

MICHIGAN STATE
UNIVERSITY



MICHIGAN STATE UNIVERSITY *Fall 2016*

Design Day

COLLEGE OF ENGINEERING

 **TechSmith®**

Executive Partner Sponsor
Honoring Dean Craven

Welcome from TechSmith

As a Michigan technology company headquartered just one mile from MSU, TechSmith takes a special pride and thrill in the Design Day event. We are continually amazed by the creativity, passion, and ambition of MSU's engineering students.

As with all technology companies, our ability to reach our goals in delivering value to our customers is entirely dependent on the continued availability of talented engineering graduates. But that is a tiny example of the potential impact that these students can have to all of our lives, to the nation, and to the world. We all want them, and need them to succeed. Evidence of the importance of science, technology, engineering and mathematics is all around us - under our feet, on our handheld devices, and in the air we breathe. Not only is raw STEM knowledge required in the next generation of graduates, but also the creativity to connect this knowledge to real world problems, and the perseverance to take action. We love that Design Day touches on all the components needed for success.

This is a special anniversary for us in two ways. First, it's our 10th year as Design Day and capstone program sponsors. Second, the individual who was the driving force behind our decade-long commitment to MSU is retiring from TechSmith. We join MSU in honoring our former CTO, Dean Craven. Dean demonstrated incredible passion and support for MSU engineering students, and was an evangelist for the Design Day program at TechSmith and in the community for many years.

Dean loved the energy and creativity exhibited by the participants in the capstone/design day projects. He enjoyed, of course, working with the TechSmith team, but was fascinated by many of the projects and the commitment of the students to putting their skills to work creating solutions to real problems. Over the course of 10 years, Dean has contributed to over 20 CSE capstone projects. We, of course, will continue Dean's legacy of commitment to MSU.

TechSmith extends our gratitude to Dean, to the many other corporate sponsors and, of course, to the MSU academic team. Thank you for everything you do to recognize the importance of STEM education, and to prepare our youth for the future.

And to all of the participants of Design Day - congratulations and enjoy. It is time to marvel at the impact of engineering on of our lives and well-being; time to appreciate the talent in the coming generation; time to thank all who make this happen every year.

Sincerely,



Wendy Hamilton
CEO, TechSmith Corporation



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MICHIGAN STATE UNIVERSITY Spring 2017
Design Day
 COLLEGE OF ENGINEERING

**Mark Your Calendars!! It's time to save
 the date for Spring 2017 Design Day!**

**Join us April 28, 2017, for another energetic celebration
 showcasing talented engineering students**



Welcome from the Dean



As Dean of the College of Engineering, on behalf of the entire faculty, I welcome you to Design Day!

We wish you an enjoyable event as you experience our students and their amazing talents through presentations, competitions, demonstrations and posters.

We are pleased to acknowledge TechSmith as our Design Day Executive Partner Sponsor and Urban Science as our Design Day Directing Partner Sponsor. Our Design Day Supporting Partner Sponsors include Amazon, Boeing, Bosch, General Motors, Meijer, the MSU Alumni Association, Norfolk Southern, and Salesforce.com. We thank all of our sponsors for their generosity and their ongoing commitment to Design Day.

As you explore the exhibits throughout the Engineering Building, you are encouraged to take time to learn about the projects by talking with our students. They are an incredible group of people who love to share their enthusiasm for engineering.

Starting in their first semester, our freshmen learn about the importance of engineering and the positive impact that engineers make on society and the world around them in our Cornerstone and Residential Experience for Spartan Engineers program. Be sure to stop by and see how they innovate, communicate and perform at the highest levels in an increasingly global and demanding world.

Another exciting part of Design Day is the Dart Foundation Day of Engineering Innovation and Creativity, which involves some 200 high school students. On Design Day, these future engineers explore design principles with hands-on projects requiring the application of their creativity and ingenuity.

The headliners of Design Day are our graduating seniors as they present their design projects through exhibits, posters and presentations. Their projects represent the capstone of their educational career. You will see that our graduating MSU engineers are ready to lead, create and innovate.

Our capstone programs and Design Day would not be possible without the continued support of our capstone project sponsors who provide both funding and a professional experience for our capstone design teams. We appreciate their generosity and their time.

Please join us for the Design Day Awards Ceremony in Anthony Hall Room 1281 at 1:15 pm when we will honor all of our talented Spartans, the best of the best.

A handwritten signature in black ink, appearing to read 'Leo Kempel', with a long, sweeping horizontal line extending to the right.

Dr. Leo Kempel

Dean of the College of Engineering
Professor of Electrical and Computer Engineering
Michigan State University



Mid-west location. West coast perks.

Located in the heart of Michigan, TechSmith is the go-to company for visual communication software tools, with more than 30 million users worldwide.

We love our employees even more, and it shows through our culture and employee perks. If you're looking for a west-coast style environment that will challenge and engage you and reward your outstanding performance along the way, learn more about TechSmith at www.techsmith.com and apply today!



Design Day Events Schedule: Friday, December 9, 2016

| EVENTS | 7 a.m. | 8 a.m. | 9 a.m. | 10 a.m. | 11 a.m. | Noon | 1 p.m. |
|-----------------------------------|--------|---|---|---------|---------|------|--------|
| Audio Enthusiasts and Engineers | | 2nd Floor Room 2228 8:00 a.m. – Noon | | | | | |
| Engineering Student Organizations | | 1st Floor Lobby 8:00 a.m. – Noon | | | | | |
| ECE 101 Presentations | | | 2nd Floor 2200 Hallway 9:00 a.m. – Noon | | | | |
| EGR 100/102 Presentations | | | 2nd Floor 2300/2200 Hallway 9:00 a.m. – 11:30 a.m. | | | | |
| ME 371 Demonstrations | | | 1st Floor Rooms 1230 & 1234 9:00 a.m. - Noon | | | | |
| ME 412 Competition | | 1st Floor Room 1252 8:00 a.m. - Noon | | | | | |
| ME 471 Competition | | | 1st Floor Room 1345 8:30 a.m. - 11:10 a.m. | | | | |
| ME 491 Demonstrations | | | 1st Floor 1200 Hallway 9:00 a.m. - Noon | | | | |

| CAPSTONE COURSES | | | | | | | |
|----------------------------------|--|--|---|--|--|--|--|
| CSE & ME Posters and ECE Posters | | CSE & ME Posters: 1st Floor 1300/1200 Hallway 8:00 a.m. – Noon ECE Posters: 2nd Floor 2200 Hallway 8:00 a.m. – Noon | | | | | |
| CE 495 Project Presentations | | 3rd Floor Rooms 3400 & 3540 8:00 a.m. – Noon | | | | | |
| CSE 498 Project Presentations | | 3rd Floor Room 3405 7:30 a.m. – Noon | | | | | |
| ECE 480 Project Presentations | | | 2nd Floor Rooms 2205 & 2250 8:30 a.m. – 11:00 a.m. | | | | |
| ME 481 Project Presentations | | | 1st Floor Rooms 1202, 1220 & 1300 9:00 a.m. – 12:30 p.m. | | | | |

| OPENING, LUNCH AND AWARDS | | | | | | | |
|---------------------------|--|--|---|--|--|--|--|
| High School Opening | | | 1st Floor Anthony, Room 1279 8:00 a.m. – 8:40 a.m. | | | | |
| High School Awards | | | 1st Floor Anthony, Room 1279 12:15 p.m. – 12:30 p.m. | | | | |
| MSU Awards | | | 1st Floor Anthony, Room 1281 1:15 p.m. – 2:00 p.m. | | | | |



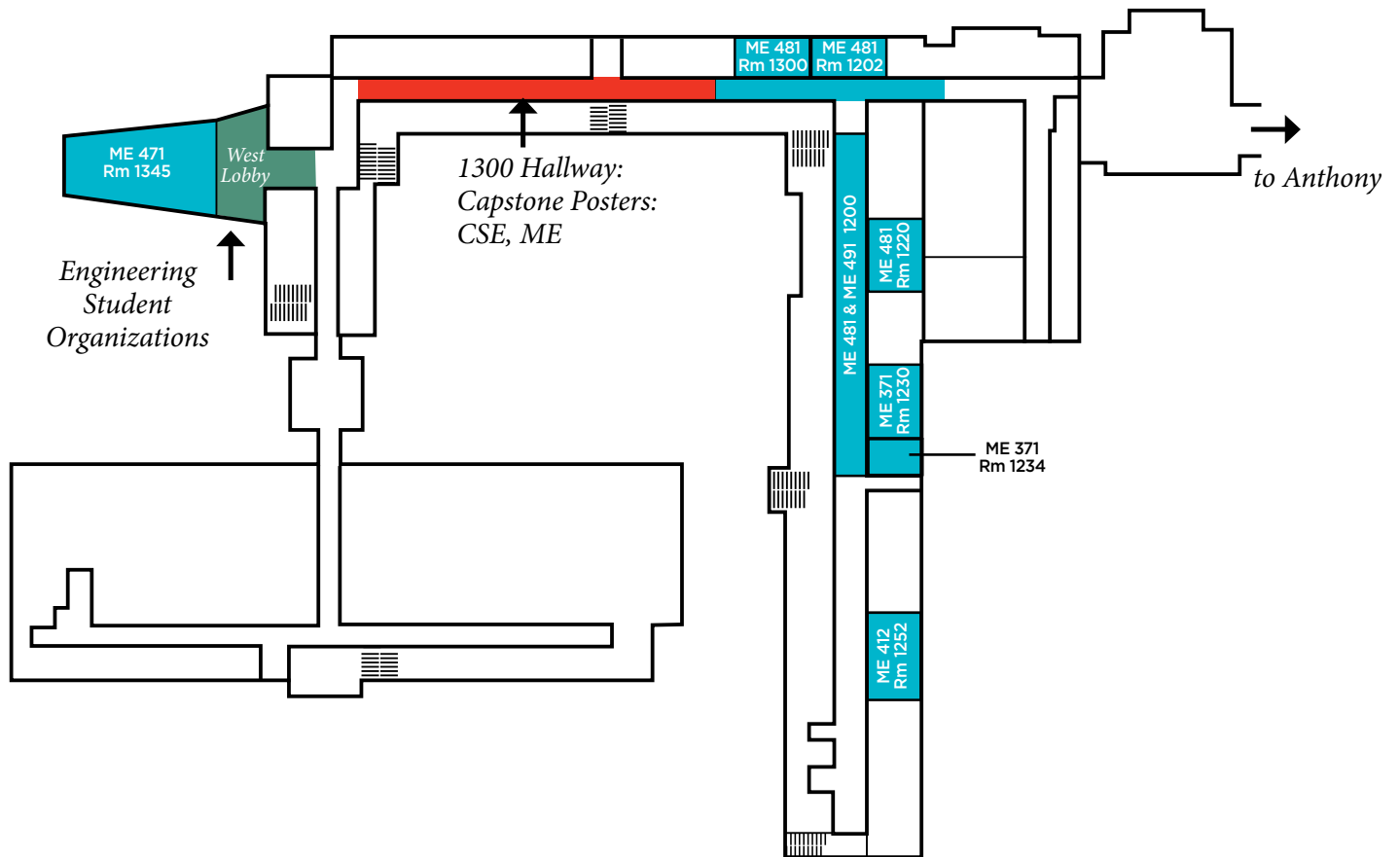
Social Media Links:

"Like" the College: <https://www.facebook.com/SpartanEngineering>
 "Follow" the College: https://twitter.com/msu_egr_news

