Paddock, P.E. Daniel Zitomer, P.E., Ph.D.
Sponsors:	R.A. Smith and Associates, Inc. CH2M Hill, Inc. Marquette University

The Sigma Group Building LEED-EB Certification

Project Team:	Kevin Coughlin Walid Sukkar Mohd Badly
Mentors:	Natalie Behne, P.E. Kenneth E. Kaszubowski, P.E.
Sponsor:	The Sigma Group

USH 41/STH 60 Interchange Ramp Reconstruction

Project Team:	Daniel Morrison Anna Stawski Mike Krynski
Mentor:	Bao Tran
Sponsor:	Wisconsin Department of Transportation

CTH Q Redesign USH 41 to Pilgrim Road

Project Team:	Joseph Lenahan Anthony Fahres Chris McNally
Mentors:	Ricardo Santiago Aaron J. Bubb, P.E. Justin M. Arndt
Sponsor:	Kapur and Associates, Inc.

CTH V and Good Hope Road Intersection construction

Project Team:	Nick Young Tim Shebesta Brian Sattler
Mentor:	Gary Evans, P.E.
Sponsor:	Waukesha County Department of Public Works

PROJECTS

Automotive/RV Retailer Building Design

Project Team:	Jack Schuessler
	Evan Leicht
	Jim Blackwood
Mentors:	Tom Hildebrandt, P.E.
	Tony Raab, P.E.
Sponsor:	Pierce Engineers, Inc.

Lift Station/Force Main Upgrade Walworth County Metropolitan Sewerage District, Elkhorn, WI

Project Team:	Iain McPherson
	Brad Metler
	Vinnie Bergl
Mentor:	Peter L. Muth, P.E.
Sponsor:	Ruekert and Mielke, Inc.

PROJECT AWARD WINNERS

2006

Water Distribution System Design: Guatemala

Mentors: Paul Johnson, P.E., R.A. Smith and Associates, Inc. (Retired),
Michael Paddock, P.E., CH2M Hill, Inc.
Daniel Zitomer, P.E., Ph.D., Marquette University

Project Team: James Mullen
Pat McNamara
Ryan Carr

(First Place in the College of Engineering)

Ridgefield Meadows residential Development: Kane County Illinois

Mentor: Kevin J. Micheli, P.E., Cowhey, Gudmundson, Leder, Ltd.

Project Team;
Daniel Caceres
Anne Kuehl
Jerad Protaskey

(Second Place in the College)

2005

Marquette Interchange: ES Connector Ramp Over Menomonee River

Mentors: Steve Miller, P.E.
Thad Kosmicki, P.E, CH2M –Hill

Project Team: Lisa Abraham
Anne Marie Jensen
Katie Coletto

(First Place in the College of Engineering)

2004

Rio Grande Pachilip-Joyobaj Bridge, El Quiché, Guatemala

Mentors: Mike Paddock, P.E., Milwaukee Transportation Partners
Christopher Foley, Ph.D., P.E., Marquette University

Project Team: Robert Merkel
Carl Schneeman
Kendra Hansen
Brian Porter

(First Place in the College of Engineering)

ABOUT THE DEPARTMENT

Welcome to the Department of Civil and Environmental Engineering. While some people think of us as building bridges, roads, and buildings as well as safeguarding our environment, what we really do is educate future engineers to improve the quality of life for others.

It's all about service to others, or as the Jesuits call it -- *Cura Personalis*.

What do Civil Engineers do?

Civil engineers design and build the infrastructure of civilization -- highway systems, bridges, skyscrapers, airports, water treatment and distribution systems, and even cities themselves. Civil engineers designed the "Chunnel" linking England and France, as well as the world's tallest building. They are also involved in the design of high-speed train systems and systems used to restore areas affected by oil or chemical spills. Clearly, civil engineering is a very broad field that includes several exciting areas of specialization.

Undergradudate Program Civil and Environmental Engineering

The Department offers a Bachelor of Science (B.S.) degree in Civil Engineering. The program is fully accredited by the Engineering Accreditation Commission (EAC) of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, telephone: (410) 347-7700. Students have the choice of majoring in either civil engineering or environmental engineering. Regardless of the major chosen, the curriculum has a high degree of flexibility, enabling the student to specialize in a particular area or to pursue a broad-based mastery of the major field. The curricula for both majors are identical in the first two years of study, so that a student need not decide between the two majors until the junior year. By selecting several technical electives during the senior year, the student is able to specialize within the major and tailor his or her program to meet particular interests or needs.

Areas of Specialization

The diverse needs of people and society for many types of constructed facilities give a broad range to civil engineering. The breadth is well-suited to allow specialization in one of the major divisions of this branch of engineering. However, it is not necessary to make a commitment to only one area of concentration while in the undergraduate college. The curriculum at Marquette is arranged to permit students to prepare themselves generally in civil engineering by completing the core courses which provide all the necessary fundamentals and selecting electives to acquire the additional depth in one or more of the areas of specialization. All the electives offered by the department are open to students with the required prerequisites. Selection of appropriate courses requires careful planning between the student and a faculty advisor. Students may focus on any of the following areas of specialization:

Construction Engineering and Public Works Management

Construction and public works projects of all types require management as well as the traditional engineering skills. This program is arranged so that a student may vary the usual undergraduate program to obtain the knowledge needed to enter a graduate program in construction and public works management while still maintaining the essentials of a general civil engineering program.

Environmental Engineering

The environmental specialization is concerned with the control and improvement of natural surroundings using scientific and engineering principles. A student may elect to major in environmental engineering or simply choose to emphasize environmental engineering within the civil engineering major. In either case, the student with environmental interests may select from courses in water and wastewater treatment, water resources engineering, and air pollution engineering. Areas of application include

conceiving and designing systems for water supply, wastewater disposal, air pollution control, solid and hazardous waste managementl, and design of dams and hydroelectric power plants.

Structural and Geotechnical Engineering

The structural/geotechnical engineering specialization deals with the planning, analysis, design and construction of various types of structures such as buildings, bridges and foundations. Students will learn to analyze and design structures made of concrete, steel, and other materials. They will also learn to analyze and design the foundations that support these structures. Another possible focus area within structural engineering is "forensic engineering," i.e., the investigative analysis of structural failures in an attempt to identify the cause of failure and to prevent future failures.

Transportation Engineering and Planning

The civil engineering major who specializes in transportation engineering and planning learns to identify critical problems in transportation systems and in urban planning, and how to solve these problems. Elective courses that may be of interest to the student deal with traffic control, roadway design, pavement design, airport design, and bridge design. A course in urban planning is also offered for the student to explore the large-scale issues associated with the complexities of metropolitan areas. For those who elect to proceed to the graduate program, the undergraduate program will provide a valuable background to explore the transportation/planning area in greater depth and detail.

