Senior Design Projects

2023

JOINT DEPARTMENT OF
BIOMEDICAL ENGINEERING

MARQUETTE UNIVERSITY

MEDICAL COLLEGE OF WISCONSIN

Contents

On the cover
Students adjust the seat of the Heart Kart III device used to allow patients with paracorporeal ventricular assist devices to exercise while waiting for a donor heart. More information on this project can be found on page 11.

Senior Design Projects

2023

To our Industry Partners

We are pleased to present the Biomedical Engineering Senior Design Projects completed during the 2022-2023 academic year as part of The Marquette University and Medical College of Wisconsin Joint Department of Biomedical Engineering.

The Marquette University and Medical College of Wisconsin Joint Department of Biomedical Engineering 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 several design challenges in the freshman year and a year-long project-based capstone design course in the senior year. 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. They consider legal and regulatory issues, use standards where applicable, conduct economic analyses, and learn about packaging, sterilization, and testing of medical devices. 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 effective contributing members of a medical device company, clinical engineering department, or academic research laboratory, and create value for their customers.

This was the seventh year of our new Joint Department of Biomedical Engineering between Marquette University (MU) and the Medical College of Wisconsin (MCW). Department faculty from MU and MCW served as advisors to project teams. This year we continued our 18-year collaboration with the Milwaukee Institute of Art and Design (MIAD). Four of our project teams collaborated with industrial design students from MIAD during the spring semester.

In the Joint Department of Biomedical Engineering, 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.

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.
Professor of Practice in Biomedical Engineering
Senior Design Course Instructor

Frank Pintar, Ph.D.
Professor and Chair
Joint Department of Biomedical Engineering

Requirements for Industry Sponsorship of Senior Design Projects

Senior Design Course Sequence:

At Marquette University, all senior biomedical engineering students are required to successfully complete a set of project-based capstone design courses (BIEN 4920 Principles of Design, and BIEN 4998 Senior Design).

At the end of these courses, students will demonstrate:

- The ability to connect and apply the knowledge and skills developed in previous engineering (and other) courses towards a design solution (to a specific problem) that creates value for a customer.
- The ability to plan and produce a product or service that will meet customer needs.
- The ability to work effectively in teams.
- Written technical and oral communication skills.

Senior Design Project:

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 medical device market and the operations of a company. Experience gained from industry sponsored projects helps prepare students for careers in the medical device industry. Teams are advised by a biomedical engineering faculty member and a representative from the sponsoring company.

Benefits of Sponsorship of Senior Design Projects:

Benefits to companies:

- Additional resources at little 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 higher priority projects.
- 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:

- Opportunity to work on real-world problems important to industry
- Exposure to the medical device industry and market
- Experience with project management and product development
- Familiarity with requirements and constraints of medical device design

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 customer needs, provide technical expertise and advice, and approve design concepts and prototypes.

Faculty advisors will be responsible for administrative issues (grading, 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 virtual, in-person, or by phone or e-mail. The industry advisor determines the frequency of communications.

Travel:

The industry advisor determines the need for travel.

Funding:

Depending upon the needs and expectations of the sponsor, a fund of $1000–$1500 may be necessary to pay for prototypes and testing.

Other:

Students have access to Marquette University's computer network, libraries, Discovery Learning Laboratory (machine shop, collaboration space, 3D printers, prototyping resources), 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 proprietary information.

To Sponsor a Biomedical Engineering 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 **Dr. Jay Goldberg at jay.goldberg@marquette.edu.**

We look forward to working with you.

Industry Sponsors

2022-2023
eClusion, Milwaukee, WI
GE Healthcare, Waukesha, WI
Medtronic USA, Minneapolis, MN
Fresenius Kabi, Lake Zurich, IL

2021-2022
GE Healthcare, Waukesha, WI
eClusion, Milwaukee, WI
Spectroscopy and Data Consultants, Pty. Ltd., Brisbane, Australia

2020–2021
SeaSpine, Carlsbad, CA
Spectroscopy and Data Consultants, Pty. Ltd., Brisbane, Australia

2019–2020
SeaSpine, Carlsbad, CA
Medtronic USA Inc., Minneapolis, MN
GE Healthcare, Waukesha, WI
Spectroscopy and Data Consultants, Pty. Ltd., Brisbane, Australia
FreedomTrax, Waukegan, IL

2018–2019
GE Healthcare, Waukesha, WI
Spectroscopy and Data Consultants, Pty. Ltd., Brisbane, Australia
Resolution Medical, LLC, Minneapolis, Minnesota

2017–2018
Mortara Instruments, Milwaukee, WI
3M, Minneapolis, MN
GE Healthcare, Waukesha, WI