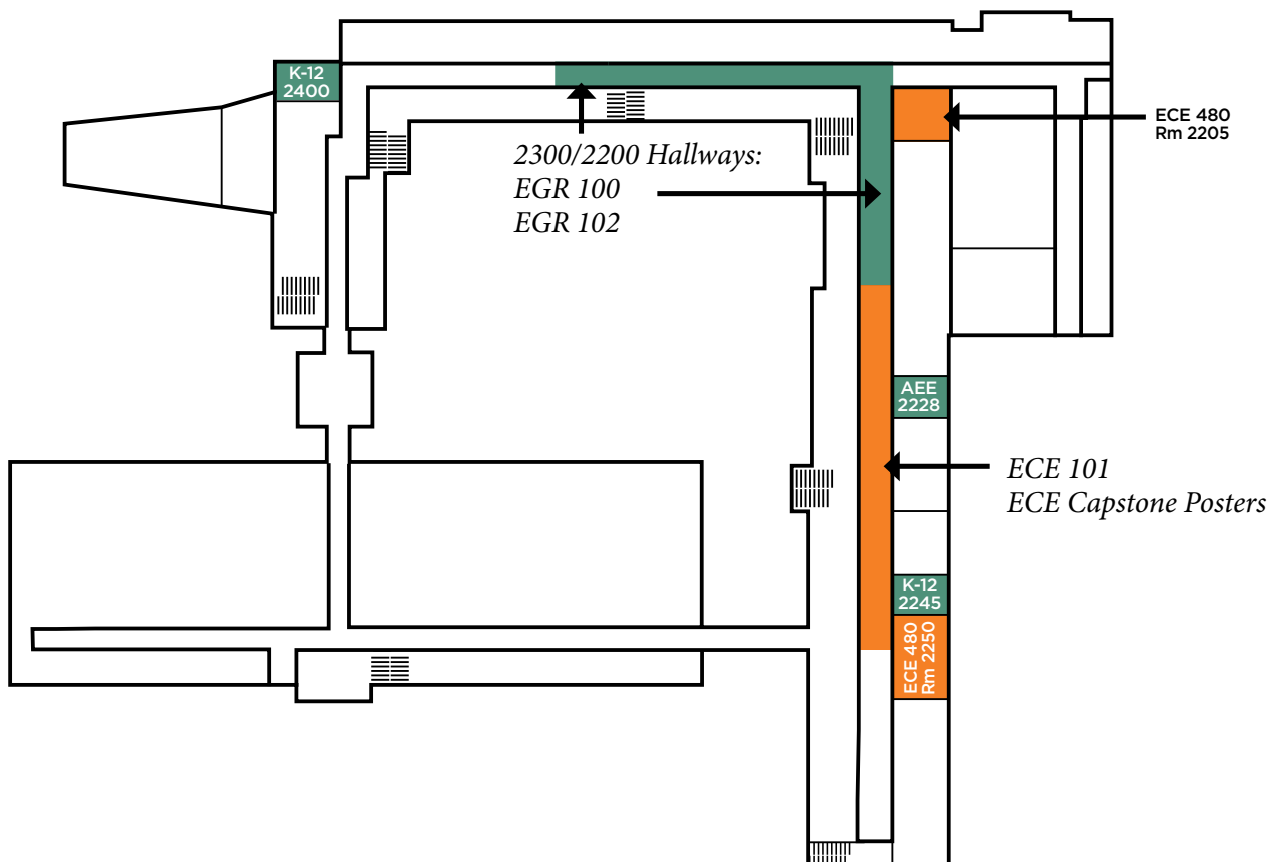
To stay up to date w/Careers in Engineering:

"Like" Us <http://www.facebook.com/pages/The-Center-for-Spartan-Engineering/226159694117936>
 "Follow" Us: <https://twitter.com/msuengineer>

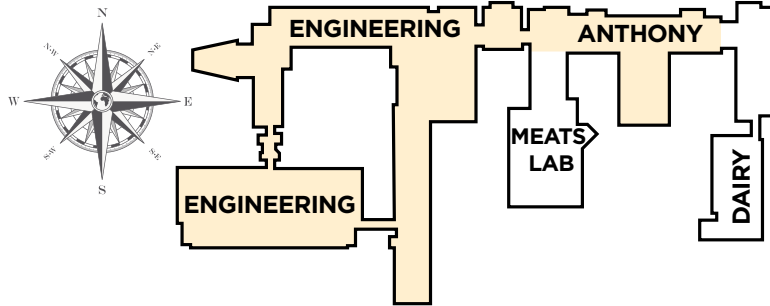
1st Floor Engineering



2nd Floor Engineering

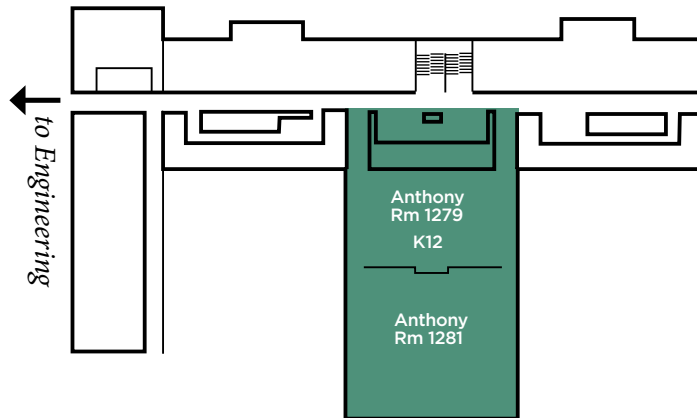


Overview



Design Day Floor Plans of the MSU Engineering Building

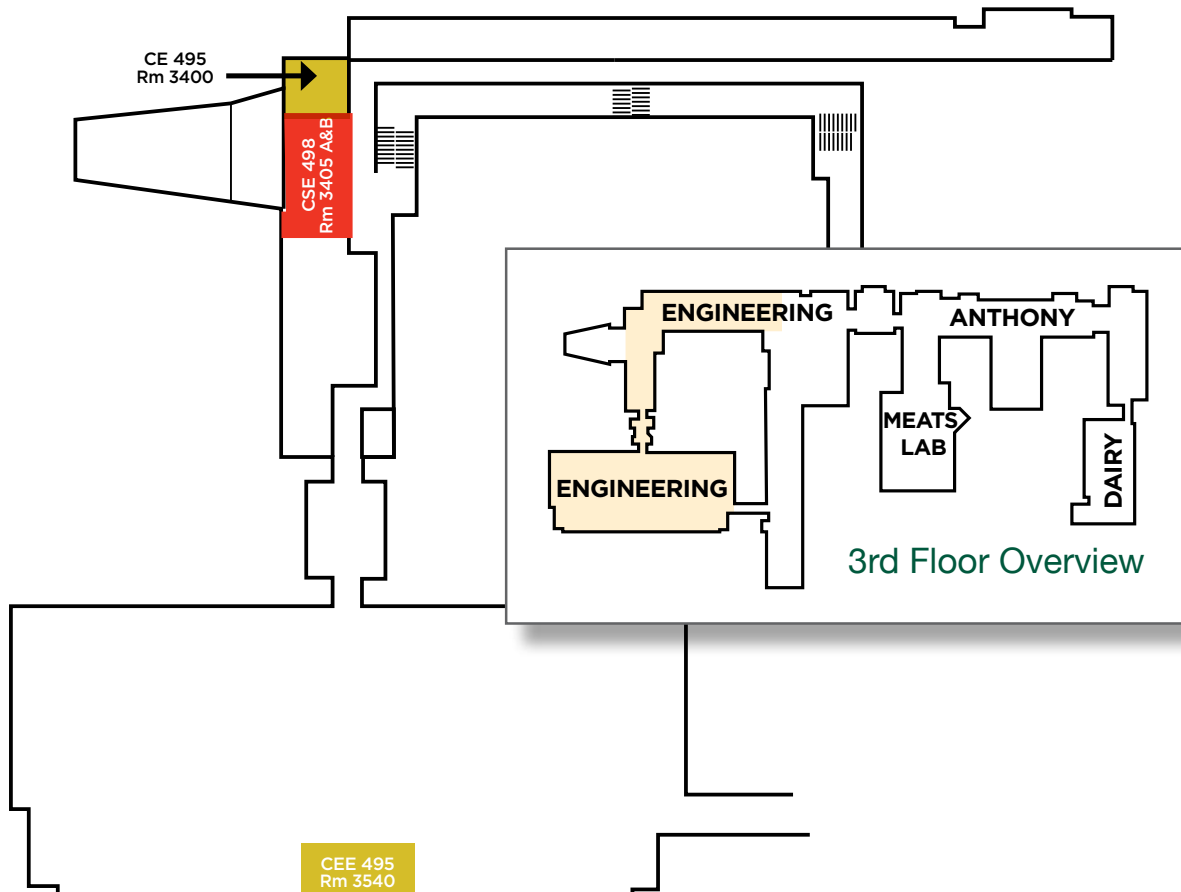
1st Floor Anthony



Color Legend:

| | |
|-------------|-----|
| CEE | CSE |
| ME | ECE |
| Joint/Other | |

3rd Floor Engineering





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Dart Day of Innovation and Creativity *for 7th-12th Grade Students*



Our Future Lies in Some Very Precious Hands...

At the Dart Foundation, we are committed to developing scientifically literate students in Michigan. We're proud to sponsor the MSU College of Engineering Design Day for pre-collegiate students.

Funded by the Dart Foundation



MICHIGAN STATE UNIVERSITY | College of Engineering

High School Innovation and Creativity Day

Precollege Student Voting: During the morning on Design Day all visiting precollege students will be viewing Engineering Projects and voting.

During this time college students will have a chance to interact with “non-engineering” students and demonstrate the underlying principles from their projects. This interaction allows the college students an opportunity to practice explaining engineering concepts to non-engineers. As the precollege students work their way through the wide variety of presentations, they will get an overview of the many different branches of engineering. Additionally, as the precollege students see both entry-level and advanced engineering applications, it allows them to see the natural progression of engineering. Lastly, this session also provides a chance for the precollege students to interact with student organizations within the College of Engineering.

The following schools will be participating in this Fall’s Design Day events: Jackson High School, Kalamazoo Math and Science Center, LIFE Homeschool Co-op, Renaissance High School, Women in Engineering.



| | Room 1279 Anthony Check in | C.E./M.E. Team Build Room 2245 | VEX Robotics Room 2400 | 1st & 2nd Floor Voting/ project viewing | Center for Highway Pavement Preservation Room 2243 |
|--------------------|--|--------------------------------------|---------------------------|---|---|
| 8:00–8:40 | All Schools 1 thru 8 | | | | |
| 8:40–9:30 | | Schools 1 & 2 | Schools 5 & 6 | Schools 3 & 4 | Schools 7 & 8 |
| 9:30–10:20 | | Schools 7 & 8 | Schools 1 & 2 | Schools 5 & 6 | Schools 3 & 4 |
| 10:20–11:10 | | Schools 3 & 4 | Schools 7 & 8 | Schools 1 & 2 | Schools 5 & 6 |
| 11:10–12:00 | | Schools 5 & 6 | Schools 3 & 4 | Schools 7 & 8 | Schools 1 & 2 |
| 12:15–12:30 | All students in Room 1279 Anthony for the awards ceremony. Lunch will immediately follow. | | | | |

<http://www.egr.msu.edu/future-engineer/>  **LIKE US:** <https://www.facebook.com/futurespartanengineers>

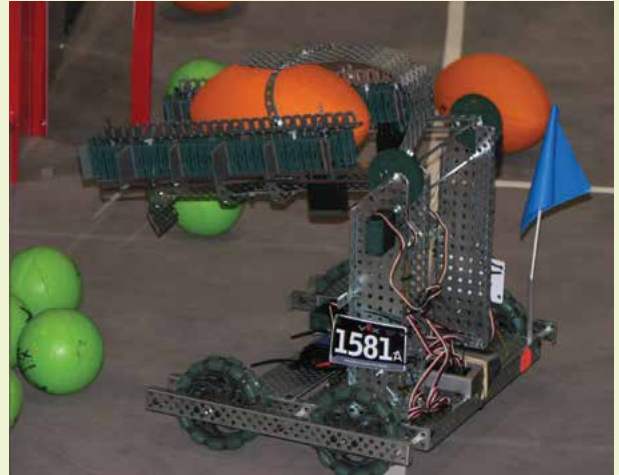
UNIVERSITY TRANSPORTATION CENTER FOR HIGHWAY PAVEMENT PRESERVATION (CHPP)

The need to protect the massive national highway infrastructure investment is recognized by Congress and clearly cited in the “Moving Ahead for Progress in the 21st Century Act” or the “MAP–21.” The establishment of CHPP is consistent with the U.S. Secretary of Transportation’s strategic goal of “State of Good Repair.” The mission of CHPP is aimed at providing a new platform for accelerating innovation in highway pavement preservation. The center will assist in meeting the increasing

demand for highway pavement preservation research and will further the goal of increasing the reliability and performance of the nation’s highways. Encouraging the best and brightest future engineers pursuing degrees and careers in transportation-related engineering disciplines should be a big priority. This CHPP session will center on showcasing innovative, creative, and fun challenges, as well as opportunities for participating high school students and teachers.

VEX ROBOTICS

Our team of experts has designed a lab experience to give precollege students an introduction to robots. Students will work in small groups and have a hands-on approach learning to control the VEX robot. They will write programs using Robot C language, and they will program the robot to be controlled by a remote control. Application and discovery of how programming works will be similar to lessons presented in science and math classes. Each team will discover how to adjust their programs based upon the program inputs and actual output (robot performance). During each phase, new challenges will be introduced to engage the students. This will reinforce new ideas and concepts while exposing students to the newly emerging capabilities of student-controlled robotics programs.