Co-op Program

The College of Engineering Cooperative Education (Co-op) Program is one of the first-ever and most renowned programs in the nation. Established in 1919, the Co-op Program integrates classroom work with practical industrial experience. Students alternate semesters of school with semesters of employment for at least three alternating work terms once they have completed their sophomore year.

The work is related to some phase of the field of study in which she or he is engaged and is often diversified to afford a wide range of experience. The objective is balanced training, combining the science of engineering with communications and team-building skills during the early years of professional development.

Student participants have said the program helps to clarify career goals, applies classroom theory to real life situations, and provides a source of both real-time and future income. This year the salary for students entering their first Co-op work term ranges from $2,400/month to $3,400/month. Upon graduation, many of the corporations retaining Co-op students hire them full-time for their work experience.

Service Learning

Service Learning is an academic program that enables students to perform meaningful community service related to their courses. Combining community service with classroom theory enriches students' learning, personal growth and sense of civic responsibility. At the same time, this work builds community and enhances the efforts of the collaborating agencies. Students in the Department of Civil and Environmental Engineering are able to participate in a number of service learning initiative in various programs throughout the university. One example is the HEILA program.

HEILA: Marquette's International Service Learning Experience

The Health, Environment, and Infrastructure in Latin America (HEILA) initiative is an exciting opportunity for students to perform 2-week service learning projects in countries such as El Salvador, Guatemala, and Honduras while learning about the region's history, culture, and politics. Students also explore their profession and its relationship to civil society in the US and abroad.

For more information

Please contact us:
Professor Michael S. Switzenbaum
Professor and Chair
Ph.: (414) 288-7030
e-mail: michael.switzenbaum@marquette.edu
Please visit our web site:

http://www.marquette.edu/engineering/pages/AllYouNeed/civil.html

For Admission Information:

Office of Undergraduate Admissions
c/o Marquette University
PO Box 1881
Milwaukee, WI 54201-1881
Ph: (800) 222-6544 or (414) 288-7302
Web site: http://www.marquette.edu/student/

FACULTY

Clifford J. Crandall, Associate Professor (Ph.D., Illinois Institute of Technology), water and wastewater treatment, wastewater collection systems, water distribution systems, hydraulics, hydrology.

James A. Crovetti, Associate Professor (Ph.D., University of Illinois), geotechnical engineering, pavement design, evaluation, rehabilitation and management.

Alexander Drakopoulos, Associate Professor (Ph. D. Michigan State University), transportation and traffic engineering, transportation planning, traffic safety, traffic control devices.

Christopher M. Foley, Associate Professor (Ph.D., Marquette University), analysis and design of structures, inelastic behavior of partially restrained steel frames using parallel processing and supercomputers.

Stephen M. Heinrich, Professor, (Ph.D., University of Illinois), anisotropic elasticity, solder joint formation in surface mount technology, boundary element analysis, fluid-solid interaction.

Saeed Karshenas, Professor, (Ph.D., University of Illinois), construction engineering, construction safety, computer applications in construction.

Charles S. Melching, Associate Professor, (Ph. D., University of Illinois), surface-water hydrology, hydraulics, watershed management, water-quality modeling, reliability and uncertainty analysis for water and environmental problems.

Jonathan Meus, Adjunct Assistant Professor, (M.S. Marquette University), structural mechanics, structural analysis.

Michael S. Switzenbaum, Professor and Department Chair, (Ph.D. Cornell University), environmental engineering microbiology and biological treatment processes, wastewater engineering and solid waste management.

Sriramulu Vinnakota, Professor, (DSc., Swiss Federal Institute of Technology), analysis and design of steel structures, in-elastic stability, composite structures.

Baolin Wan, Assistant Professor, (Ph.D., University of South Carolina), Repair and retrofit structures, FRP materials, high performance concrete prestressed concrete, numerical and experimental modeling.

Thomas H. Wenzel, Associate Professor, (Ph. D. Northwestern University), concrete analysis and design, material properties of concrete, computer analysis.

Daniel H. Zitomer, Associate Professor, (Ph. D., Vanderbilt University), biological treatment of wastewater, contaminated soil, groundwater, and hazardous waste.

LETTER TO INDUSTRY SPONSORS

The following pages describe the Electrical and Computer Engineering Senior Design Projects completed during the 2005-2006 academic year at Marquette University.

The Department of Electrical and Computer Engineering at Marquette University is dedicated to preparing students for their professional and personal lives after graduation. Undergraduates specialize in Electrical and Electronic Engineering, Electrical and Computer Engineering, or Computer Engineering. In addition to courses in engineering, mathematics, and the life sciences, students complete a year long project-based capstone design course. This course is a culmination of their undergraduate education and provides them with the opportunity to apply and develop their undergraduate education and provides them with the opportunity to apply and develop their design, analytical, project management, interpersonal, and communication skills through a team-based project experience. Students develop their teamwork skills, learn about the product development process used in industry, and are made aware of the restrictions that economic and time constraints place upon their designs.

As you read through this report and learn the benefits of industry sponsorship of senior design projects, please consider becoming a sponsor. The experience our students gain by participating in our Senior Capstone Design Course sequence and our Cooperative Education Program are highly significant in preparing them for productive careers in industry. We value strong ties to industry and are interested in working with additional companies to help us prepare our students for careers in engineering.

Martin Seitz, Ph.D.
Professor of Electrical Engineering
Senior Design Course Instructor

Edwin Yaz, Ph.D.
Professor and Chair, Department of Electrical and Computer Engineering
Marquette University

INDUSTRY SPONSORS

2006-2007

Dedicated Computing, Milwaukee, WI
GE Medical Systems, Waukesha, WI
Harley Davidson, Milwaukee, WI
MU Gasday, Milwaukee, WI
Techteriors, Milwaukee, WI

2005-2006

Poznan Technical University, Poland
Rockwell Automation, Mequon, WI
Rho Sigma Associates, Whitefish Bay, WI

2004-2005

A. O. Smith Corporation, Milwaukee, WI
Atomic Park, Inc., Milwaukee, WI
Bruno Independent Living, Oconomowac, WI
Discovery World Museum, Milwaukee, WI
Gasday, Milwaukee, WI
Waukesha Electric Systems, Waukesha, WI