2016–2017
Siemens Medical Solutions USA Inc., Hoffman Estates, IL
Safe Place Bedding, LLC, Conesville, OH
9 Degrees of Human, Milwaukee, WI

2015–2016
Medtronic USA Inc., Minneapolis, MN
Trek Bicycle Corporation, Waterloo, WI
Cardiac Profiles Inc., Franklin, TN
Zimmer Biomet, Warsaw, IN

2014–2015
GE Healthcare, Waukesha, WI
Medtronic USA Inc., Minneapolis, MN
Rowheels, Fitchburg, WI

2013–2014
Cytophil, Inc., East Troy, WI
DesignWise Medical, Loretto, MN
GE Healthcare, Waukesha, WI
Siemens Healthcare, Hoffman Estates, IL
Medtronic USA Inc., Minneapolis, MN

2012–2103
NeoCoil, LLC, Pewaukee, WI
Gauthier Biomedical, Grafton, WI
3M, Minneapolis, MN

2011–2012
GE Healthcare, Waukesha, WI
Medtronic USA Inc., Minneapolis, MN
Innovator of Disability Equipment and Adaptations, LLC, Pewaukee, WI

2010–2011
Cardiac Science Corporation, Deerfield, WI
DePuy Orthopedics, Inc., Warsaw, IN
GE Healthcare, Waukesha, WI
Medtronic USA Inc., Minneapolis, MN

2009–2010
DePuy Orthopedics, Inc., Warsaw, IN
GE Healthcare, Waukesha, WI
3M, St. Paul, MN

Project Team:
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Luke Fiebig
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Bryan Sanden

Faculty Advisor:
Dr. Jay Goldberg

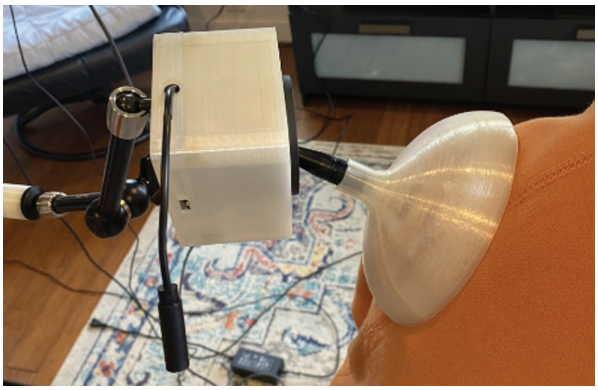
Industry Sponsors:
Chris Hege (eClusion)

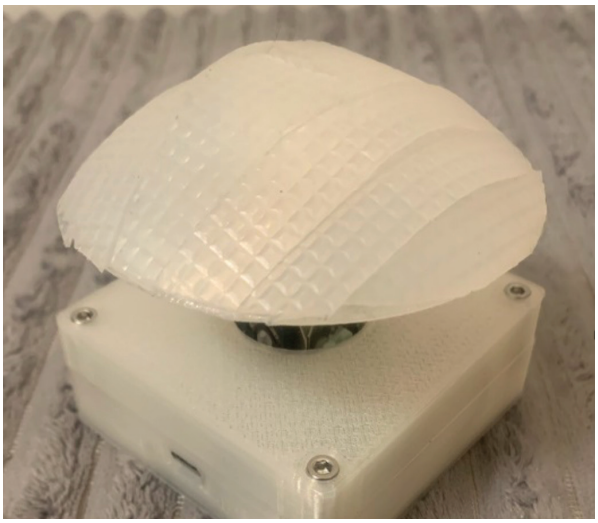
Adaptive Directional Input Device for Individuals with Disabilities

Video games have become widely popular over the past couple of decades. Although there are numerous games, controllers, and consoles for able bodied individuals, only a handful of controllers have been designed for people with disabilities. Traditional controllers and input devices are functional for the general population of people with full body mobility, but disabled individuals may find these conventional input devices difficult to use. The few devices designed for individuals with disabilities are often subject to a phenomenon called the disability tax, where nearly identical products are sold at higher prices just because they are targeted toward individuals with disabilities.

The goal of this project was to design a low-cost directional input device that would be beneficial to disabled individuals who enjoy gaming. This was achieved by using 3D modeling software and filament to design and print various knob designs for interaction with different parts of the body. Various joysticks were also selected based on customer preference to convert physical movements to onscreen movements in a video game. Also, a QTPy microcontroller was selected for communication between the joystick and the gaming console. In addition to the directional input device, an adjustable mount was designed to hold the device in a wide variety of positions for any potential user. The mount was built using aluminum T-slots, a linear actuator, and 3D printed brackets.