INTERDISCIPLINARY ENGINEERING BUILD

In this build you and your team will be integrating practices from multiple fields of engineering to build and evaluate a support system. Support systems can range from simple beams to intricate bridges composed of gussets, trusses, cables, etc. These types of systems are used throughout Civil, Mechanical and Structural Engineering works. This session will start with a brief introduction to the forces and stresses that act on support systems. Additionally, you will see how digital sensors can read and convey data about these stresses to a computer. We will also look at the computer code that takes this raw data and converts it into a format that can easily be interpreted.

During the build portion of this session you and your team will be given the design constraints for the structure. Utilizing the information learned at the start of the session and the limited materials provided, your team will need to design and then construct a model to be tested. Your finished structure will be placed on one of our

test beds for evaluation. With the help of MSU Engineering students, the results will be collected by a sonic ranging sensor. These data points will be interpreted by the computer program and your team will be evaluated on percent deflection of your support. Throughout this session you will need to listen, learn and utilize your team to be successful. Good Luck.



MEMBERS OF THE ORGANIZING COMMITTEE FALL 2016



Drew Kim
MSU Engineering
Assistant to the Dean
Recruitment,
Scholarships, and
K-12 Outreach



Dean Buggia
Instructor and
Technology
Teacher, Okemos
High School



Rigoberto Burgueno
Civil Engineering
Faculty



Luis Donado
Assistant
Director of MSU
Engineering
Recruitment and
K-12 Outreach



Rachel Esch
K-12 Outreach
Secretary



John Plough
AP Physics Teacher
East Lansing
High School



Bob Watson
MSU Engineering
K-12 Outreach
LEGO and
VEX Robotics
Coordinator



Imen Zaabar
UTC Faculty and
Outreach Team

K12 Awards Spring 2016



Trebuchet Design and Competition

Instructed by Mr. John Plough
Incoming WIE group launches furthest to win!



Bridge Building and Deflection Testing

Taught by Mr. Dean Buggia.
Students from Macomb Math Science Center had the lowest deflection to take the title.



VEX Robotics Programming and Race

Presented by Mr. Robert Watson
Our newcomer, University Prep School from Detroit, won the race. Great job!



ECE 480 Design Award

as voted by the participating high school students
Winners: Great Lakes Controls & Engineering
Regenerative Electric Driven Power Cart
Taught by Dr. T. Grotjohn and Dr. L. Udpal.



ME 371 Best Project Award

as voted by nearly 200 high school students
Winners: "Bribe the Beast"
Dr. B. Thompson is the faculty instructor for the course.



EGR 100 Design Project

EGR 100 Design Project. Only a small number of EGR 100 groups were selected to display at the Design Day. This team is the overall winner selected by participating high schools. Congrats! Taught by Mr. T. Hinds. Dr. P. Walton is the director of the First Year Experience.



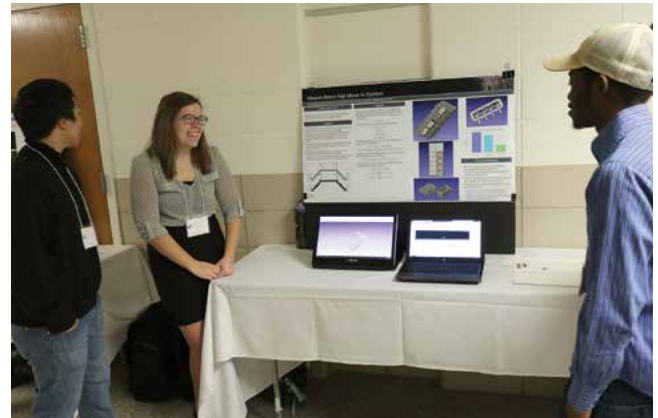
EGR 100 **Introduction to Engineering Design**

Dr. Jenahvive Morgan
Academic Teaching Specialist

Course Project

EGR 100, Introduction to Engineering Design, is a college-level course required of all incoming first-year engineering students. It is an integral part of the CoRe (Cornerstone and Residential) Experience. The course introduces students to the engineering profession and the engineering design process through team-based, interdisciplinary design projects and assignments. There are 1,045 students enrolled in EGR 100 this semester.

For the final course project, the student teams selected from seven project types: (i) Solar Car Competition, (ii) Cell Phone App Inventor, (iii) Robotic Competition, (iv) MSU Adaptive Sports and Recreation Club Project, (v) Residence Education and Housing Services (REHS) Design, (vi) Peckham and RCAH Straw Bale Structure Design, and (vii) CoRe Industry-Sponsored Projects. The Adaptive Sports and Recreation Club project involved the design of an athletic wheelchair support. The REHS project addressed improvements to the residence hall move-in / move-out process, and the Peckham and RCAH Structure included assessments of straw bale structure design. CoRe industry-sponsored projects involved collaborations with ArcelorMittal on an annealing furnace gas sampling system, Delphi on 48-volt mild hybrid architecture, and Tenneco on the design of a pothole reporter. Teams from each of the project types will display their prototypes at Design Day along with posters detailing their design concepts. Pre-college students will recognize the most outstanding projects with awards.



Students presenting Automotive Exhaust System Redesign project at Design Day



MSU Adaptive Sports and Recreation Club



Residential College in the Arts and Humanities



RESIDENCE EDUCATION AND HOUSING SERVICES
RESIDENTIAL AND HOSPITALITY SERVICES



BOSCH
Invented for life

Spring 2016 EGR 100 Project Poster Award Winners:

l-r: Pat Walton, Ben Schafer, Susanne Constantakis, Fiona Muegge, Tim Hinds, Dean Kempel, Peg Asmus Not Pictured: Matt Mastromatteo



<http://www.egr.msu.edu/core/>



EGR 102 **Introduction to Engineering Modeling**

Dr. Janet Lam
Academic Teaching Specialist

Course Project

EGR 102, Introduction to Engineering Modeling, is a course required of the majority of engineering students. It is a foundational course in programming, data management and numerical modeling.

This year, EGR 102 partnered with BP to solve a real-world optimization problem. BP's Whiting plant has a range of turbines that can be run to produce energy. Students used the programming skills learned in class to develop models that would solve a variety of problems, including minimizing emissions, maximizing energy output, and minimizing waste. A select group of EGR 102 projects will be demonstrated.



Students working on projects in the computer lab



BP Whiting Plant



The Capstone Projects

Faculty Advisors:
Professors Haider, Ingle, Kruth, Li and Masten



Haider



Ingle



Kruth



Li



Masten

Presentation Schedule – Room 3400

| Time | Team | Room |
|------------|-------------------------------------|--------------------------|
| 8:00 a.m. | Team 1 – HTGN Engineering | Third Floor Room 3400 EB |
| 9:20 a.m. | Team 2 – Green Line Engineering | Third Floor Room 3400 EB |
| 10:40 a.m. | Team 3 – Spartan Construction, Inc. | Third Floor Room 3400 EB |

Presentation Schedule – Room 3540

| Time | Team | Room |
|------------|------------------------------------|--------------------------|
| 8:00 a.m. | Team 4 – Ember Engineering | Third Floor Room 3540 EB |
| 9:20 a.m. | Team 5 – Sustainable Solutions | Third Floor Room 3540 EB |
| 10:40 a.m. | Team 6 – Engineers Without Borders | Third Floor Room 3540 EB |

CE 495

Senior Design in Civil & Environmental Engineering

Undergraduates in civil and environmental engineering must take CE 495. This capstone course prepares students for the workplace by providing an experience with the following challenges:

- A project with multiple issues that must be resolved using civil and environmental engineering knowledge;
- Formulation of conceptual solutions and resolution of conflicting design elements;
- Development of plans that comply with regulations and provide a basis for cost estimates;
- Balancing individual responsibility and group participation in a team based effort;
- Preparation of written reports and oral presentations.

Each team is responsible for developing a design that addresses environmental, geotechnical, hydrological, pavement, transportation, and structural issues for the project. A student project manager coordinates each team. Design reports are judged by the faculty; progress reports and the oral presentations are judged by a board of practicing professionals.

CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

Michigan State University To Lake Lansing Trail Connector

Meridian Township has proposed a pathway linking Michigan State University to Lake Lansing. Ultimately this project would require about 5 miles of new pathways along a corridor that connects the MSU campus to commercial and employment destinations such as the Meridian Mall, Meijer, as well as other township and county park facilities. The first phase of this project consists of approximately 1.1 miles of pathway running mostly north along the Red Cedar River between Hagadorn Road and Park Lake Road. This phase of the project will include a new pedestrian bridge crossing the Red Cedar River, as well as two separate boardwalk locations.

The preliminary engineering design must identify infrastructure improvements necessary to procure this project for construction. At the west end of the project, the trail will connect to Hagadorn Road at Shaw Lane at an existing pedestrian crossing to the MSU Campus. The trail crosses the Red Cedar River just east of Hagadorn Road from the MSU Community Music School. From that point, the trail will be positioned north of the river banks along various residential (apartments), commercial, and industrial parcels. Initial plans call for approximately 1,200 feet of boardwalk at specified locations due to the topography and access constraints. The project is coupled with potential expansion of the operations at a local brewery near the midpoint of the trail. Ellison Brewery was evaluated for expansion of their production capacity with regards to their water use and wastewater production. These two projects were considered as occurring simultaneously with coordination mutual to the benefit of the public.



Fig. 1: Aerial view of project site

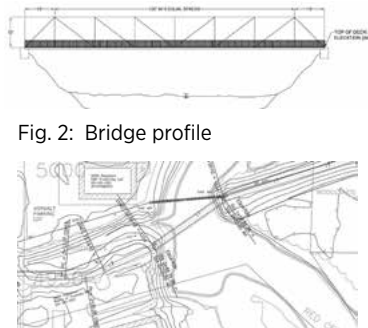


Fig. 2: Bridge profile

Fig. 3: Bridge contour site plan

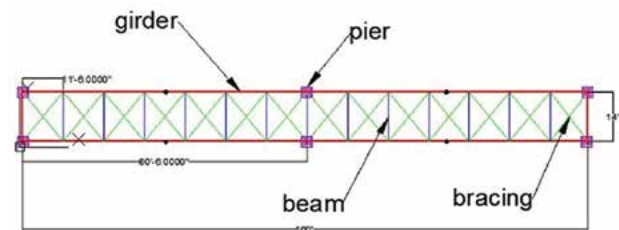


Fig. 4: Bridge Plan View



Fig. 5: Example crossing along Okemos Road

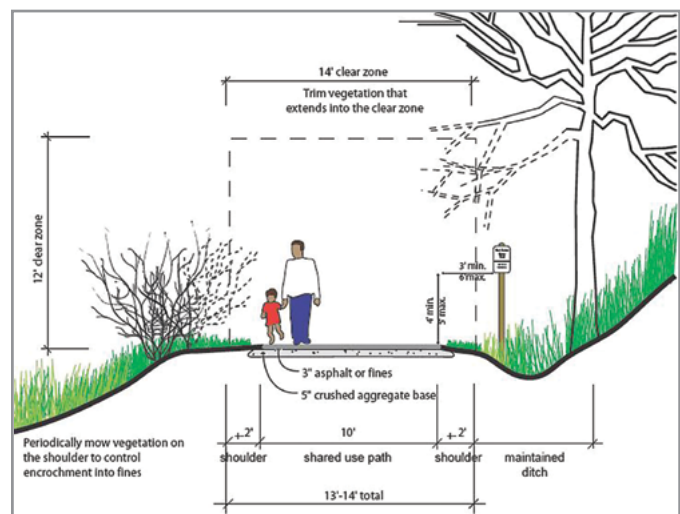
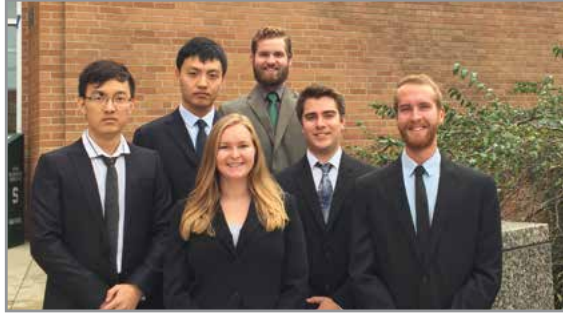


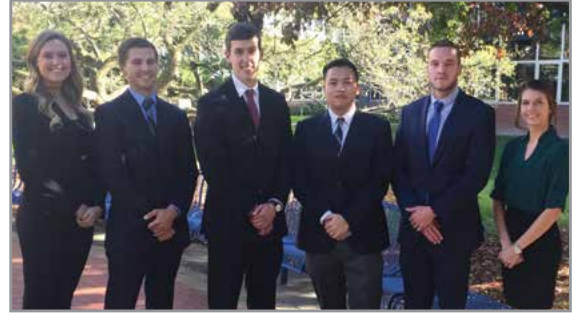
Fig. 6: Pathway cross-section per AASHTO

TEAM 1: HTGN Engineering



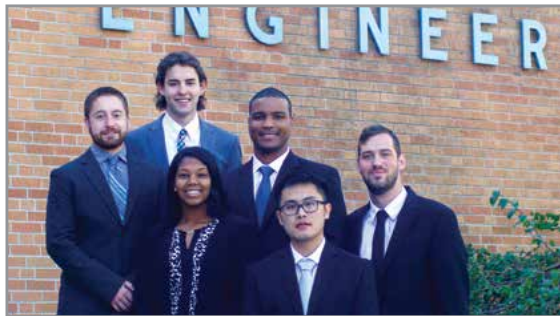
Left to Right: Peiwen Wang (T), Sihao Gu (S), Stephanie Fierens (PM), Nolan Pacitto (H), Ryan Singles (P), Jacob Dolecki (E)

TEAM 2: Green Line Engineering



Left to Right: Emma Floyd (T), Eric Williams (PM), Drew Valentine (S), Xing Su (P), Mitchell Harvey (H), Erin McMachen (E)

TEAM 3: Spartan Construction, Inc.