2003-2004

Advocate Health Care, Chicago, IL
Aurora Health Care, Milwaukee, WI
Central City Realty, Chicago, IL
Disney Animal Kingdom, Orlando, FL
Gasday, Milwaukee, WI
Rho Sigma Associates, Whitefish Bay, WI
Waukesha Electric Systems, Waukesha, WI

2002-2003

Kimberly Clark, Neenah, Wi
Gasday, Milwaukee, WI
Plexus Technology Group, Neenah, WI
Rockwell Automation, Mequon, WI
Waukesha Electric Systems, Waukesha, WI

2001-2002

Briggs & Straton, Milwaukee, WI
Innovatec Communications, Milwaukee, WI
Gasday, Milwaukee, WI
Engage Network Inc., Milwaukee, WI
EATON Corp., Milwaukee, WI
GE Medical Systems, Waukesha, WI

PROJECTS

ASIC Design for a Gas Flow Meter

Project Team: Eric Bomkamp
Kevin Kerber
Mike Sherry
Faculty Advisor: Dr. Shrinivas Joshi

Natural gas is a leading source of energy throughout the states. It heats our homes, our water, and occasionally powers our lights. Because natural gas is such a widely used product it is imperative that utility companies have an accurate tool to measure the quantities consumed. Currently, most homes and businesses have a gas meter on the property. This meter is a bulky, unsightly, mechanical device that builders and owners often try to hide from visitors. In addition, current meters have inaccuracies that can cost the company, which in turn raises the price of natural gas for consumers.

The purpose of the project was to design, build, and test an ASIC (Application Specific Integrated Circuit) that received, calculated, and digitally displayed the flow rate of natural gas through a system. The ASIC received the signal from an existing Surface Acoustic Wave (SAW) sensor. The signal's frequency was then converted to a flow rate and displayed on a 3.5 digit display.

This method of measuring the flow rate of natural gas provides an accurate and economical alternative to the current meters. We created a device that met everyone's needs, the utility company got a more accurate gas reading, and the property owners did not have to worry about hiding the unsightly mechanical meter of the past.

Team E-6 Lap-O-Meter

Project Team: Kevin Bailey
Ryan Bertram
Patrick Hittman
Miguel Martorell
Michelle Walcher

Faculty Advisors: Dr. Susan Schneider
Dr. Roger Schneider

There is a need for swimmers to accurately keep track of the number of laps completed while swimming. With most pools ranging between 25-50 meters long, keeping track of the number of laps can be a problem, especially when swimming long distances. Having a counter to accurately count and keep track of laps completed and elapsed time will allow the swimmer to concentrate on other factors such as form, speed, and breathing.

The purpose of this project was to design a low cost lap counter for swimmers while they work out. Customer interviews revealed that the two most important factors were to have an easy to see display and the ability to keep track of elapse time. An RFID sensor was chosen because of its ability to transmit signals through water. A water-resistant container, that could be placed at the end of the pool, housed the RFID sensor's transmitter and digital circuitry. This unit also contained a power switch, and start, stop, and reset buttons. The swimmer wears an identification tag that will alert the sensor when the swimmer is in a specified range. Once the swimmer exits the range, the lap counter is incremented.

PROJECTS

Pitch-Adjusting Speech Prosthetic Device

Project Team: Christopher Butcher
Albert Cutler
Matthew Gnadt
Roumiana Valtcheva
Marc Yeoh
Faculty Advisor: Dr. Mark Polczynski
Sponsors: Discovery Learning Center
National Collegiate Innovators and Inventors Alliance

A laryngectomy is an operation that involves removing the larynx, cutting off all airflow from the mouth into the lungs. An incision in the neck creates the stoma, a hole that provides a new air pathway, allowing the patient to breathe. However, laryngectomy patients can no longer speak normally and thus require a speech prosthetic device in order to communicate. Current speech prosthetics are mechanical in sound, and/or require costly surgical procedures. Customer needs have illustrated a desire for a device that is low cost, low maintenance, easy to use, and capable of producing a natural sounding voice.

The goal of this project was to utilize sensor technology in order to improve upon an existing device, an electrolarynx , that is available to laryngectomy patients. The electrolarynx is a surgery free prosthetic that the user holds to the cervical region of the neck. The device creates a vibration that acts as the voice box of an individual who has had their larynx removed. Current issues with the electrolarynx are namely mechanical tones and constant manual manipulation in order to vocalize. It is possible to adjust pitch with these devices by using a knob located on the side of the electrolarynx. However, this method is very tedious, and inefficient.

An aiflow sensor that was placed over that stoma was used to solve the problems currently associated with the use of an electrolarynx. As the patient breathes, the sensor detects the amount of exhalation through the stoma. The sensor then outputs a differential floating analog signal. This signal is manipulated through various circuit components, and eventually used to vary the power supply provided to the electrolarynx. As the amount of voltage varies, so does the pitch. Since pitch changes are now associated with airflow changes, the pitch is adjusted almost instantaneously. This low-cost design enables the user to create voice inflections, and moves closer toward providing a hands-free solution.

PROJECTS

Smart Locator

Project Team: Steven Sass
Kunal Pate
Niraj Swami
Faculty Advisor: Dr. Sheikh Iqbal Ahamed
Sponsor: UbiCOMP Lab, M.S.C.S. Department, Marquette University.

As the applications for GPS become more apparent, so do its limitations. These limitations include navigation in an urban environment; an environment similar to Marquette University. Thus, the problem faced was the limited reliability of GPS navigation in an urban setting. To solve this problem the team explored other forms of location determination.

The solution developed, SmartLocator, takes an image file and allows organizations, universities and other custom surroundings to configure a location-based mobile service for PDA/Phone users using our PC/Mac tool, the SmartZone Assistant. Once all places are configured for location-based support, a simple click of the button generates a deployable file that can be transferred to a mobile device, which has SmartLocator installed on it. The target device that was implemented for the prototype consisted of devices running Windows Mobile 2005 OS. The implementation can be extended to Java and Symbian technologies as well. The programming language used was .NET Compact Framework and C#, along with C libraries for OS interaction.

The soul of our solution consists of a unique zoning algorithm that works efficiently at real-time to locate the user's device accurately. It consists of a high-end user experience with audio, video and graphic intensive user interaction. This concept can be adapted to museums, theme parks, urban campuses etc.

PROJECTS

Artificial Life for Computer Animation

Project Team: Joe Harman
Jen Leonard
Kari Schmidt

Faculty Advisor: Dr. James Factor

Nowadays once a video game is beaten, the gamer has no use for it and they are off to the store to buy a new game, but what if they didn't have to? By implementing artificial intelligence into the characters of the game, as the gamer got more advanced and so would their opponents in the game. The gamer would no longer be able to predict his opponent's reaction because every time they played it would be different. This is the advantage of a branch of artificial intelligence called artificial life.