After initially meeting with a customer and creating a list of target specifications, several tests were conducted on the directional input device to ensure functionality. These experimental verification tests proved that the device was compatible with an Xbox adaptive controller and any game of choice, and had the ability to change inputs within a gaming application. A test was also conducted by controlling the device with different extremities to ensure that fine motor control was not needed to control the device effectively. While each team member was able to control the device, customer tests are planned to determine whether the device functions efficiently at this time.





Projects

Project Team:
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Nathan Balthazor
Riley Mitchell
Josh Feryance

Faculty Advisor:
Dr. Scott Beardsley

Sponsor:
Dr. Hernan Rey, MCW

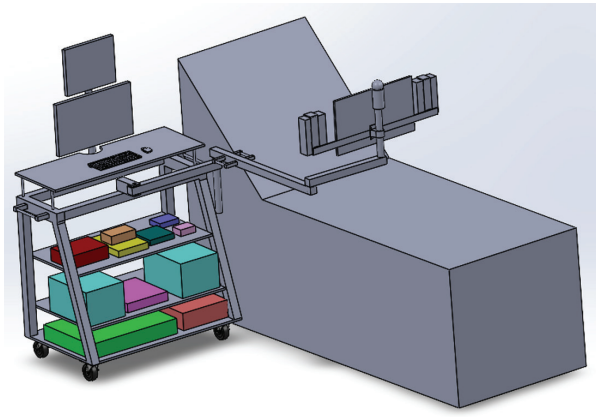
Brain Cart & Adjustable Display for Clinical EEG Research

2022-2023

Epilepsy is a neurological condition characterized by recurrent seizures that can vary in size and severity. Neurosurgery is required when conventional treatments and medications fail to lessen the effects of these epileptic events. Surgical success depends on the accurate localization of the epileptic zone, and invasive neural mapping has emerged as a promising method for doing so. This project centered on the development and implementation of a novel cart and arm system to be used at the Medical College of Wisconsin to support 24/7 EEG recording experiments for invasive neural mapping.

The system encompasses a collapsible, mobile cart and a mechanical arm that can safely hold a monitor, speakers, and microphone at an optimal distance from the patient's face. The system allows for easy storage and seamless integration into a clinical environment, including the ability to be positioned on either side of the patient's bed. To increase comfort and engagement throughout experimentation, the cart includes a third testing monitor that can be adjusted by the patient, which can also be used for entertainment activities.

A series of experiments were designed to test the functionality of the cart and arm system. The ergonomics of the arm control, the monitor's viewing distance and height, the fit of the cart in the recording room, the continuity of digital connections, and the storage capacity for hardware components were all characterized with respect to the customer needs. The results demonstrate that the system meets the specified requirements including but not limited to ease of use, adaptability, and patient-centered design.



Overall, the project focused on creating a cart, arm, and peripheral mount design, as well as the routing of digital I/O connections and cable management. The innovative system has the potential to significantly improve the invasive neural mapping process by offering a more adaptable, safe, and patient-centered approach. By facilitating the ability to obtain continuous EEG recordings to identify the epileptic zone, the system will help improve surgical outcomes for patients who require neurosurgery as a treatment option for severe epilepsy. The adaptability and versatility of the system will make it an asset to modern medical facilities leading to more effective testing and more comfortable patient care.

Project Team:
Chris Roberts
Juls Lanzar
Julia De La Cruz
Filip Kempa

Faculty Advisor:
Dr. Brian Schmit

Sponsor:
Dr. Max Krucoff, MD

Improved Cranial Stabilization System

Cranial stabilization systems are used in neurosurgeries to ensure that a patient's cranial nerves, neck, and head are stabilized during a procedure. Intraoperative magnetic resonance imaging (iMRI) uses MRI to create scans of the brain during surgery. This is done to help neurosurgeons identify whether an entire tumor has been removed during complex surgeries in the brain or spinal cord. The DORO LUCENT iMRI Cranial Stabilization System is the current solution for this market, but there are some improvements that can be made to the range of motion of the device. The project sponsor wanted the improved system to lock in more positions and provide vertical translational movement without arching the patient's head.

The purpose of this project was to create a prototype of an improved cranial stabilization system that could provide a larger range of motion. The prototype needed to be iMRI compatible, and include an extra degree of freedom to allow for more movement and a locking mechanism that would allow the system to lock in any desired position. This prototype added one degree of freedom at the head clamp to create another axis of rotation, and shaft collars were used to create variability and range in the locking positions for the cranial stabilization system. The extra degree of freedom also allowed the head clamp to translate vertically without extending or shortening the device.

Collecting data on the multiple locking positions at different axes of rotations and positions verified that the prototype demonstrated an increased range of motion compared to the current solution. This device could lock in a greater number of positions at smaller intervals to ensure that the surgeon can orient the patient's head in multiple ways. Further optimization of materials, locking mechanism, and strength needs to be completed before a complete working prototype can be manufactured.