Left to Right: Mitchel Reed (E), Matthew Sylvester (H), Alyse Way (PM), Kemir Kouassi (P), Zhencheng Yang (S), Cole Moody (T)

TEAM 4: Ember Engineering



Left to Right: Sheng Chen (S), Brandon Vasher (T), Katie Haynes (E), Michael Stevens (PM), Jerome Rogers (P), Andrew Bertapelle (H)

TEAM 5: Sustainable Solutions



Left to Right: Spencer Koblinski (H), Michael Bucrek (S), Alexandria Burt (PM), Yuanpeng Wang (P), Dandre Walker (E), Jacob Swanson (T)

Key to primary roles and responsibilities of each team member:

E = Environmental, G = Geotechnical, H = Hydrology,
P = Pavements, PM = Project Manager S = Structures,
T = Transportation

TEAM 6: Engineers Without Borders



Left to Right: Anna Nguyen, Anthony Dilernia, Nathaniel Weeks, Kelsey Khoury

Team 6 has a special project in cooperation with Engineers without Borders (EWB) working on the design of a Rainwater Collection and Purification System in Buyuni, Tanzania. Buyuni is a rural community located 40 kilometers from the city center of Dar es Salaam, the capital of Tanzania. The completed system will include collection, storage, treatment, and distribution of collected rainwater. With the construction of the school and water supply, the children would no longer have to travel 3 hours a day to/ from school. The scope of work includes the design of a rainwater collection system and purification system (including all piping, valving, and tanks). This project is scheduled for construction next summer.

CE 495 SENIOR DESIGN IN CIVIL & ENVIRONMENTAL ENGINEERING

PROFESSIONAL SEMINAR SPEAKERS

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Detroit Diesel

Emin Kutay, Ph.D.
Michigan State University

Cheryl A. Kehres-Dietrich, CGWP
Soil & Materials
Engineers, Inc.

Ryan D. Musch, P.E.
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PROFESSIONAL EVALUATORS

Engineers and scientists associated with the following firms, municipalities, and companies donated time to provide students with a practicing professional's perspective. We gratefully acknowledge their generous contributions.

Daniel Christian, P.E.
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Tyler Dawson, P.E.
NTH Consultants

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Lauren Warren, P.E.
Parsons Brinckerhoff

Design Day Awards Spring 2016

Rolla C. Carpenter Senior Design Award

The Rolla C. Carpenter Senior Design Award (\$700 and plaques) is presented to the best team as judged by the faculty and a panel of practicing engineers.

Rolla C. Carpenter, Renaissance Engineer, was a graduate of The State Agricultural College in 1873 with a Bachelor of Science degree. After earning a Master of Science Civil Engineering, he was appointed professor of the Department of Mathematics and Civil Engineering at the State Agricultural College, which would later become MSU. He designed bridges, built ice houses, taught students French, astronomy, mathematics, mechanical drawing, hydrostatics, hydraulics, survey, and civil engineering. He prepared the design and working drawings for the Farm Lane Bridge, laid a water supply pipe to Williams and Wells Halls, and designed a pile driver for a dam built across the Red Cedar River. He later designed several buildings on campus, including the Mechanical Building, which was constructed in 1885. Throughout all of his work on campus, he involved students throughout the analysis, design and construction, forming what was essentially the first senior capstone design class.



The faculty and students of the Department of Civil and Environmental Engineering gratefully acknowledge the generous contributions from Fishbeck, Thompson, Carr & Huber, Inc. (FTC&H) and Barr Engineering Co.

Rolla C. Carpenter Senior Design Award Winners, Spring 2016

Coulton Pierce, Vivian Ruffolo, Michael Baker, Melanie Kasten, Chris Powell, Veronica Crowley, and Anuj Thaker



Computer Science and Engineering

Capstone Course Sponsors

We thank the following companies for their generous support of the computer science capstone course.



Detroit, Michigan & Seattle, Washington



Detroit, Michigan



Lansing, Michigan



Venice, California



Dearborn, Michigan



Warren, Michigan



Grand Rapids, Michigan



Mountain View, California



East Lansing, Michigan



Indianapolis, Indiana



Grand Rapids, Michigan



Mountain View, California



Okemos, Michigan



Detroit, Michigan



Benton Harbor, Michigan



Chicago, Illinois



The Capstone Projects

Dr. Wayne Dyksen
Professor of Computer Science and Engineering

Spencer Ottarson
Teaching Assistant



Presentation Schedule – Engineering Building, Room 3405

| Time | Team | Project Title |
|------------|-----------------|--|
| 7:30 a.m. | Amazon | Asa: Your Amazon Shopping Assistant |
| 7:46 a.m. | Auto-Owners | Mobile Event App |
| 8:02 a.m. | Avata | Security Analytics Suite: Dataset Merger Tool |
| 8:18 a.m. | Ford | SYNC Calendar |
| 8:34 a.m. | GM | Gemini: Predictive Rich Cards |
| 8:50 a.m. | Meijer | Intelligent Shopping List |
| 9:06 a.m. | Mozilla | Improvements to Select Dropdown for Firefox |
| 9:22 a.m. | MSUFCU | Member Ratings and Reviews |
| 9:38 a.m. | Break | |
| 9:53 a.m. | Quicken Loans | Pharos: Hiring Process Automation |
| 10:09 a.m. | Rook | Anomaly Detection Suite v2.0 |
| 10:25 a.m. | Spectrum Health | Healthier Communities Time Banking |
| 10:41 a.m. | Symantec | Web Frameworks for Multi-Factor Authentication |
| 10:57 a.m. | TechSmith | Video Sentiment Analysis |
| 11:13 a.m. | Urban Science | Dealership Simulator 2017 |
| 11:29 a.m. | Whirlpool | Mooch |
| 11:45 a.m. | Yello | Visualizing Dynamic Data Exploration |

CSE 498 Collaborative Design

CSE498, Collaborative Design, provides the educational capstone for all students majoring in computer science. Teams of students build software systems for corporate clients.

During the capstone experience, students:

- design, develop, debug, document, and deliver a comprehensive software system for a corporate client,
- work in a team environment,
- develop written and oral communication skills,
- become proficient with software development tools and environments,
- build and administer computer systems, and
- consider issues of professionalism and ethics.

Our clients are local, regional, and national including Amazon, Auto-Owners Insurance, Avata Intelligence, Boeing, Bosch, Chrysler, Dow Chemical, Electronic Arts, Ford, GE, General Motors, Google, IBM, Meijer, Microsoft, Mozilla, MSU Federal Credit Union, Quicken Loans, Spectrum Health, Rook Security, Symantec, TechSmith, Urban Science, Whirlpool and Yello.

Amazon

Asa: Your Amazon Shopping Assistant

Amazon is the largest e-commerce company in the world, accounting for 1 in 3 shopping transactions in North America.

The number of active users on messaging platforms reached 3 billion in 2015. Asa is a shopping assistant chatbot who allows Amazon to access this market. She helps users discover and purchase items through conversations on Facebook Messenger.

Asa's core functionality enables users to search for items and ask for product recommendations.

For example, if a user says, "I'm looking for Animal Farm by George Orwell," Asa replies with a collection of Amazon listings for the book Animal Farm along with purchase links.

Through these conversations, Asa learns about each user and tailors future product recommendations based on what she learns. If a user asks, "Can you recommend a good book?" Asa sends a list of books based on that user's past purchases.

Users can also ask Asa to remind them to do something, such as buying a gift for their mother or purchasing textbooks before the start of the semester.

To learn how to shop with Asa, users can ask her for help at any time. Asa responds with an instructional message that gives examples of ways to chat with Asa, including examples of how to ask Asa questions.

Asa is written in JavaScript and hosted on AWS Lambda. Asa uses Wit.ai for natural language processing and AWS DynamoDB for persisted data storage.



Michigan State University

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Auto-Owners Insurance Mobile Event App

Celebrating its 100th anniversary, Auto-Owners Insurance is a Fortune 500 company working with more than 6,200 independent agencies in 26 states.

Auto-Owners regularly hosts events ranging from conferences for their associates to golf outings for their agents to recruiting events for prospective employees, as well as many others.

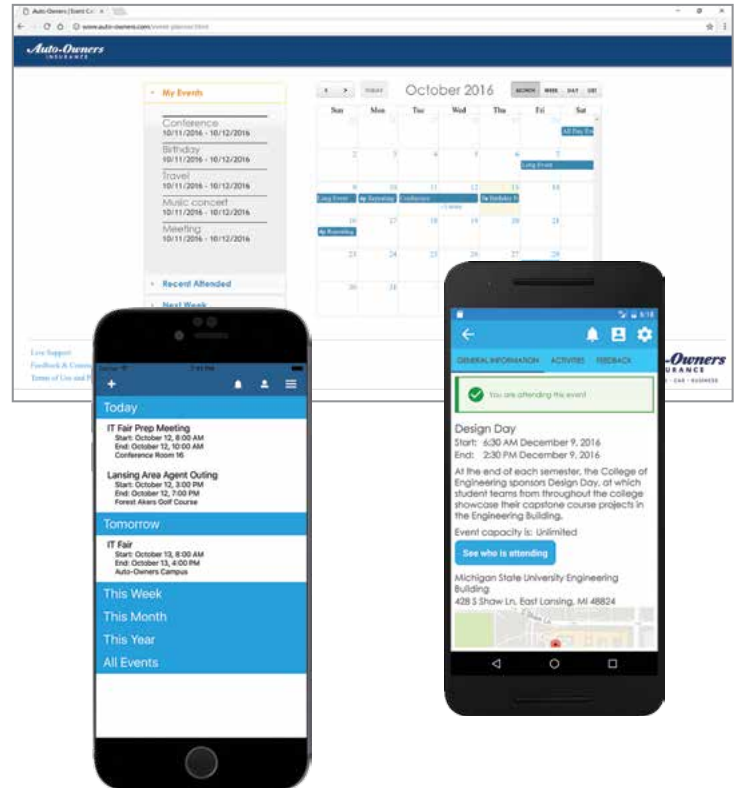
These events vary significantly, with each designed for a specific purpose. Distribution materials describing an event may be a brochure or a website. Variations include other things like maximum capacities or options like breakout sessions.

Our Mobile Event App with its companion web app enables Auto-Owners and their guests to manage events.

Event administrators use our web app to create events including all of the relevant information and to send invitations to prospective attendees. Administrators can view lists of registered attendees along with waiting lists for events over capacity. They can create customized surveys to garner feedback about events in order to improve future events.

After receiving an event invitation, attendees use our mobile app to view the event details and RSVP. If the event is at capacity, an invitee can be placed on a waiting list and get information about similar future events. Attendees can view a list of the specific event activities so they can build a personal agenda for the event.

Our Mobile Event App, written in Swift and Java, runs on most iOS and Android devices. Our web app, written in PHP, runs on most browsers. They connect through an SQL database hosted on a Microsoft 2012 R2 server.



Auto-Owners
INSURANCE
LIFE • HOME • CAR • BUSINESS



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Avata Intelligence

Security Analytics Suite: Dataset Merger Tool

Avata Intelligence leads the security industry in artificial intelligence and advanced analytics, supporting world organizations with integrated data-driven solutions.

For example, law enforcement units can use Avata's platform to analyze crime records to predict when and where future crimes will occur. Rather than patrolling randomly or uniformly, officers can patrol when and where crimes are more likely to occur, thereby increasing safety and security.