The purpose of the project was to create a fish using C++ that moved realistically and incorporated artificial intelligence to simulate natural behavior and learning.

The design for the project was based off of three different coding tasks. The first task was coding the wire frame fish which consisted of twenty-three nodes and ninety-one lines. The lines are used to pull the nodes, which simulates realistic muscle movement. The next task was to add in a way for the fish to sense objects in the environment. This was done by using an equation to give the fish a vision range of 300 degrees. The behavior section of the code includes the different artificial intelligence routines. Once a fish senses something in its line of vision, it will tap into the behavior section to identify what that particular object is. The routines that were included in the project were the hunger and predator routines. When an object was spotted, the artificial intelligence routine would run through several lines of code to identify the object and then store this into a matrix for future use.

DeviceNet to USB Communications Adapter

Project Team: Carrie Lee
Chad Pahnke
Brandon Renner
Karen Swiat
Faculty Advisor: **Dr.** Susan Riedel
Sponsor: Rockwell Automation
Milwaukee, WI

DeviceNet is one of the world's leading device-level networks for industrial automation. With USB (Universal Serial Bus) technologies becoming more popular, most new products are designed to implement it. A new low-cost Human-Machine Interface product in development required a way to communicate between DeviceNet and USB. A feasible solution to this is the design and implementation of an inexpensive communications card.

The purpose of this project was to design a DeviceNet to USB adapter card for consumers to connect their product to a DeviceNet network. The card actively translates commands and data between DeviceNet objects and a USB connection. Data packets are stored within the card, where they can be accessed by either port.

The processor of the card is an Atmel ARM7-based microcontroller. The chip has both a USB device port for communicating with the HMI and a CAN controller for communicating on the DeviceNet network. The microcontroller is powered by the HMI through the USB power bus, but is still capable of knowing when the DeviceNet power is off. This design acted as a proof-of-concept for later development as well as a low-cost solution for DeviceNet communication.

PROJECTS

Silent Rhythm Teacher

Project Team: Bradley Fessenbecker
Kathryn Holterman
Christopher Jablonowski
Matthew Marquette
Emily Stockhausen
Brandon Zingsheim

Faculty Advisor: Dr. George Corliss

Sponsors: Amulet Technologies
Texas Instruments
Discovery Learning Center

The benefits of musical instruction to the development of academic, artistic, and social skills in children have been widely documented. The deaf or hearing impaired are not able to experience music in the same way that most people do, and hence cannot be taught in a traditional way. This impairment has far-reaching consequences that the hearing cannot fully appreciate. Concepts of timing and synchronization are extremely difficult to grasp. This poses many limitations on the extent to which an affected person can become involved in learning to play and appreciate music.

This project involved the creation of a tabletop silent rhythm teacher, which provides visual feedback to a student while he or she plays the drums according to pre-defined rhythms. These rhythms are displayed on a programmable LCD touch screen, which also allows the user to create and save custom rhythms. While the student plays, a microphone detects the sound wave produced by the impact of the drum. The signal is then amplified and filtered to reduce noise. A microcontroller processes the signal and displays an indication of the impact in real-time on the LCD display window. The indicator is a checkmark if the student played the note within a specific timeframe of the expected beat, and an "X" if the impact was outside this range.

PROJECTS

Women In Engineering Program (WIEP)

Project Team: Josh C. Gozdzialski
Carly J. Hanson
Daniel C. Merkel
Katie S. Rasmussen
Faculty Advisor: Dr. Jon Jensen

Marquette University's College of Engineering has experienced a disproportionate growth of women enrolling in engineering curricula compared to other engineering schools and is currently witnessing a decline in women enrollment. Specifically, the current percent of female enrollment is 17% where as only 5 years ago it was 24.9%. This is over a 7% decline. If Marquette University's College of Engineering is to stay competitive, the need to establish and foster the growth of an increased number of women enrolling in engineering should be addressed.

The project objective was to research and develop a detailed business plan regarding the implementation of a "Women in Engineering Program" in the College of Engineering at Marquette that focused on the issues of recruitment and retention. The team developed a business action plan for the College of Engineering. To help facilitate the continued growth and sustainability of this program, this team began collaboration with Milwaukee Public Schools through the Wisconsin Girls Collaborative Project. In addition, a "Myth Buster" publication was developed that specifically targeted the recruiting of women.

PROJECT AWARD WINNERS

2006

Silent Electric Metronome

Faculty Advisor: Dr. George Corliss
Project Team: Bradley Fessenbecker
Kathryn Holterman
Chris Jablonowski
Matthew Marquette
Emily Stockhausen
Brandon Zingsheim

2005

Hitch-Mounted Accessory Durability Tests

Faculty Advisor; Dr. Robert Weber
Industry Sponsor: Bruno Independent Living Aids
Oconomowoc, WI
Project Team: Sarah Drilling
Jason Gaare
Chris Potokar
Steve Richmond
Megan Schaefer
Michael Schultes
Steve Wiemer
John Zeirke

2004

Sound Safari

Faculty Advisor: Dr. Michael Johnson
Industry Sponsor: Disney Animal Kingdom
Orlando, FL
Project Team: Andrew Basta
Mark Dreger
Scott Guzlecki
Mark Scheuber
Kathy Sokalski

2003

Wind and Temperature Sensitive Fan Control

Faculty Advisor: Dr. Martin Seitz
Industry Sponsor: Waukesha Electric Systems
Waukesha, WI
Project Team: Jason Becker
Andrew Black
Joseph Knoernschild
Andrew Phillips
Phillip Radlowski

2002

Cluster Computing Environment

Faculty Advisor: Dr. Richard Povinelli
Project Team: David Graat
Chris Juhasz
Omar Kasmi
Jack Szeto
Brian Sobek
Kevin Indrebo

ABOUT THE DEPARTMENT

Electrical Engineering involves the generation, transmission, distribution of electricity and the different uses that we make of it. Electrical engineers design electronic systems such as computers, televisions, DVD players and avionic packages for commercial and military vehicles. Electrical engineers are responsible for the control of power plants, not to mention control of cable and telephone networks. Electrical engineers design and maintain our power transmission and distribution systems, mass transportation systems, and energy utilization systems.