2022-2023

Projects

2022-2023

Wheelchair Adaptation for Paracheer Athlete

Project Team:
Addison Koehler
Mary Slattery
Sophie Tuma
Gabby Gramz
Molly Riddler

MIAD Partners:
Emma Travitz
Chloe Schreurs
Roger Bryant
Zach Scharrer

Faculty Advisor:
Dr. Frank Pintar

Sponsor:
Tess Stumvoll

This project involved the redesign and adaptation of a wheelchair for a paracheer athlete. Our client is a 32-year-old woman with low functioning cerebral palsy, leaving her with minimal motor control. She is involved in paracheer, which is a cheerleading team consisting of athletes with varying levels of ability. Paracheer is a relatively new organization, and there are no current guidelines or established norms for the ways a paracheer wheelchair should be outfitted like there are for wheelchairs that are modified in other sports such as basketball or racing.

For this reason, families and teams like our client's are tasked with the challenge of making their own adaptations so that the athletes can participate and be involved in the performances. The homemade attachments aren't as safe as they could be for the other athletes on the team, or our client, and are not meant for long-term use and often need to be replaced. Her involvement on the team is important to her, and as the sport continues to grow, she will need a more permanent solution.

We partnered with students from the Milwaukee Institute of Art and Design to design and build a new stand that would be safe and durable and attach to her wheelchair. The stand extends across the back of the wheelchair above the back handles at a height of 37.5 inches. It has two steps on each side at 23.25 inches above the ground, allowing for the cheerleaders to step up to the top platform. New attachment points and a braking mechanism were added to provide a safer stand and wheelchair when the athletes are using the stand. The braking mechanism was changed to allow the brakes and locks to be used from the back handles instead of the front of the wheelchair. From testing and the feedback of Marquette cheerleaders, the team feels that it has met the goal of creating a successful and usable prototype.

Heart Kart III

Project Team:
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Patrick Hynes
Austin Torri

MIAD Partners:
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Mac Lewellyn
Fabian Rico Sanchez
Carl Sabroff

Faculty Advisor:
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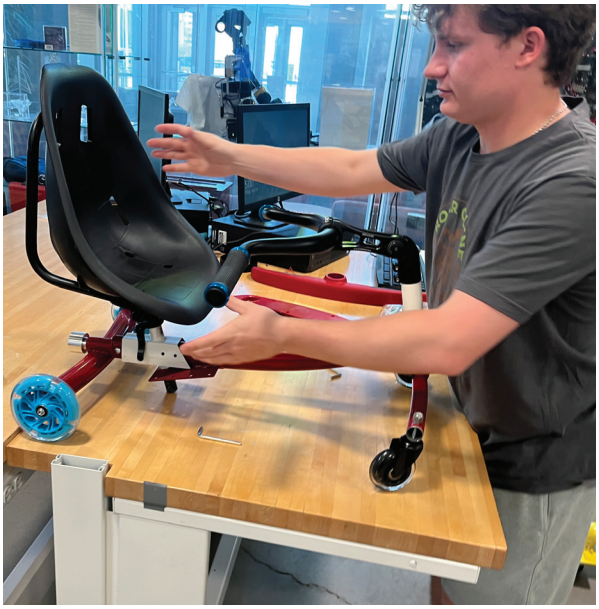
Sponsors:
Dr. Casey Vogel,
Ann & Robert H. Lurie Children's Hospital of Chicago

Over 400 pediatric heart transplants are performed in the United States annually. This can be a long and stressful process. Once a patient has been accepted for transplantation, they are placed on a nationwide waitlist. Typically, patients wait weeks to months before a donor heart is made available. However, it is common for patients to wait over a year for a donor heart. While waiting for a donor heart, pediatric patients are supported by paracorporeal ventricular assist devices which help circulate their blood. These devices utilize pumps that are located outside of the body due to the size of the patient's heart. While supported by these devices, normal activities become more strenuous for the patient due to surgical site pain and weakness. Furthermore, due to cannula tubing length and the limited battery life of the pump, normal activity can become difficult.

The Heart Kart allows patients to gain back some of their activity while being supported by a paracorporeal ventricular assist device. It is a 4-wheel push bike that will allow the patient to exercise while in the hospital. It is important that these patients move and exercise while waiting for a donor heart to become available. Movement and exercise promote strength, coordination, rehabilitation, and can improve the outcome of the heart transplant procedure. Furthermore, the ability to ride a bicycle while in the hospital is uplifting for the patients. This device can bring joy to those patients who must wait in the hospital for months on end.