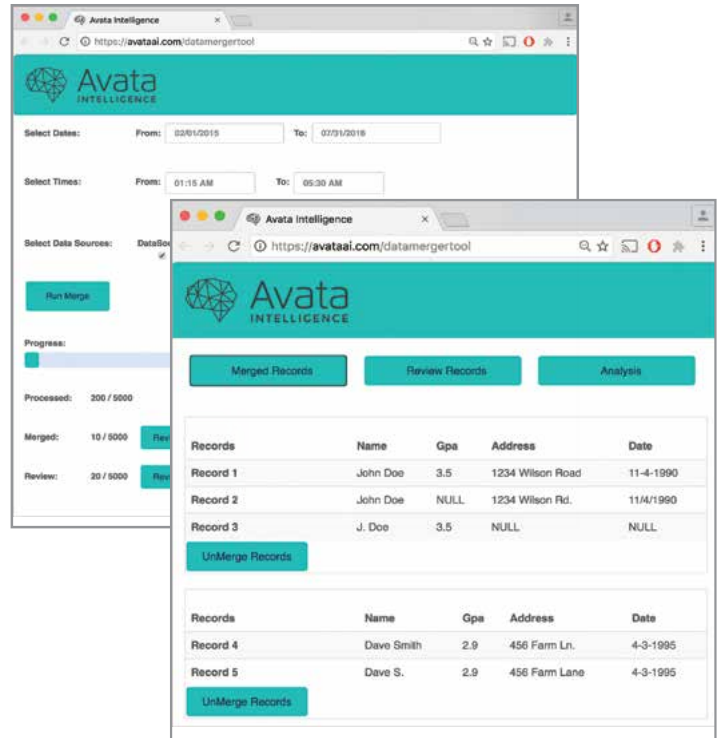
Accurate analysis of crime records depends on having accurate data. Slightly different entries from different sources often represent the same crime. If there are duplicate copies of the same incident, the system may falsely predict this crime to be more common than it truly is. Unfortunately, such datasets are way too large to be checked manually for duplicates.

Our Dataset Merger Tool is a web app that automatically identifies and merges duplicate records within and across datasets in the Avata platform.

After a user selects data sources to be merged, our system uses advanced algorithms to identify duplicate records. When records are identified as duplicates with high similarity, the records are merged automatically. Potential duplicates that fall below a certain similarity threshold are presented to the user for approval before merging.

Upon completion, our system produces a report containing information useful for analyzing the resulting data integrity.

Our Dataset Merger Tool is written in ReactJS for the front-end and Java for the back-end, utilizing the Spring Boot framework. Datasets are stored in a MySQL database.



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Ford Motor Company

SYNC Calendar

Ford Motor Company is a Fortune 500 company headquartered in Dearborn, Michigan. Last year, Ford sold over 3 million vehicles in North America while employing over 199,000 employees worldwide.

The average American spends over five hundred hours per year in their car, time which is often time wasted. For many, time is their most precious resource.

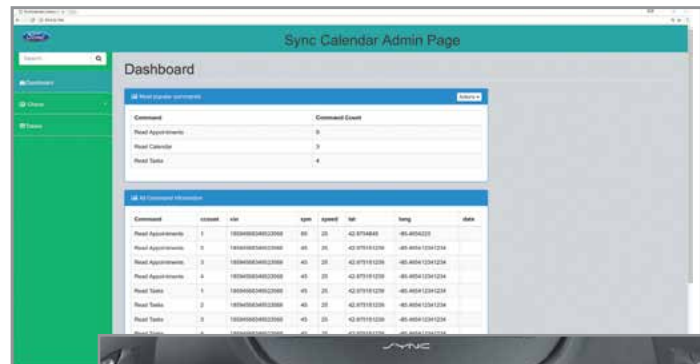
SYNC Calendar enables drivers to interact with their mobile calendar while driving in their Ford vehicle. With SYNC Calendar, the time spent driving may be used more productively.

SYNC Calendar is a SYNC AppLink application, which connects a third-party calendar service, such as Google Calendar, with the Ford SYNC onboard vehicle system.

Upon entering a vehicle, a driver is automatically prompted to sign in with their Google Calendar login credentials. Once connected, the driver can access and update their calendar using SYNC voice commands and the SYNC dashboard.

Using our companion web app, Ford analysts can view vehicle usage statistics related to SYNC Calendar, such as the most frequently used commands. Our web app presents data visually with user-friendly charts and graphs. These analytics enable Ford to optimize and improve the app in the future.

SYNC Calendar is a mobile app for Android and iPhone devices, written natively in Java and Objective-C, respectively. The administrative web app stores all data in a Microsoft SQL database.



Sync Calendar Admin Page

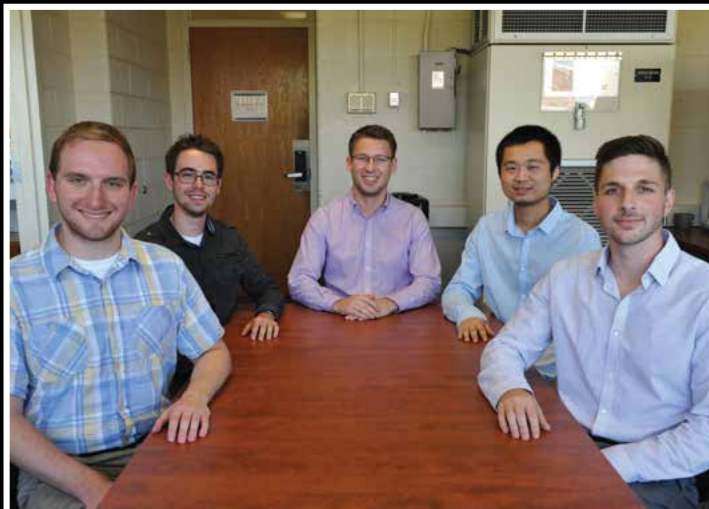
Dashboard

Command Count

| Command | Count |
|-------------------|-------|
| Read Appointments | 9 |
| Read Calendar | 3 |
| Read Tests | 4 |

All Command Observations

| Command | Account | Lat | Long | Speed | Alt | Temp | Date |
|-------------------|---------|-----------|------------|-------|-----|-----------|------------|
| Read Appointments | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
| Read Appointments | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
| Read Appointments | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
| Read Appointments | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
| Read Appointments | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
| Read Tests | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
| Read Tests | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
| Read Tests | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |
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| Read Tests | 1 | 18.000000 | -82.000000 | 80 | 25 | 43.075000 | 01-05-2016 |



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General Motors

Gemini: Predictive Rich Cards

General Motors is one of the world's foremost designers and manufacturers of cars and trucks sold in more than 120 countries. Headquartered in Detroit, GM has over 215,000 employees.

GM's Warren Technical Center comprises over 40 buildings covering one square mile, and is home to one out of ten GM employees.

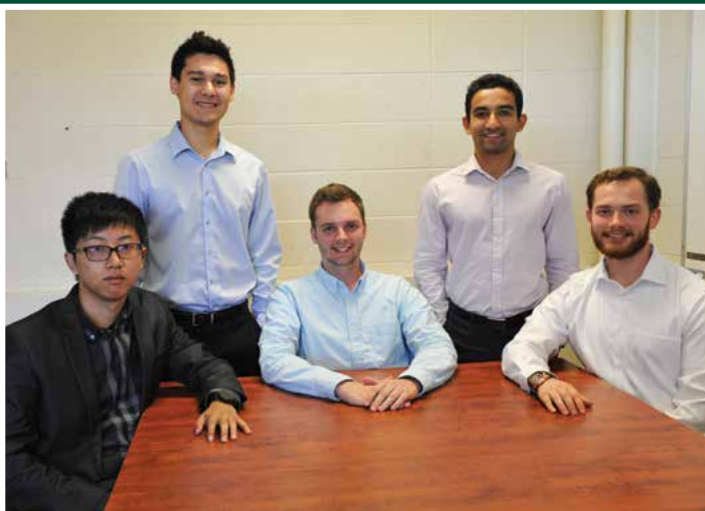
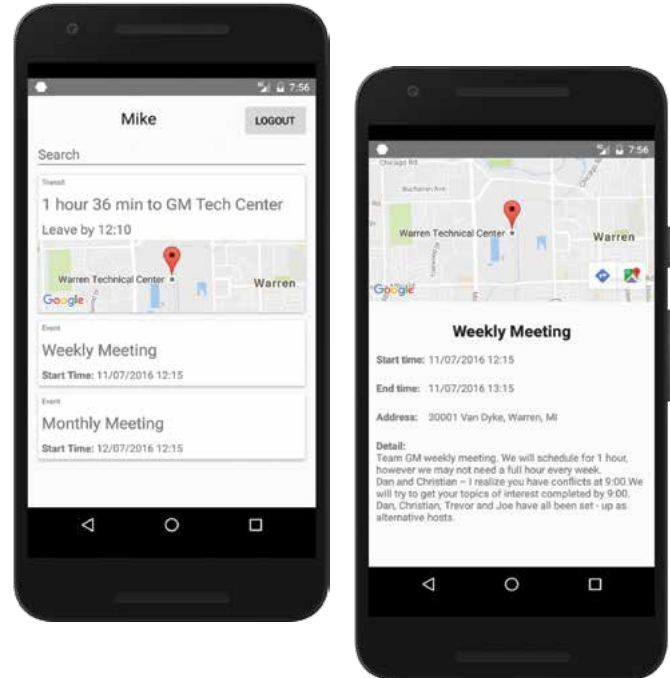
Our Gemini mobile app uses predictive rich cards to help GM employees navigate the expansive Warren campus and to manage their busy workday efficiently.

After learning about a GM employee and their typical workday, Gemini provides many helpful services. For example, it may remind them to send a follow-up email, suggest they schedule a shuttle to a distant meeting, or provide a list of close and available conference rooms when creating a meeting.

Employees using Gemini are able to spend more time on their work and less time on repetitive tasks. By drawing from geographic location, emails, search history and calendars, Gemini is able to assist users by suggesting what they may want to do next. This predictive nature is the focus of Gemini's user experience.

A central aspect of Gemini's interface is the use of cards. Similar to a physical notecard, Gemini's cards present a summary of information to the user and, when selected, present a more detailed view of that information.

Written using Xamarin, a cross platform framework, our Gemini app runs on both Apple iOS and Google Android devices.



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Meijer

Intelligent Shopping List

Meijer is one of the country's largest supercenter chains, providing high quality food and merchandise in six states across the Midwest. Meijer is leading the fast moving retail market with innovative products and services.

Our Intelligent Shopping List app automatically generates a personalized shopping list for Meijer customers, thereby streamlining the time spent on repeat purchases and potentially eliminating the need to go to the store all together.

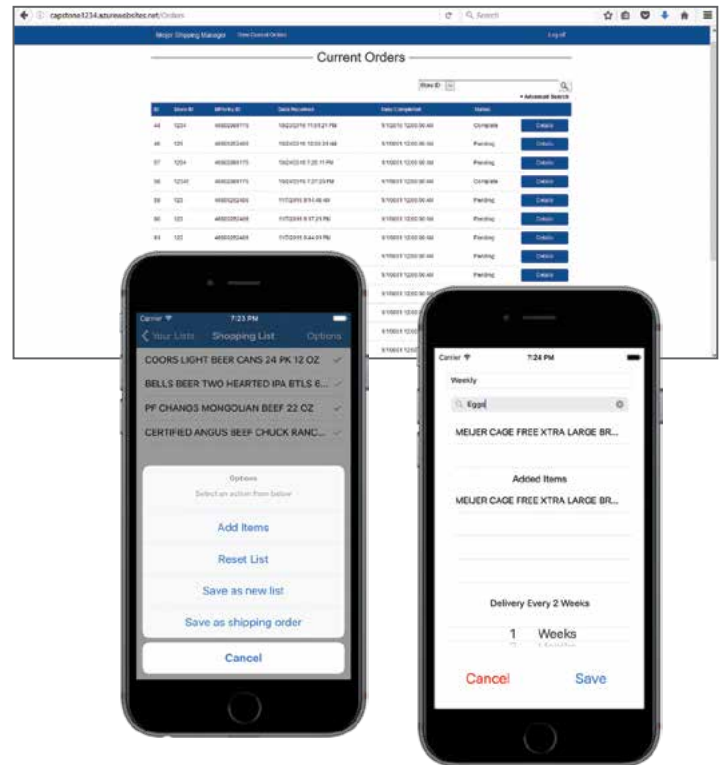
mPerks is Meijer's customer loyalty program. Among other features, customers use mPerks to receive and redeem coupons at checkout.