Computer Engineering involves the design, manufacturing, and programming of computers to solve diverse problems for society and industry. Computer engineers design software systems to control many of the systems that electrical engineering design. Computers and microprocessors are found in most modern consumer appliances – televisions, DVD players, microwave ovens, stereo systems and even toothbrushes contain computer microprocessors. Automobiles contain computer systems and associated software to control the engine, the comfort systems, the suspension systems and even the braking system. Computers are everywhere and computer engineers are the people who design the hardware and software that make them run.

Both Electrical and Computer engineers are involved in medicine, law, and politics. Electrical and Computer engineering aspects exist in virtually everything we touch and electrical and computer engineers conceive, design and maintain these devices and systems.

And, Electrical and Computer engineers dream for the future and make it happen.

The Department of Electrical and Computer Engineering embraces the missions of Marquette University and its College of Engineering. In this context, it is the mission of the Department to offer its students high-quality, up-to-date, nationally recognized programs in Electrical and Computer Engineering that prepare them for successful careers marked by a commitment to lifelong learning and a deep concern for the impact of their work on others, to advance the frontiers of technical and scientific knowledge through research, and to serve its professional and civic communities.
To give strength and vision to our Mission, the Computer Engineering Program has adopted a set of Program Educational Objectives that detail what our graduates will be able to accomplish as a result of their experiences at Marquette University.

Educational Objectives

Values-Based Education: Computer Engineering graduates will be able to make professional and personal decisions which conform to appropriate moral and ethical standards.
Fundamental Skills and Design: Computer Engineering graduates will be able to formulate and analyze computer engineering problems by applying mathematics, basic science, and engineering knowledge as well as appropriate computational techniques in order to design viable solutions.
Practical Training: Computer Engineering graduates will be able to select and learn to use appropriate software engineering and hardware engineering tools.
Communication Skills: Computer Engineering graduates will demonstrate effective oral and written communication skills in professional settings.
Team Skills: Computer Engineering graduates will be able to work effectively as members or leaders of an engineering design team.
Life-Long Learning: Computer Engineering graduates will practice life-long learning.

COMPUTER ENGINEERING

The Computer Engineering Program is fully accredited by ABET and leads to the degree of Bachelor of Science in Computer Engineering. The Computer Engineering Program requires a total of 133 credits and includes a well-rounded selection of liberal arts courses in addition to the technical program. Our program also provides students the flexibility to transfer into or out of the Computer Engineering Program with a minimal time or course loss in the first two years as well as the option to participate in the co-operative education program.

ELECTRICAL ENGINEERING

The Electrical Engineering Program is fully accredited by ABET. Two majors exist within the undergraduate Electrical Engineering Program:

Electrical and Electronic Engineering
Electrical and Computer Engineering

Both programs lead to the degree of Bachelor of Science in Electrical Engineering (BSEE). Both Electrical Engineering majors require a total of 133 credits and both include a well-rounded selection of liberal arts courses in addition to the technical program. These programs provide students the flexibility to transfer into or out of the Electrical Engineering Program with a minimal time or course loss in the first two years as well as the option to participate in the co-operative education program.

ELECTIVES

When choosing electives, the student and faculty advisor talk about the student's individual interests and objectives and together specify a selection of upper division courses that will best meet their needs. By careful choice of an elective program, students can obtain in-depth knowledge in one or possibly two areas of concentration in addition to the broad fundamental background developed in the required courses in either major. When choosing electives, the student and faculty advisor talk about the student's individual interests and objectives and together specify a selection of upper division courses that will best meet their needs.

FACULTY

Ronald H. Brown, Ph.D.
Director of Center for Intelligent Systems Systems/ Controls, Intelligent Controls, Adaptive Systems, Neural Networks in Identification and Controls

George F. Corliss, Ph.D.
Validated Scientific Computation, Interval Arithmetic, Automatic Differentiation, Taylor Series, Numerical Solution of Ordinary Differential Equations, Mathematical Modeling, Industrial/Applied Mathematics

Nabeel A.O. Demerdash, Ph.D.
Electrical Machines & Drives, Computational Electromagnetics/Finite Elements, Power Electronics, Power Systems

Xin Feng, Ph.D.
Optimization Theory & Applications, Artificial Neural Networks, Fuzzy Systems, Time Series Analysis and System Identification, Heuristic Algorithms

Mostofa Howlader, Ph.D.
Communication Theory, Wireless Communications, Cognitive Radio, Propagation, Communication Simulation, Cross-layer Optimization, Electro-Optics, Fiber Optics, Polarization, Telemedicine

Francis (Frank) X. Jacoby, M.S., P.E.
Director of Undergraduate Electrical Engineering Labs. Curriculum development and implementation

Michael T. Johnson, Ph.D., P.E.
Signal Processing, Speech Recognition, Microphone Arrays, Bioacoustics and Animal Communication, Natural Language Understanding, Machine Learning

Shrinivas G. Joshi, Ph.D.
Acoustic Wave Devices, Solid State Sensors

Fabien J. Josse, Ph.D.
Director of Graduate Studies and Director of Microsensors Research Laboratory. Solid State and Acoustic Wave Device Sensors (Chemical Sensors, Biochemical Sensors), Micro-electro-mechanical Systems (MEMs), Devices (Microcantilevers) and Sensors, Optical Waveguide-based Sensors. Smart Sensors Systems. Characterization of Viscoelastic Properties of Polymers.

Richard J. Povinelli, Ph.D., P.E.
Director of Undergraduate Computer Engineering Labs. Time Series Data Mining, Dynamical Systems, Chaos, Nonlinear Signal Processing, Machine Learning, Evolutionary Algorithms, Financial Engineering

James E. Richie, Ph.D.
Electromagnetic Scattering, Antennas and Wave Propagation, Indoor Propagation, Numerical Techniques

Susan A. Riedel, S.M., P.E.
Computer Engineering Curriculum Coordinator. Mathematical models of physiological systems that control posture and gait, assessment of abnormal posture and gait in children, design and implementation of undergraduate teaching materials.

Susan C. Schneider, Ph.D.
Associate Chair and Electrical Engineering Curriculum Coordinator. Acoustic Wave Sensors, Smart Sensor Systems, Educational Methods and Assessment

Martin A. Seitz, Ph.D., P.E.
Minard Professor and Director of Materials Science and Technology Center. Electronic Materials & Devices

FACULTY

Edwin E. Yaz, Ph.D., P.E.
Chair. Modeling, stability/performance analysis, control and estimation of stochastic systems, nonlinear and chaotic dynamics, applications to sensor systems, communication, and electric machine diagnostics.

Research Faculty

Abd A. Arkadan, Ph.D., P.E.
Computer-Aided Modeling and Design Optimization of Electromagnetic and Electromechanical Devices as well as Electric Machines and Motor Drive Systems using Power Electronics Theory, Computational Electromagnetics and Artificial Intelligence.