The Heart Kart III has made earlier versions of the Heart Kart devices more child-friendly, adjustable, and accommodating to children of all sizes. It features a bicycle bell, light-up rubber duck, and a basket for the patients. This device includes a seat and handlebars that are adjustable to fit the size of each patient. The handlebars utilize a rotating attachment arm that allows them to rotate 90 degrees. The seat utilizes a bicycle seat post that allows the seat to be adjusted 3.5 inches in height. Heart Kart III is the mobility device that any patient ages 2 – 6, who is supported by a paracorporeal ventricular assist device, can benefit from.



2022-2023

Projects

2022-2023

Project Team:
Meredith Schiferl
Patrick Hetlage
Joe Potempa
Noah Gumushian

Faculty Advisor:
Dr. Brian Stemper

Sponsor:
Mary Houser, Menomonee Falls School District

Workstation for Independent Learning

Teachers often use assistive devices when trying to engage a student with disabilities using learning materials. Sometimes the available options do not provide the necessary assistance that the teachers are looking for. These devices can be too small, cumbersome to handle, and can move around causing frustration during lessons. Frustration can be distracting to students and decrease learning engagement. These effects increase exponentially in the special education environment.

The purpose of this project was to provide a solution that offers teachers a way to display learning materials in a compact area while holding all materials. Our solution was to modify a premade slant board, like the current solution used by the teachers. The modifications include the ability to hold all learning materials, have interactive attachments, and overall help the teachers increase the learning engagement of special education students.

Testing was completed to verify that the workstation would not move around during lessons, hold all learning materials, and overall be safe for use in the classroom. Various mechanical tests were completed to ensure the safety of the device for use in the classroom. Other important safety factors included no splinters from the wood surface, reduced risk of the workstation falling over, and reduced risk of bruising if students accidentally hit the workstation.

Feedback from users showed that many aspects of the design increased student engagement. Additionally, attachment activities provide an interactive teaching method that allows students to visualize concepts. Overall, the workstation created by the team will help a student achieve their learning objectives and continue to grow.

Project Team:
Abby Anderson
Aine Grady
Kendra Meintz
Megan Peters
Addie Vear

Faculty Advisor:
Dr. Phil Voglewede

Industry Advisor:
Tom Current, CPO

Locking 4Bar AFO

Drop-foot is a phenomenon often caused by stroke that results in the inability to dorsiflex the toes, leading to possible falls and an altered gait pattern. Stroke patients that suffer from drop-foot often have extensor tone which causes difficulty flexing the knee and hip while walking, leading to a step-to gait pattern in which the affected leg is circumducted around to match the unaffected leg. This modified gait pattern is not beneficial for muscle rehabilitation or reducing extensor tone and can affect quality of life when patients are unable to reach their mobility goals or keep up with loved ones when walking. Current solutions include articulated ankle foot orthoses (AFOs) that hold the foot at a neutral angle during swing phase and allow for some dorsiflexion during stance phase. Unfortunately, these solutions only reduce tripping and do not promote muscle rehabilitation or a more natural gait pattern.

This project involved the design of an AFO that pulls the patient's foot into dorsiflexion during terminal stance phase and locks the foot in dorsiflexion only in swing phase. Locking the foot in swing phase exclusively allows for better toe clearance, a larger step past the unaffected leg, and movement of the muscles through the normal range of motion to aid in rehabilitation. Upon heel strike, the AFO unlocks and releases the foot down for initial loading, similar to a normal gait pattern. The Locking 4Bar AFO consists of a thermoplastic AFO fit with a custom shaped aluminum support beam, two free motion joints on each ankle, and a three-bar aluminum mechanism on the lateral ankle with a spring and magnet to aid in the ankle movement. The use of a magnet allows for locking of the foot in dorsiflexion during swing phase and the spring aids in bringing the foot into dorsiflexion and slowing plantarflexion of the foot at heel strike.

Gait Analysis testing to verify the design indicated that the device allowed for a more normal gait pattern and locked the foot in dorsiflexion during swing phase creating ample toe clearance. The device also increased stride length, and reduced knee flexion and hip flexion for a drop-foot patient. The device was also tested using an Instron machine per ISO 22675 and met the requirements of the standard. Stroke patient studies were not conducted but will be required for commercialization of the device.