Our app uses a customer's mPerks account history to create a personalized shopping list based on previous purchases and buying habits. It uses frequency of purchases, quantity of items purchased and time of year. Once automatically created, Meijer customers can edit their shopping list.

In addition to in-store shopping lists, customers can create shipping lists to have items shipped directly to their home at a frequency of their choosing. Deliveries can be suspended and resumed at any time.

Meijer associates use a companion web app for home delivery order fulfillment. With it, they view all pending and completed orders.

Our Intelligent Shopping List app is written using Xamarin and runs on any iOS device. Our companion web app uses Microsoft's .NET framework and is deployed in Microsoft Azure cloud services.



meijer



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Mozilla Foundation

Improvements to Select Dropdown for Firefox

Mozilla is a global, nonprofit organization dedicated to improving the World Wide Web. Mozilla's international community of developers creates open source software such as Firefox, which is the second most popular web browser with about 16% of worldwide usage.

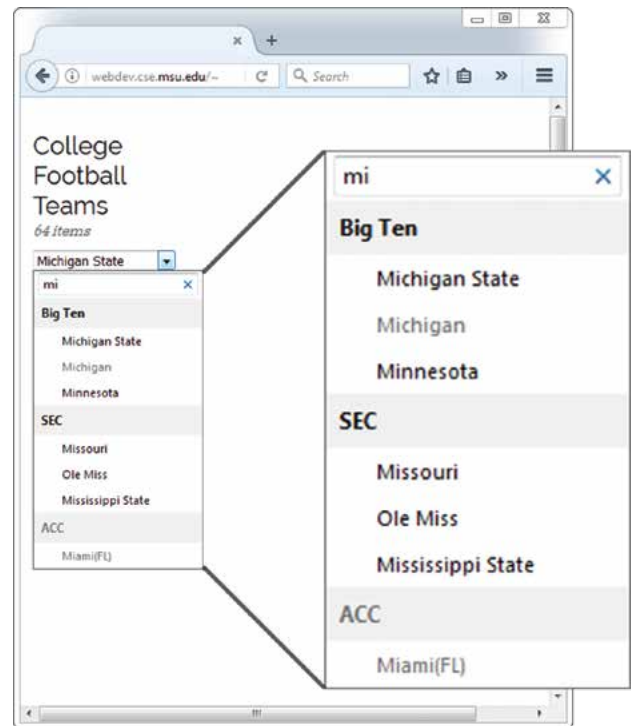
Currently, Firefox is undergoing the largest redesign in its history. This redesign involves new styling, new features and new ways for Firefox to do multiple tasks simultaneously.

Options in Firefox are often presented to users in the form of a list like the one at the right, which is called a "select dropdown." Our improvements to the select dropdown implement the new Firefox styling and add new search features. Our improvements provide a more modern and faster web browsing experience.

With our new search functionality, users can find items in a long dropdown list quickly by typing a few letters from the item of interest, like the example of typing "mi" shown at the right. Only the list items that contain these search letters appear in the list, thereby shortening the list and making it much easier to find the desired item.

Our improved select dropdown also features enhanced styling with modern web fonts used by the computer on which Firefox is running, which gives a more seamless and familiar browsing experience to roughly half a billion Firefox users worldwide.

Our improvements to the select dropdown require the addition of code in many sections of Firefox's 4.5 million line code base. Our code is written in C++, JavaScript and XUL. The new styling is accomplished with CSS.



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Fred Luo
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Mozilla

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MSU Federal Credit Union Member Ratings and Reviews

Founded in 1937, Michigan State University Federal Credit Union serves the Michigan State community, as well as the Oakland University community. MSUFCU provides financial security and exceptional service to its members. MSUFCU has 17 branches, over 228,000 members, and more than \$3.28 billion in assets.

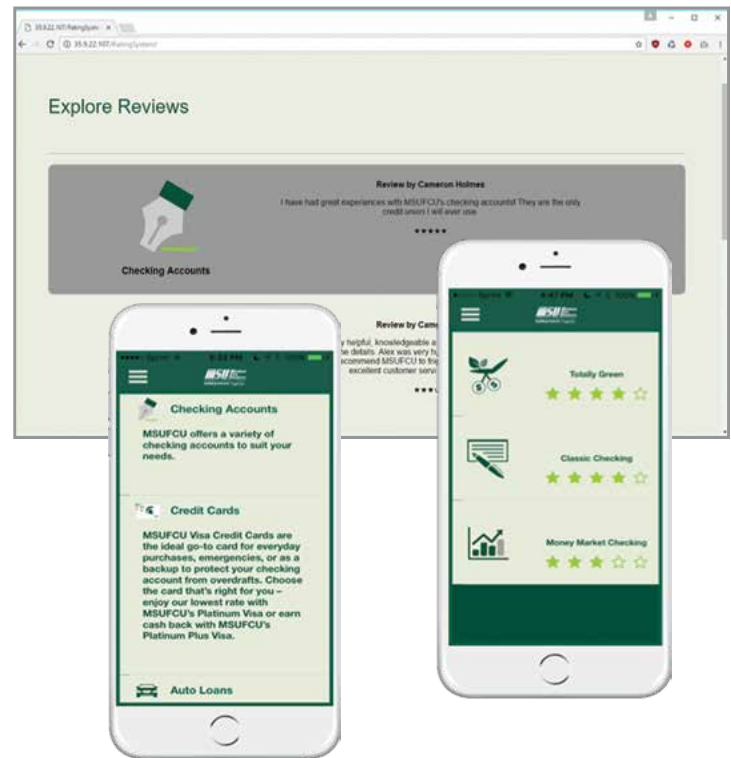
Our Member Ratings and Reviews system enables MSUFCU members to provide feedback on MSUFCU products and services. Members can give ratings from one to five stars and write reviews for any product or service, or the customer service related to any product or service.

MSUFCU members can browse reviews by category, sort them by rating or helpfulness, and filter them by keyword. Members can comment on or rate the helpfulness of a review.

A user preferences page allows members to upload a profile picture or set a display name. Members can also check a box to remain anonymous to other members when posting.

An administrative dashboard gives MSUFCU staff access to detailed information about the reviews for each product. MSUFCU staff can reply to member reviews to get more information from members about their experiences, or to assist with members' issues or concerns.

Our Member Ratings and Reviews web app is written in HTML, CSS, JavaScript and PHP. The mobile versions are native apps written in Swift for Apple iOS and Java for Google Android devices. All three interface with a MySQL database.



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Quicken Loans

Pharos: Hiring Process Automation

Quicken Loans, based in Detroit, Michigan, has been providing affordable mortgages and award-winning client service for more than 30 years. It is the nation's largest online mortgage lender.

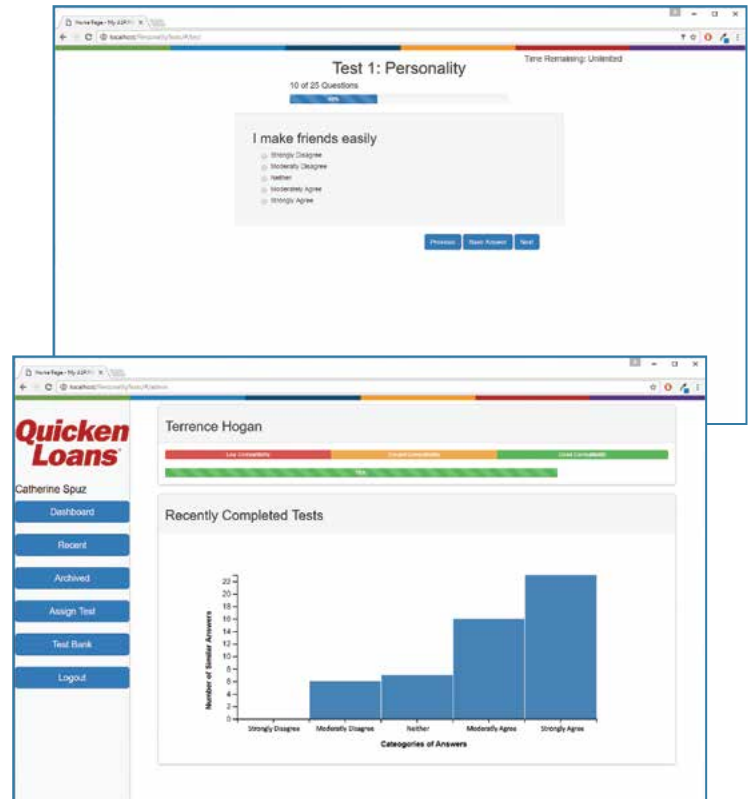
Identifying and recruiting the very best talent is key to Quicken Loans' success. Unfortunately, the interview process is not an exact one and has the potential to produce inconsistent results.

Our Pharos software system removes the potential subjectivity of interviews by administering personality and intelligence tests to job candidates. In addition, our app determines whether or not a recruit is compatible with Quicken Loans' corporate culture.

After logging into Pharos, recruits are presented with a dashboard of the tests that they can complete. For timed tests, a clock appears indicating the time remaining. A progress bar indicates how many questions are left. When a test is completed, the test link on the dashboard is disabled, thereby preventing users from retaking a test.

Quicken Loans associates use our Pharos' administrative dashboard to create a test, view available tests, assign a test to a recruit, and view test results. The test results are summarized graphically in a clear and concise manner, which gives the Quicken Loans associate an easy way to digest large amounts of data.

Our Pharos web app is written in C#. It runs on the ASP.NET Web API and uses JavaScript with an AngularJS frontend framework. D3.js is used to handle data analytics and visualization. Our platform is supported by a MySQL database which stores recruit information.



Quicken Loans®
Engineered to Amaze®



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Rook Security

Anomaly Detection Suite v2.0

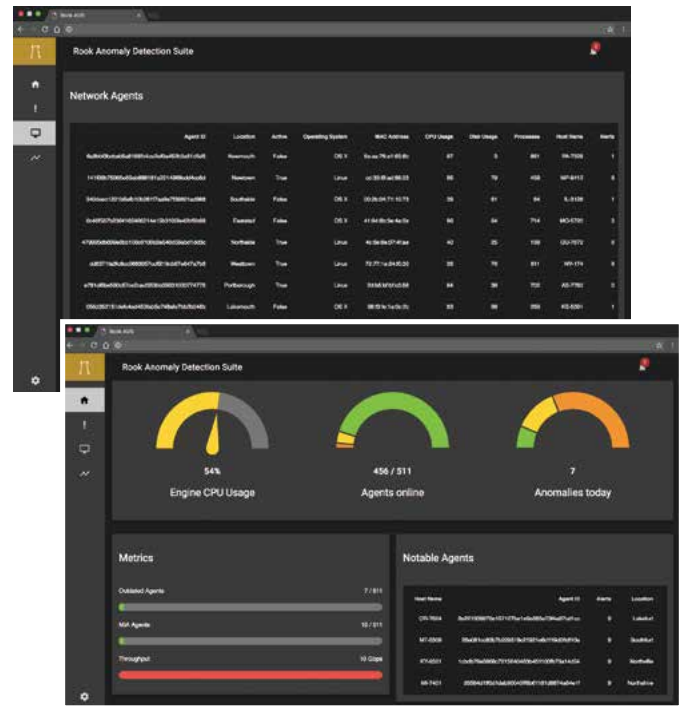
Rook Security, based in Indianapolis, Indiana, is a managed threat response force that is dedicated to providing global IT security solutions that anticipate, manage and eliminate threats.

Among Rook's security solutions is the Anomaly Detection Suite (ADS) v1.0, which clients use to protect their networks against a wide range of cybersecurity threats. Through network traffic analysis, a specialized computer running patent-pending Rook software detects anomalies allowing action to be taken before an attack occurs. However, the recent advent of large-scale, cloud-based, virtual computing creates a need for a more distributed approach.

Our ADS v2.0 adds new capability by deploying highly specialized "intelligent" agents running on all of the client's computers. These agents perform analysis locally, thus creating a distributed workload model. ADS v2.0 uses machine learning to detect attacks sooner and with greater accuracy.

In addition, ADS v2.0 includes a new web-based management dashboard providing real-time visual representations of detected anomalies, threat statistics, as well as information regarding agent health. The dashboard allows admins to deploy and configure agents remotely. It also ensures that analysts can quickly find and act upon infringing anomalies, as well as ensures that all agents are working properly.

Our ADS v2.0 agent software is written in C for both Windows and Linux. Our ADS v2.0 dashboard is written in JavaScript using ReactJS and is supported by a RESTful Python web service, which leverages the Django framework.



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Spectrum Health

Healthier Communities Time Banking

Spectrum Health, located in Grand Rapids, Michigan, provides high quality, high value healthcare through its seven hospitals, more than 140 service sites, and Priority Health, a health plan with nearly 500,000 members.