Richard Hirthe, Ph.D.
Electrical Properties of Materials

Charles Koehler, Ph.D.
Materials Science, Solid Oxide Fuel Cells, Impedance Spectroscopy, Chemometrics, Fluid Condition Monitoring, Self-Assembled Monolayers, Biosensors

Affiliated Faculty

Stephen M. Heinrich, Ph.D.
Solid mechanics, theory of elasticity, analytical methods.

Stanley V. Jaskolski, Ph.D.
Engineering Education

Dean C. Jeutter, Ph.D., P.E.
Implantable transcutaneous radio-frequency power transfer, biotelemetry, biomedical instrumentation, radio frequency circuit design and development.

Donald R. Matthys, S.J., Ph.D.

Robert A. Scheidt, Ph.D.
Human motor control, systems identification, rehabilitation engineering, embedded systems, product development

Adjunct Faculty

Panos Datskos, Ph.D.
Adjunct Professor
Physical and Chemical MEMs Sensor Technology, Micro- & Nano-Cantilevers

Wesley Davis, Ph.D.
Adjunct Associate Professor

Steven Deibele, Ph.D., P.E.
Adjunct Assistant Professor

Richard W. Kelnhofer, Ph.D., P.E.
Adjunct Assistant Professor
Analog and digital communication systems, information theory, and system modeling.

J. Christopher Perez, M.S., M.B.A.
Digital electronics, microcontrollers.

Jacques Pistré
Adjunct Professor
Microsensors, Solid State Device Sensors

Tom Quinn, M.S.
Software engineering, software systems and design.

Peter B. Schmidt, Ph.D.
Adjunct Associate Professor

LETTER TO INDUSTRY SPONSORS

The following pages describe the Mechanical Engineering Design Projects completed during the 2005-2006 academic year at Marquette University.

The faculty of the Mechanical Engineering Department are committed to the ongoing development of a curriculum that enables our graduates to meet the ever-changing needs of industry in a global marketplace. In this communication, we hope to provide you with a sense of the important role that our capstone senior design course plays in preparing our students for the rigors that are now commonplace in a global economy. This 2-semester course places the students in an competitive environment where complex decisions must be made within the context of a comprehensive engineering project. Students learn how to professionally interact with team members that are from different cultural and ethnic backgrounds. Moreover, their involvement in this project exposes them to a wide range of activities that are vital to product development processes, including product ideation, the analysis of consumer needs and socio-economic constraints, and the development of skills that enable one to schedule and provide deliverables in a timely manner. At the same time, the faculty, in conjunction with an industrial advisory committee, critically evaluates the impact that this capstone design course has on the students as they enter industry. Consequently, both the structure and composition of this course is dynamic, and changes are regularly made that can positively affect the preparedness of students as they enter the workplace.

Upon completing your review of the enclosed materials, we hope that you will become an active participant in this important capstone design experience. Your support of projects plays an essential role in the learning experience of students as they undergo a transition from being engineers-in-training, to becoming engineers-in-practice. Indeed, your participation has become an important component of our academic program, and we are confident that this liaison will empower our graduate engineers to become productive members of the industry-engineering community.

Vikram Cariapa, Ph.D., P.E.
Associate Professor of Mechanical Engineering
Senior Design Course Instructor

Kyle Kim, Ph.D.
Professor and Chair, Department of Mechanical Engineering
Marquette University

PROJECT SPONSORS

Mr. Tony Patrick
from Direct Supply,
Milwaukee, Wisconsin

Marquette University
with a grant from
Kimberly-Clark
Corporation

ASME, local businesses

Mr. Scott Taylor
from Connor Sports
Flooring, Salt Lake
City, Utah.

SAE, local businesses

PROJECTS

Windmill Design for Developing Countries

Project Team: David Okoniewski
Casey Robinson
Dan Wagner
Dan Welch
Mohamad Faiz Zainuddin
Faculty Advisor: Dr. Vikram Cariapa

Design of a Flexible Automation System

Project Team: Dujin Park
Muthupalaniappa Navin
George J Yust IV
John Zeidler
Faculty Advisor: Dr. Vikram Cariapa
Sponsor: Uniplex Corporation

ASA Late Model Data Acquisition System

Project Team: Marc Ardiente
Alex Barr
Michael Froelich
Joseph Hirsch
Abby Mattson
Tim McCabe
Jason Taghikhani
Faculty Advisor: Dr. Mark Nagurka

PROJECTS

SAE Mini Baja Vehicle

Project Team: John Marlow
Matt Schuller-Rach
Chad Wetzel

Sponsors: Marquette University
College of Engineering
Wisconsin Steel and Tube Corp.
Superior Stainless and Erecting
Polaris Industries
Dana/Spicer
Land Pride
HB Performance Systems

Faculty Advisor: Dr. James Rice

XR 150 X-Ray Device Mount

Project Team: Philip Ritger
Samuel Gavin
Travis Harvey

Faculty Advisor: Dr. Dean Jeutter

Sponsor: Dr. Tom Radmer
Marquette University School of Dentistry
Milwaukee, WI

Solar Powered Water Pumping System for Guatemala

Project Team: Khir Yazid Abdul Mutalib
Mohd Zulhilmi Jaafar
Mohd Fadzli Mohd Radzi
Atikullah Salleh

Faculty Advisor: Dr. John Borg

PROJECTS

ASME Human Powered Vehicle Challenge

Project Team: Michael Gorrilla
Matt Davis
John Dupree
Doug Temeyer
Norazman Jusof
Khairuzzama Zakaria
Faculty Advisor: Dr. Scott Goldsborough
Sponsors: Wheel & Sprocket
440th Airlift Wing AFRC
Jim Wall Painting
Structural Systems Corporation

SAE Mini Baja Vehicle

Project Team: Joel De La Torre
Dan De Rosia
William Harris
Antone Long
Faculty Advisor: Dr. James Rice

Tennis Serve Simulator

Project Team: Keith Gubat
Milad Moin
Christopher Karow
Richard Servoss
Ian Kawas
Andrew Teske
Terence Maiellaro
Faculty Advisor: Dr. Mark Nagurka

PROJECT AWARD WINNERS

2005-2006

Component feeding system for Uniplex Corporation

Faculty Advisor: Dr. Vikram Cariapa

Project Team: Navin Muthupalianiappa
Dujin Park
George Yust IV
John Zeidler

(First Place in the Mechanical Engineering Department. Third place in the College of Engineering.)