2022-2023

Projects

2022-2023

Simulated Blood Glucometer

Project Team:
Kasia Lechowska
Claire Kraft
Megan Leighton
Jack Mundinger
Jake Lawrence

Faculty Advisor:
Dr. Said Audi

Clinical Advisors/ Sponsor:
Anne Costello, MSN, RN
Amanda Potter, MSN, RN
Theresa Bullis MSN, RN
Marquette University College of Nursing

Ensuring that our future nurses and medical professionals have the best education and training for their careers is vital. Thus, it is important that healthcare professionals have thorough training in order to provide the best possible care for their patients. This includes providing them with the most realistic and accurate simulation experiences. Simulation centers work to help future healthcare workers visualize scenarios in a safe way, while also honing their skills and gaining valuable experiences for when they begin practicing in a clinical setting. One important skill that medical professionals, specifically nurses, need to learn is measuring a patient's blood glucose level and recognizing how to react to the readings. It is important to monitor blood sugar levels, especially for diabetic patients, in order to prevent or delay any health complications.

The purpose of this project was to develop a simulated blood glucometer for the Wheaton Franciscan Center for Clinical Simulation, part of the Marquette University College of Nursing. We developed the blood glucose monitor using an Arduino board and a TFT touch screen. It was modeled based on the Accu-Chek blood glucose meter that is used in hospitals. The blood glucose value displayed to the screen is set by the simulation coordinator using a Bluetooth application (LightBlue), allowing them to manipulate the simulation lab experience that the nursing student will have. The physical blood glucose monitor that will be used by the nursing students has numerous screens, replicating those of the Accu-Chek, which prompt the nursing students to scan a barcode, as they would in a hospital setting, and to insert a test strip before displaying the blood glucose value that the instructor has sent to the Arduino. This simulator will help Marquette nursing students prepare for more realistic clinical scenarios they will be presented with during their careers.

Confidential Projects

Sponsor:
Scott Slavic, Advanced Technologies, GE Healthcare, Waukesha, WI

Faculty Advisor:
Dr. Taly Gilat-Schmidt

Team:
Erin Niebler
Heidi Schuler
Sean McLaughlin
Sarah Hayden
Austin Clark

Sponsor:
Scott Slavic, Advanced Technologies, GE Healthcare, Waukesha, WI

Faculty Advisor:
Dr. Robert Cooper

Team:
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Giuseppe Caringella
Sahil Kothari
Erin Cahill
Gavin DeGroot

Sponsor:
Val Eisele, Cindy McCahery, Irene O'Hara, Medtronic USA, Minneapolis, MN

Faculty Advisor:
Dr. Brandon Tefft

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Kyle Frank
Nathan Loy
Eddie Bartoletti
Mary Schumar

MIAD Partners:
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Daniel Emeterio
Lance Knight

Sponsor:
Dr. Ben Beran, Medical College of Wisconsin

Faculty Advisor:
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Konstantin Plested
Patrick Sanders
Daniel McTigue

MIAD Partners:
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Liam Druley
Ross Pflum

Sponsors:
Dr. Beth Erickson and Dr. Josh Corteville, Department of Radiation Oncology, Medical College of Wisconsin

Faculty Advisor:
Dr. Bing Yu

Team:
Leti Salazar
Kelly Colmone
Miah Ducklow
Austin Larson

Sponsor:
Augustin Min, Fresenius Kabi, Lake Zurich, IL

Faculty Advisor:
Dr. Lars Olson

Team:
Haley Hovland
Elizabeth Egbers
Matthew Breunig
Nati Monosov

Marquette University and Medical College of Wisconsin Joint Department of Biomedical Engineering

Undergraduate Program

The Marquette University and Medical College of Wisconsin Joint Biomedical Engineering program is founded on one of the longest accredited biomedical engineering programs in the nation and was developed in collaboration with active industry professionals. We offer three selective undergraduate majors to better prepare students for competitive, career-building roles within the biomedical engineering profession. These include biocomputing, bioelectronics, and biomechanics.

Our undergraduate program offers students all the educational opportunities and campus community experiences of Marquette University along with access to the libraries, laboratories, lectures, faculty and clinical settings of the Medical College of Wisconsin and its clinical partners.

Accelerated Degree Program (ADP)

Our Accelerated Degree Program allows qualified students to receive a bachelor's and a master's in biomedical engineering in five years. Students with qualifying grade point averages enroll in the program during their junior year and begin thesis research the summer between their junior and senior years. Research laboratory experiences will continue during the summer before their senior year through their fifth year, culminating in a written thesis and defense.

Graduate Programs

For those considering advancing their career in biomedical engineering by pursuing a master's or doctoral degree, our graduate programs provide engaging clinical and research experiences designed to shape students into leaders in their chosen field.

Graduate School Programs

- Doctoral Program
- Master of Science in Biomedical Engineering
- Master of Engineering in Biomedical Engineering

Featuring more than 30 dedicated labs designed to facilitate the transfer of new knowledge into innovations directly impacting patient care, our joint program supports student education with a rigorous research practice that offers a dynamic range of novel opportunities for the world's next generation of biomedical engineers. With a focus on collaboration, our research brings together world-class engineers and faculty physicians within state-of-the-art facilities to create solutions for the greater good.