Spectrum Health's patients include homebound adults who often lack family and friends to care for them. Without caregivers, homebound adults can become lonely and even depressed, resulting in a poor quality of life.

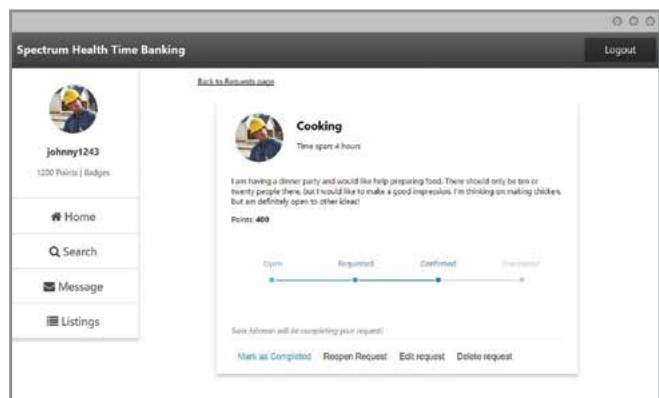
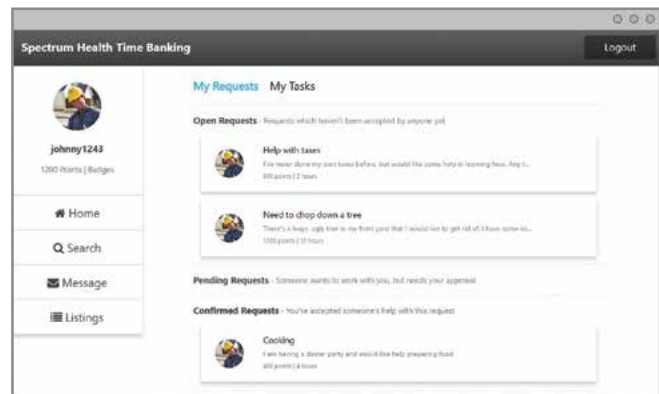
Our Healthier Communities Time Banking social web app connects homebound adults with volunteer caregivers. Homebound adults can post requests for services. Volunteer caregivers are able to browse these requests and respond.

For example, homebound users themselves may be able to fulfill requests of other homebound adults by providing help with using a computer. Users requesting a service can offer payment in the form of "time banked" when helping others, thus giving them the much needed feelings of being useful and having a purpose.

Our chat system also enables homebound adults and volunteer caregivers to chat with each other. Users can set up fulfillment of requests or just talk with each other and get the socialization that all humans need.

By enabling caregivers to provide for their needs, our app is improving the lives of homebound adults throughout West Michigan.

Our Healthier Communities Time Banking web app utilizes Angular 2 and .Net Core for MVC and WebAPI utilization.



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Symantec

Web Frameworks for Multi-Factor Authentication

Countering the threats of tomorrow, Symantec Corporation is a global leader in cybersecurity technologies. Located in Silicon Valley, Symantec offers software solutions and services related to information and computer protection.

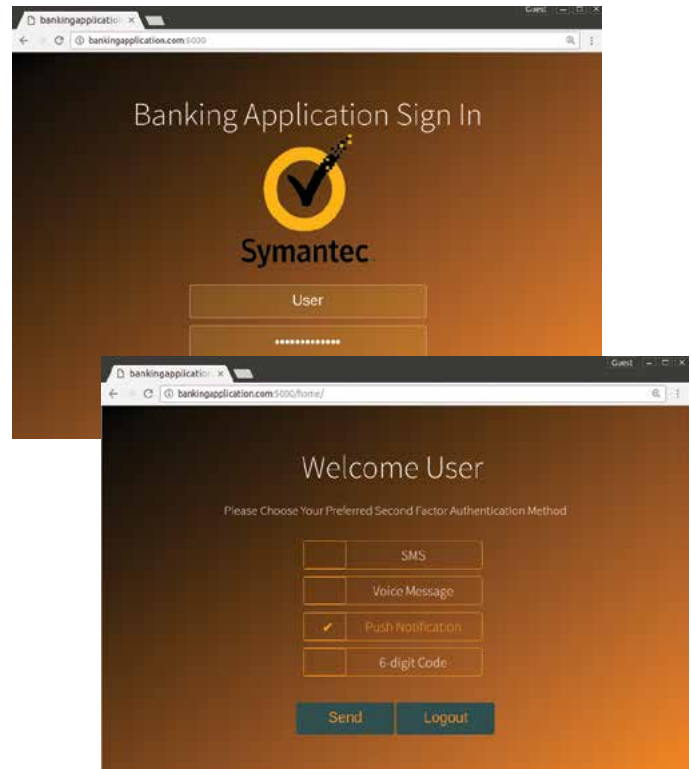
Currently, users' data is protected often with only a password, which is no longer adequate. One approach to increase security is to use two-factor authentication (2FA), which adds a second factor such as a security code sent as a text message.

Symantec provides a 2FA product called Validation and ID Protection, also known as VIP Service, which is a Simple Object Access Protocol (SOAP) web service. Unfortunately, using the XML-based SOAP APIs is challenging in modern web frameworks, creating a barrier to entry that is significant enough for most developers to choose a competitor's 2FA product.

Our Web Frameworks for Multi-Factor Authentication enables developers to integrate Symantec's VIP easily into any modern web framework. We provide software development kits (SDKs) for three of the most widely used web technologies: Ruby, Python and Node.js. Using our SDKs, developers can implement Push, SMS, voice code or VIP 6-digit security code methods as a second factor of authentication.

Sample applications demonstrate the ease of making and receiving function to VIP Service calls in native programming language. Along with these sample applications, documentation is available on the GitHub.

Open-source SDKs are provided for Ruby, Python and Node.js on the Ruby Gems, PyPi and NPM repositories, respectively.



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TechSmith

Video Sentiment Analysis

Located in Okemos, Michigan and founded in 1987, TechSmith creates software platforms that enable users to share ideas and information in dynamic and engaging ways.

One of TechSmith's flagship products, Camtasia, makes video creation easier now than ever before. Yet, producing good content is still a challenge because it's very difficult to obtain accurate feedback from viewers. Often, comments and ratings reveal very little about a video's actual impact on viewers.

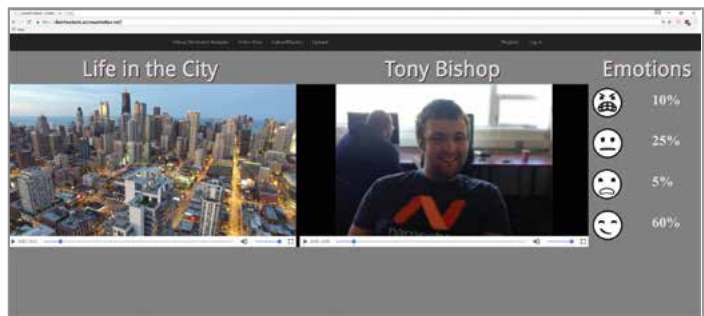
Our Video Sentiment Analysis (VSA) system records reactions of a viewer to a video without any interactions other than watching the content using our player app.

VSA determines the viewer's emotions automatically by analyzing a video recording of the user watching the video. VSA also records the viewer's usage of media controls including playing, pausing and skimming.

In addition to our video player, our VSA system provides a web app for video authors. Viewers are selected and sent an email invitation to view a video using our player app. As part of accepting the invitation, viewers agree to return their usage data and webcam footage for analysis.

The video author then uses our web app to analyze a viewer's responses. By looking at a specific response, an author can see the emotional state of the viewer, and determine whether or not the video is eliciting the desired reaction.

Video Sentiment Analysis is comprised of a Universal Windows app and a website. The app is developed with C# and XAML. The website is built with ASP.NET on Azure.



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Urban Science Dealership Simulator 2017

Urban Science delivers consulting and software solutions that help automotive clients increase market share and boost profitability through high performing retail networks.

In order for all Urban Science associates to be most effective, it's important for them to understand how automobile dealerships work. In particular, it's important for them to understand how different factors, called key performance indicators (KPIs), affect the success of a dealership.

Urban Science associates learn about running an automobile dealership by playing our video game, Dealership Simulator 2017. With each turn, players adjust KPIs on a month-by-month basis to see the effects on their dealership.

Our game provides very accurate business scenarios since the calculations for the simulated dealership in the game are based on data from actual dealerships in the real world. Players quickly learn that some KPIs have a much greater impact than others on a dealership's profitability.

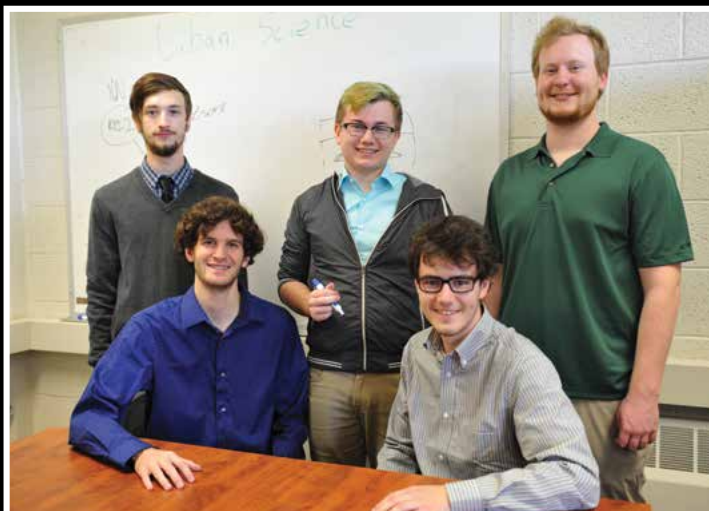
Dealership Simulator 2017 is easy for anyone to learn how to play. In addition to profitability, players see the cars in their lot, depending on how many and what type of cars they buy each turn.

Our game runs in any web browser as well as on Apple iPads and on Google Android devices.

Dealership Simulator 2017 is written with the Unity3D game engine and C# scripting. Our backend uses a Windows Server with PHP and SQL to implement our database.



URBAN SCIENCE.



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Whirlpool Corporation Mooch

The Whirlpool Corporation is the world's leading manufacturer of major appliances. With over \$20 billion in annual sales, Whirlpool's extensive brand portfolio includes Whirlpool, KitchenAid, Maytag and more.

The food market in the U.S. is a \$1 trillion business. Yet, only half of this figure is attributed to eating at home, and nearly 40% of all food goes to waste.

Our mobile app Mooch makes it easy for people living in housing communities like apartment buildings or condominium complexes to share and sell food.

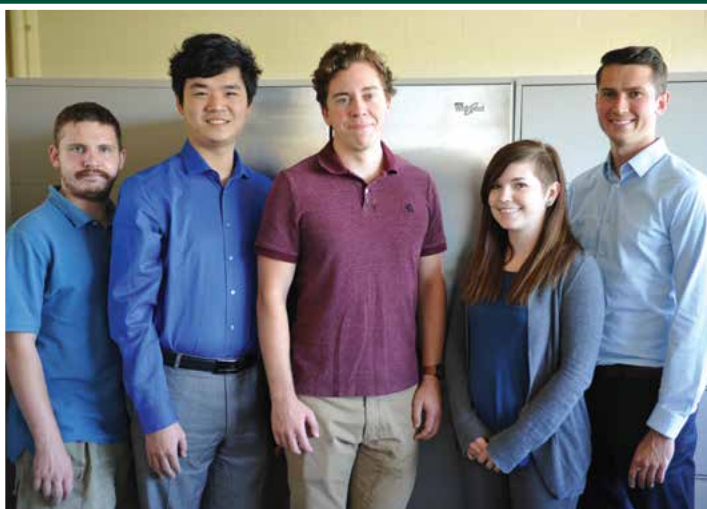
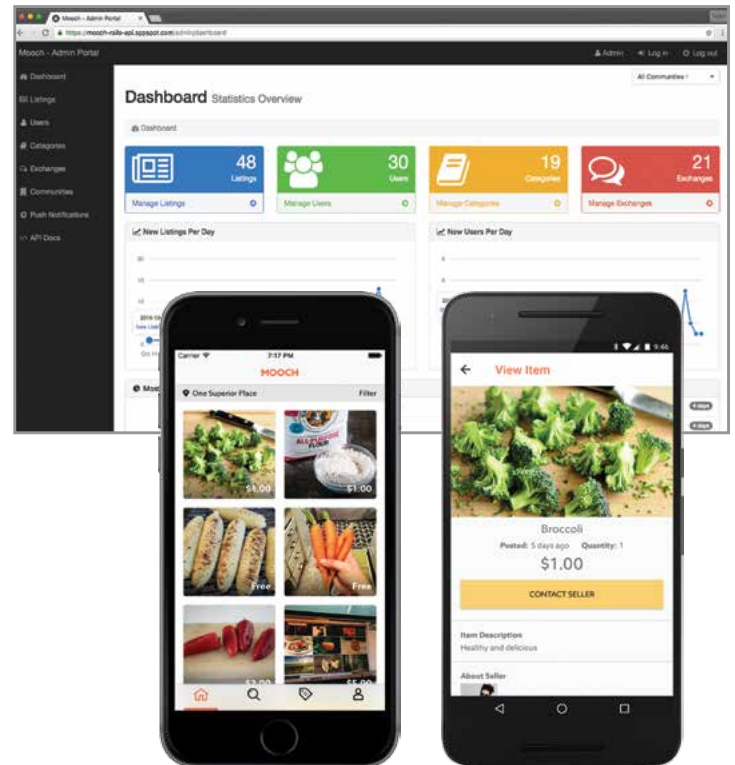
Extra food is not wasted when it's easy to find someone who wants it. And, cooking at home with Whirlpool appliances is a breeze when nearby neighbors provide the missing ingredients.