ABOUT THE DEPARTMENT

Mechanical engineering is concerned with mechanical and energy systems, along with the intelligent use of modern materials. Mechanical Engineering is constantly changing with innovative advances in technology. It touches almost every aspect of our life, from medical devices to kitchen appliances, from new materials, such as plastics and composites, to alternative fuels, from robots in manufacturing to micro-machines in electronics and surgery, from automobiles to space craft, etc.

The Department offers a bachelor of science degree program in mechanical engineering, which is accredited by the Engineering Accreditation Commission of ABET. Also, the Department offers programs leading to the master of science and doctor of philosophy degrees in mechanical engineering.

The undergraduate program in mechanical engineering was established in 1908 and the M.S. and Ph.D. programs were added in 1961 and 1984, respectively. Approximately 270 undergraduate students are currently majoring in mechanical engineering. About 50% of the junior and seniors are enrolled in the Co-Operative Education Program. The total graduate enrollment stands at about 50 students. The educational and research programs of the Department are directed by 15 full-time regular faculty, who are assisted by about 10 active emeritus, adjunct, and research professors. Three of the 15 full-time regular mechanical engineering faculty are Fellows of ASME and another two are Fellows of ASM International. Still others have received various national and international recognition.

Why choose Mechanical Engineering?

If you are intrigued by how things work, fascinated by robots and automobile engines, then Mechanical Engineering may be the profession for you. Since Mechanical Engineering is involved in almost every design imaginable, one finds mechanical engineers associated with almost any field of interest. For example, they are an integral part of the design of the high-tech equipment and devices used by the medical profession. Mechanical engineers participate directly and, often times, manage spacecraft design and research, and the design and analysis of safety systems in transportation including automobiles, aircraft, and light rail systems. The design of more efficient energy systems and producing materials that are lightweight, yet many times stronger than existing materials, are "cutting edge" areas involving mechanical engineers. The breadth of the undergraduate program in mechanical engineering makes it ideally suited for interdisciplinary research and design work in this era of complex technologies, which depend upon such a variety of physical principles. The breadth of the program can also make it a springboard for graduate study in business, law, medicine, political science, and other professions where a solid understanding of technology is important.

What is a career opportunity as Mechanical Engineers?

Most mechanical engineers work for manufacturers, aerospace companies, public utilities, the automotive industry, and the petroleum industry. They also work for architectural firm, government agencies and academic institutions. Mechanical engineers can be found testing cars of the future at an automotive research facility. Mechanical engineers are designing jet engines for aircraft manufacturers and inspecting rocket booster for NASA. Mechanical engineers are working on solar energy projects. Mechanical engineers joined together with medical professionals to create robotically controlled braces that help people to work. Mechanical engineers have also partnered with coaches and athletes to design sporting equipment. (Copied from Career as a Mechanical Engineer, published by the Institute for Career Research)

Curriculum

Classes consist of a first year program of mathematics, engineering, science, and liberal arts. This program is identical to the Freshman year programs of Civil and Electrical Engineering. In fact, the courses in the Sophomore year, which are mainly engineering science courses, are pretty much the same for these programs. It is only in the Junior year that students begin to take the specialized courses associated with their curriculum.

The mechanical engineering curriculum is designed to provide not only a thorough understanding of the engineering sciences but also of the principles of manufacturing and organization that are used to implement these fundamentals in practical engineering applications.

Integrated with the technical and scientific content of the program is a series of elective courses in the humanities, social sciences, theology, philosophy, and communication arts. These courses provide the student with an understanding of society and an awareness of his or her social responsibilities.

In order to accommodate the students' professional interests, the department offers electives in a number of areas of study within mechanical engineering. In choosing electives, the student and faculty adviser confer to determine those courses which best meet the needs and interests of the individual student. By carefully selecting technical elective coursework, the student can obtain in-depth knowledge in one or possibly two areas of study to compliment the broad, fundamental, required courses.

Areas of Study

Energy Systems

Economic growth and development are strongly dependent upon the development and conversion of energy resources. Assurance that supplies can meet demands without excessive monetary and environmental costs will depend upon political, economic, and technological decisions. But, in any case, the key to solving the problem is engineering the technological development of new and better energy conversion processes and systems. The courses offered in the energy area provide a most up-to-date background for the design of traditional energy systems and for design, research, and development of new systems.

Manufacturing Systems

Manufacturing engineering is that specialty which requires such education and experience to understand, apply, and control engineering procedures and methods of production of industrial commodities and products. It requires the ability to plan the practices of manufacturing, to research and develop the tools, processes, machines, materials and equipment and to integrate the facilities and systems for producing quality products with optimal expenditures. The courses, including manufacturing processes, materials processing, manufacturing systems and reliability, offered in this area have the aim of preparing the student to face the challenges of rapidly changing technologies present in the modern manufacturing environment.

Mechanical Systems

This area provides the students with the theoretical, computational, and experimental tools that are necessary for the detailed analysis and design of mechanical systems including structural elements, linkages, gears, and other power transmission components, precision tools, and machinery, etc. The courses offered in this area enable the student to understand the rational and methodology of the overall design process of mechanical systems, proceeding from the conceptualization stage through the detailed design and implementation phases.

Co-op Program

The College of Engineering Cooperative Education (Co-op) Program is one of the first-ever and most

renowned programs in the nation. Established in 1919, the Co-op Program integrates classroom work with practical industrial experience. The Co-op Program enables the student to develop professionally as well as academically, to explore and clarify career goals and to earn money to apply toward their educational expenses. Students alternate semesters of school with semesters of employment for at least three alternating work terms once they have completed their sophomore year.

The work is related to some phase of the field of study in which she or he is engaged and is often diversified to afford a wide range of experience. The objective is balanced training, combining the science of engineering with communications and team-building skills during the early years of professional development.

Student participants have said the program helps to clarify career goals, applies classroom theory to real life situations, and provides a source of both real-time and future income. This year the salary for students entering their first Co-op work term ranges from $2400/month to $3400+/month. Upon graduation, many of the corporations hire their Co-op students because of their work experience.

Five Year B.S./M.S. Program

This program allows students to receive a bachelor of science degree and a master of science degree in mechanical engineering in just five years. Students with qualifying grade point averages (3.5/4.0) in the undergraduate mechanical engineering program at Marquette University may apply for admission to the five-year program during their junior year. Students must submit an application to the Graduate School, indicate their interest in the five year program, and meet all other admission criteria as stated in the following Application Requirements section. (GRE test scores must be submitted before the start of the fifth year.)