Research Themes

Research themes are provided to help students drive their academic experience, ensuring they are well prepared to pursue their interests upon graduation.

- Biomechanics
- Biomedical Imaging
- Computational Systems Biology and Medicine
- Medical Devices and Bioinstrumentation
- Molecular, Cellular and Tissue Engineering
- Neural Engineering and Neural Rehabilitation

Clinical Partners

The Marquette University and Medical College of Wisconsin Joint Biomedical Engineering programs deliver far more than the reputation of two world-renowned institutions. We also offer valuable opportunities for students, faculty, and staff to conduct research with four equally reputable clinical partners, all located within minutes of each other:

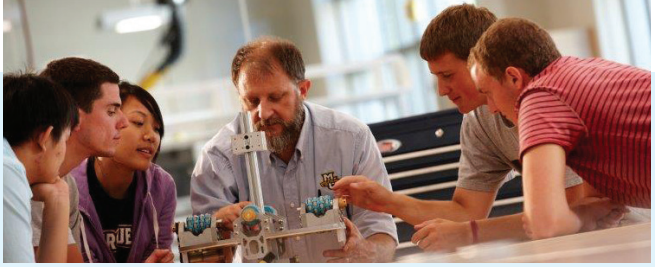
- Children's Wisconsin
- Clement Zablocki VA Medical Center
- Froedtert Hospital
- Versiti Blood Center of Wisconsin

Sponsored Research

Both Marquette and the Medical College of Wisconsin have longstanding histories of successfully partnering on sponsored research supported by federal agencies, for-profit and non-profit entities.

Industry Relations

Marquette has sustained a proud tradition of connecting students with opportunities for transformative, real-world work experience since our co-op engineering program was founded in 1919 as one of the first of its kind in the country. Today, Marquette works with more than 200 leading engineering and technology companies to help students build skills, gain invaluable professional experience, and make key connections that will help them thrive in their careers.



Partnering with Industry

To benefit patients and the future of health care, our joint department fosters collaboration with industry leaders, including such innovators as GE Healthcare, Medtronic, Baxter, and many others.

Collaborations include:

- Hiring undergraduate students for paid internships and co-op employment opportunities
- Working with senior design and freshman groups on innovative medical device projects
- Joining forces on translational research
- Developing curricula that respond to industry needs

Our industry partners value working with us to advance research for their health care products and services while seeking biomedical engineering students and graduates to join their workforces as valued members of their organizations. Our Industry Advisory Board is comprised of active and engaged alumni who are focused on helping to ensure our students are learning industry-leading skills to better prepare them for today's workforce.

The Marquette University and Medical College of Wisconsin Joint Department of Biomedical Engineering stands apart in that it is a true partnership between two institutions with a longstanding history of collaboration and innovation reaching back nearly a century. With unmatched cutting-edge clinical research and benefits and funding that allow students more opportunities for advancement, our joint department is dedicated to delivering an extraordinary educational experience designed to empower the next generation of biomedical engineers, scientists, and physicians.

Undergraduate Design Curriculum

Biomedical engineering students in the Joint Department of Biomedical Engineering learn about design throughout the four-year curriculum.

Freshman Year

Students first gain experience with the design process in the first year during BIEN 1100 and 1110 *(Introduction to Biomedical Engineering Methods I and II)*. In these courses, they participate in several team design challenges. These experiences help develop teamwork skills, and teach students about the engineering design process, including technical, legal/ethical, regulatory, and economic design constraints. Students learn to identify customer needs, develop a list of performance requirements and specifications, convert requirements into design concepts, and build and test prototypes. They also learn about basic business concepts and entrepreneurship.

Sophmore and Junior Years

During the sophomore and junior years of the biomedical engineering curriculum, students take courses that include individual and team-based design projects which allow them to apply what they are learning in the course to the solution of a related problem. This helps them relate theory to practice.

In the junior year, students take BIEN 3400 *Clinical Issues in Biomedical Engineering Design*, in which they observe procedures in the clinical environment and learn to identify unmet clinical needs and opportunities for new product development. They hear various stakeholder perspectives on the design and use of medical devices and learn about the regulatory requirements of medical device design, including those of the FDA and ISO standards.

Senior Year

During the senior year, students are required to take BIEN 4920 *Principles of Design* and BIEN 4998 *Senior Design*. These courses require students to apply what they have learned during their previous years of the undergraduate curriculum in a multidisciplinary team-based project experience. They further develop their design, analytical, project management, communication, time management, and teamwork skills. They learn about the product development process, the medical device industry, testing for safety and efficacy, design validation, standards and regulations, risk management, project scheduling, patent issues, and a variety of design issues. Students complete a design project from problem definition to design verification (per ISO 9001 and 13485) and gain experience in generating the same project deliverables as required in industry.

Faculty

Pintar, Frank, Ph.D., Professor and Chair
Biomechanics of brain and spinal cord injury, mechanics of spine surgical techniques, motor vehicle crash trauma

Audi, Said H., Ph.D.
Acute lung injury, acute respiratory distress syndrome (ARDS), lung transplantation, pulmonary hemodynamics

Beardsley, Scott, Ph.D.
Neural coding/decoding, neuroplasticity and learning, human visuo-motor processing, functional neuroimaging

Cooper, Robert F., Ph.D.
Photoreceptor mosaic structure and function, image processing, automated analysis tools, clinical imaging

Dash, Ranjan, Ph.D.
Computational systems biology & bioengineering, computational biology and bioinformatics

Garcia, Guilherme, Ph.D.
Respiratory physiology, fluid mechanics of respiratory airflow, virtual surgery planning

Gilat-Schmidt, Taly, Ph.D.
Medical imaging systems, computed tomography, image reconstruction

Goldberg, Jay R., Ph.D., P.E.
Medical device design and innovation, biomaterials

Greenberg, Adam S., Ph.D.
Cognitive Neuroscience of attention, human psychophysics and computational modeling of perceptual phenomena

Hokanson, Jim A., Ph.D.
Urologic function/dysfunction, electrical stimulation/ neuromodulation therapies, neural engineering

Joshi, Amit, Ph.D.
Molecular image-guided and remote-triggered therapies, breast cancer imaging and therapy, optical imaging

Kruger, Karen, Ph.D.
Orthopedic biomechanics, pediatric gait kinetics and kinematics using motion analysis techniques.

Olson, Lars E., Ph.D.
Mathematical modeling, biomedical instrumentation and optics, cell engineering/cardiopulmonary physiology

Onushko, Tanya, Ph.D.
Neurorehabilitation

Pawela, Christopher P., Ph.D.
Brain connectivity, neural plasticity, cerebrovascular structure and function, neurovascular coupling

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

Scheidt, Robert A., Ph.D.
Human motor control, rehabilitation engineering, human psychophysics of sensorimotor adaptation and learning

Schmit, Brian D., Ph.D.
Spinal Cord Injury, neurorehabilitation, human neurophysiology, biomechanics

Somasundaram, Karthik, Ph.D.
Motor vehicle crash trauma, pedestrian safety, computational modeling of dynamic events.

Stemper, Brian, Ph.D.
Biomechanics of traumatic brain and spine injury, biomechanics of the cervical and lumbar spine, automotive safety

Tefft, Brandon J., Ph.D.
Cardiovascular regenerative engineering and device design, tissue engineered vascular grafts and heart valves

Wang, Bo, Ph.D.
Stem cell engineering, hard tissue engineering and 3D bioprinting, cardiovascular tissue engineering, imaging

Williams, Jordan J., M.D., Ph.D.
Peripheral optogenetics for motor stimulation, brain-machine interfaces and neural prosthetics, motor learning

Yu, Bing, Ph.D.
Optical imaging and spectroscopy, optical endoscopy, cancer detection and therapeutic monitoring, global health

Opus College of Engineering

Since 1908, the Marquette University Opus College of Engineering has been uniquely blending professional engineering preparation with a liberal arts education to provide the world with well-balanced leaders in their profession.

Our mission
The mission of the College is to excel in four critical areas:

- To prepare all students for successful careers based on a strong moral and ethical foundation
- To advance the state-of-the-art in engineering
- To serve our professional and technical communities
- To contribute to our global society

The Opus College of Engineering offers six undergraduate degrees in eleven programs/majors through four departments: Biomedical Engineering; Civil & Environmental Engineering; Electrical and Computer Engineering; and Mechanical Engineering. Marquette also offers a wide range of graduate and doctoral programs.

Accreditation
All undergraduate programs offered by the Marquette University Opus College of Engineering are accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, 410-347-7700.

The University
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. Since the first graduating class of five men were awarded bachelor of arts degrees in the 1880s, Marquette has grown into a modern coed campus of more than 11,000 students who learn and grow through nationally admired undergraduate, graduate and professional programs.

Department of Biomedical Engineering
Marquette University
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For more information about the Marquette University and Medical College of Wisconsin Joint Department of Biomedical Engineering, click HERE or scan the QR code.

JOINT DEPARTMENT OF
BIOMEDICAL ENGINEERING

MARQUETTE UNIVERSITY

MEDICAL COLLEGE OF WISCONSIN

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