Students may take master's level courses in their senior undergraduate year. These graduate courses double-count toward the undergraduate and graduate degrees. The remaining courses are taken during the student's fifth year. They will begin their thesis research the summer between their junior and senior years. Their research laboratory experience will continue the summer between their senior and fifth years and throughout their fifth year, culminating in the preparation of a written thesis and defense. Upon completion of the first term as a master's candidate, the student must petition the Graduate School to transfer courses taken as an undergraduate to the master's degree. A maximum of 6 credit hours may be accepted for the graduate credit towards the requirements of the degree.

Job Placement

Average starting salaries and rate of profession of Marquette engineering graduates are consistently above the national average. Recent graduates have been placed at a rate of 98.6% within six months of graduation.

Examples of Employers

A.O. Smith, ABBOTT Laboratories, Aldridge Electric, Astronotics, Boeing, Brady, Briggs & Stratton, Bucyrus, Cooper Power Systems, Elwood, Fermi National Accelerator Laboratory, General Metalworks, GE Oil & Gas, Grede Foundries, Hamilton Sundstrand Aerospace, Harley Davidson, HATCO, Hugen Manufacturing, HUSCO International, International Truck & Engine, ITT A-C Pump, Johnson Controls, Joy Global, Kimberly-Clark, LUCAS, METSO Minerals, Metal Tech, Michael, Best & Friedrich, Milwaukee Ductile Iron, Milwaukee Metro Sewerage District, Miniature Precision Components, Modine Manufacturing, Mostardi-Platt, Navy Public Works, Rockwell Automation, S-B Power Tool, Sanford, Strattec Security, Super Steel Products, Thermoset, United Water, We Energies, ZF Industries.

FACULTY

Regular Faculty

Borg, John, Ph.D., P.E.
Shock Physics, Hydrodynamic Stability and Turbulence, Fluid Dynamics and Aerodynamics.

Brower, William E., Ph.D.
Cryobiology, Catalysis, Metallic Glasses.

Cariapa, Vikram, Ph.D., P.E.
Mass Finishing, Rapid Prototyping, Prosthesis Design for the Spinal Cord Injured.

Domblesky, Joseph P., Ph.D., P.E.
Process Simulation, Metal Forming, Materials Joining.

Fournelle, Raymond A., Ph.D., P.E.
Phase Transformations in Solids, Mechanical Behavior of Materials, Metal Joining, Failure Analysis.

Goldsborough, S. Scott, Ph.D.
Sustainable Energy Development, Alternative Power Systems, Renewable/Alternative Fuels, Impact of Science and Technology on Society.

Kim, Kyuil, Ph.D., P.E.
Computer Aided Manufacturing, Industrial Automation, Sculptured Surface Machining, Statistical Process Control.

Koch, Jon D., Ph.D.
Optical Diagnostics for Thermal, Fluid, Energy Conversion, Chemical Process Applications.

Marklin, Richard W., Ph.D., P.E.
Ergonomics, Human Factors Engineering, Lower Back Pain, Carpal Tunnel Syndrome.

Nagurka, Mark L., Ph.D., P.E.
Mechanical Systems, Modeling of Vehicle Systems, Human/Machine Interaction, Biomechanics of Motion.

Nigro, Nicholas J., Ph.D.
Surface Model Technology, Computer Aided Design, Computation Mechanics.

Rice, James A., Ph.D.
Manufacturing Processes, Modeling, Non-Destructive Evaluation, Simulation.

Schimmels, Joseph M., Ph.D., P.E.
Dynamic Systems Measurement and Control, Robotics, Kinematics, Impedance Design, Automated Assembly, Geometric Modeling.

Stango, Robert J., Ph.D., P.E.
Solid Mechanics, Composite Materials, Numerical Analysis, Surface Finish Processes.

Weber, Robert C., Ph.D., P.E.
Creativity, Teaching Methods, Graphical Mechanics.

Widera, G.E. Otto, Ph.D.
Stress Analysis, Modeling and Analysis of Deformation Processing, Shell Structures, Finite Element Analysis, and Solid Mechanics.

Research Faculty

Gaggioli, Richard A., Ph.D., P.E.
Theoretical and Applied Thermodynamics.

Park, Hyunjae, Ph.D.
Energy Conversion Systems, Computational Fluid Dynamics, Heat Exchange Equipment, Heat Transfer, Thermal Engineering.

Huang, Shuguang, Ph.D.
Robotics, Dynamics and Control.

Associate Faculty

Harris, Gerald F., Ph.D., P.E.
Quantitative assessment of neuromuscular function, human motion analysis, orthopedic biomechanics, data acquisition and control, real time analysis

Heinrich, Stephen M., Ph.D.
Solid mechanics, theory of elasticity, mechanics of electronic assemblies, analytical methods.

Jensen, Jon K., Ph.D.
Computer Aided Design, Solid and Geometric Modeling

Seitz, Martin A., Ph.D.
Electronic Materials & Devices

Silver-Thorn, M. Barbara, Ph.D.
Prosthetic limbs, soft tissue mechanics, rehabilitation engineering, orthopaedic and dental biomechanics

COLLEGE OF ENGINEERING

Founded in 1881 in Milwaukee, Wisconsin, Marquette University has been educating people of faith to be leaders in their professional lives, their communities, and in society for 125 years.

The Marquette College of Engineering was founded in 1908, and is known for its rich legacy of blending professional engineering preparation with a liberal arts education.

Today, Marquette is the largest Catholic college of engineering in the nation and the highest rated engineering college among all 28 Jesuit universities in the U.S. Over the last 20 years we have graduated more than 5700 Marquette engineers, and more than 1400 graduate and doctoral students. Students learning how to discover the next biomedical breakthrough that will facilitate a medical treatment.

Students taking the latest leap in electrical and computer engineering that further improves our quality of life. Students learning how to solve critical problems in water and wastewater treatment and infrastructure design. Students surpassing the hurdles to make a product or process faster, smaller, stronger, better.

Today we are especially proud to be atop the next great wave in graduate level engineering education through the formation of multidisciplinary research clusters that will more closely tie highly relevant, leading-edge research at the College with other universities and with industry and government agencies worldwide. Our three initial clusters —Neurosystems Innovations, Public Security, and Sustainable Engineering—will result in a significant increase in research funding and we believe even greater interest in our programs from highly qualified graduate students.

At Marquette, we will strive to remain well above the norm in our graduate engineering programs. We will continue to prepare men and women to be this century's well-rounded leaders in technology and innovation. We will continue to make the Marquette engineering degree a special key to doorways of great opportunity.

Be The Difference.

College of Engineering
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COLLEGE OF ENGINEERING



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