Mooch users find their housing community based on their current location or based on a specific address. Scrollable lists of food items for sale or for sharing are displayed on Mooch's home screen. Users can scroll through the list, search for specific items, or explore preset categories.

Tapping on a food item brings up more details such as a description, posting date, quantity, price and seller information. Items are claimed with the simple press of a button.

Administrators use our Mooch web portal to manage listings, users, categories and exchanges, and to view usage statistics.

Mooch is based on Ruby on Rails. The iOS and Android apps are written in Swift and Java, respectively. Data is stored using MySQL and NoSQL, which are hosted on Google App Engine.



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Yello

Visualizing Dynamic Data Exploration

Overlooking Millennial Park in downtown Chicago, Yello provides talent acquisition software to assist companies with filling their most challenging job openings.

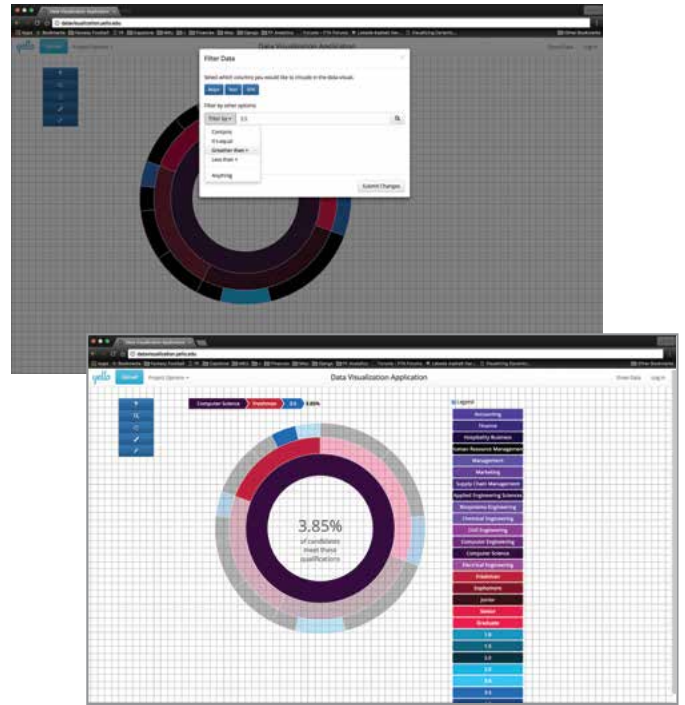
Yello's software is used by companies and candidates around the world. Each candidate inputs their contact information, academic profile and career profile, as well as uploads a digital copy of their résumé. Companies download candidate information, process candidate evaluations, and do outreach.

As Yello's software is used by hundreds of companies and many thousands of candidates over numerous years, very large amounts of useful and informative data are collected. Unfortunately, large datasets are notoriously hard to explore and even harder to comprehend.

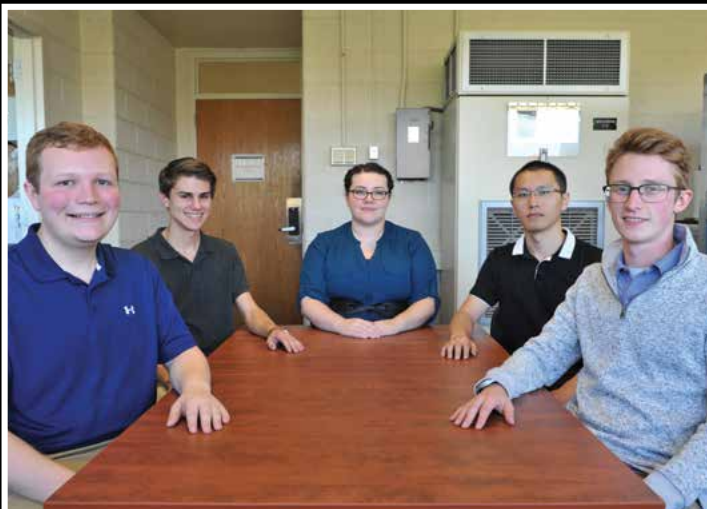
Our Visualizing Dynamic Data Exploration app provides the means for recruiters to analyze large datasets and to discover underlying trends. The data is visualized by converting it to an infographic that is dynamically viewable and editable.

A user of the app imports the data, selects what information to visualize, and then generates the infographic. Once generated, the app allows for filtering and selection of the represented data, manipulation of the infographic to help with understanding, and cosmetic adjustments to assist in the presentation of the data.

Our Visualizing Dynamic Data Exploration app is written in Python, Django, JavaScript, CSS and HTML. Additionally, SQLite is used for our database and the open-source D3 JavaScript library is utilized for the visualizations.



yello



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Yello

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Design Day Awards

CSE 498, Collaborative Design, is the senior capstone course for students majoring in computer science. Teams of students design, develop, and deliver a significant software system for corporate clients. The CSE capstone teams compete for four prestigious awards. The winners are selected on Design Day by a panel of distinguished judges.

Auto-Owners Exposition Award

Auto-Owners
INSURANCE

LIFE • HOME • CAR • BUSINESS

CSE 498 capstone teams present their projects on Design Day in a variety of ways. Teams create and set up an exhibit where they demonstrate their software systems and answer questions from Design Day attendees. Each team plays their project videos and answers questions for a panel of judges.

The CSE capstone team with the best overall Design Day performance is honored with the Auto-Owners Exposition Award, which is sponsored by Auto-Owners Insurance Company of Lansing, Michigan.

Team Auto-Owners
Catastrophic Claims Unit Mobilization



Nicole Lawrence, Jason Steele, Matt Wiechec, Nick Reuter
Presented by Scott Lake

MSU Federal Credit Union Praxis Award

MSU MICHIGAN
STATE
UNIVERSITY®
FEDERAL CREDIT UNION
Building Dreams Together

One of the hallmarks of CSE 498 capstone projects is that of praxis, the process of putting theoretical knowledge into practice. Teams apply a wide variety of information technologies to produce solutions to complex problems in areas such as business, engineering, computing, and science.

The CSE capstone team that engineers the software system that is the most technically challenging is recognized with the MSU Federal Credit Union Praxis Award, which is sponsored by MSU Federal Credit Union of East Lansing, Michigan.

Team Union Pacific
Oculus Rift Inspection and Training Tool



Sam Berndt, Grant King, Mitch Leinbach, Michael Aughton, William Norman
Presented by Samantha Amberg

Spring 2016

Design Day Judges

| | | | | |
|--|---|--|---|--|
| Samantha Amburgey <i>MSU Federal Credit Union</i> | Barb Dawson <i>Michigan State University</i> | E. J. Dyksen <i>Michigan State University</i> | Rich Enbody <i>Michigan State University</i> | Garret Gaw <i>Amazon</i> |
| Adam Haas <i>Ford Motor Company</i> | Louise Hemond-Wilson <i>IBM</i> | Fred Killeen <i>General Motors</i> | Keith Landau <i>GENBAND</i> | David Mysona <i>Blackstone Technology Group</i> |
| Marty Strickler <i>Rose Packing Company</i> | Dave Washburn <i>MSU Foundation</i> | Mark Welscott <i>Foundation Spectrum Health</i> | Karen Wrobel <i>Chrysler</i> | |

TechSmith Screencast Award



Each CSE 498 capstone team produces a video that describes and demonstrates their software product. Starting with a storyboard and a script, teams use Camtasia Studio to synthesize screen recordings, video, audio and other multimedia to produce their project videos.

And the TechSmith Screencast Award goes to... the CSE capstone team with the best project video. The award is sponsored by the creators of Camtasia Studio, TechSmith of Okemos, Michigan.

Team GM
IT Advocate Live Help



Jake Price, Jenna Sanocki, Shuhao Zhang, Zack Keith, Joe Dinkha
Presented by Dean Craven

Urban Science Sigma Award



The CSE 498 experience represents the capstone of the educational career of each computer science major. An intense semester of teamwork produces impressive deliverables that include a formal technical specification, software, documentation, user manuals, a video, a team web site, and Design Day participation. The resulting sum, the capstone experience, is much greater than the parts.

The capstone team that delivers the best overall capstone experience is recognized with the Urban Science Sigma Award, which is sponsored by Urban Science of Detroit, Michigan.

Team MSUFCU
Money Smash Chronicle



Brandon Max, Wyatt Hillman, Amy Leung, Yuming Zhang, Cory Madaj
Presented by Elizabeth Klee



Opportunities for students and new graduates

At Amazon, our evolution has been driven by the spirit of innovation that is part of our DNA. As a new college graduate or intern, you can have multiple opportunities to innovate and solve real-world, complex technical and business problems as you join us on our journey.

We strive to hire the brightest minds from the best universities globally, and have various career opportunities available for undergraduates and advanced degree students with diverse academic backgrounds.

The work environment here is fast-paced and continually evolving, and every Amazonian is passionate about ownership and delivering results for the company. If

you want to work in an environment that will challenge you to relentlessly improve the Amazon experience for our customers, where each day is different from the next, and your learning never truly ends, take a look at Amazon's many university and graduate opportunities.

www.amazon.jobs





Salesforce is a team sport —and we play to win

Make an impact, win as a team and celebrate success in our fun, fast-paced environment. We're growing fast, which means unlimited opportunities for you to do the best work of your life. Hey, we don't call it a #dreamjob for nothing.

We have a ton of employer awards, including being ranked as a Forbes' "Most Innovative Company" 5 years in a row and included in Fortune's "Top-ten Companies to Work For".

Salesforce.org supports MSU and invites Spartans to learn more about us!

Visit careers.force.com/jobs and www.salesforce.org/highered/





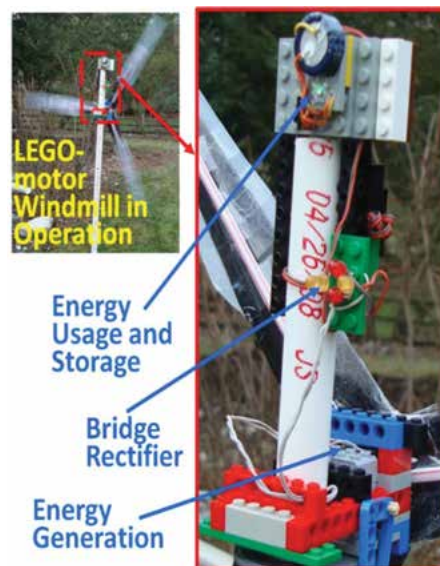
Introduction to Electrical and Computer Engineering

Dr. Dean M. Aslam

Professor of Electrical and Computer Engineering

Problem statement

ECE 101 is an elective course introducing freshman students to Electrical and Computer Engineering through a series of innovative hands-on laboratory experiments linked to new research and teaching areas. These experiments relate to (a) computer switches, (b) C programming of robots based on MSP430 microcontrollers and NXT LEGO controllers, (c) pH measurement using NXT sensors, (d) maple-seed robotic fliers (MRF) with onboard electronics, (e) location of bio-molecules using RFID, (f) renewable energy resources using windmill and solar cells, and (g) nanotechnology study using a LEGO gear-train.



This semester's projects include:

| Teams | Project Title |
|---|------------------------------|
| Team #1: Steven Andary Saad Hasan Connor McMahon | Wireless Phone Charger |
| Team #2: Nicolau Esteves Jamal Michel Cole Nelson | Autonomous EV3 Walking Robot |
| Team #3: Rania Alshammasi Madison McCullough | NXT Maze Robot |

LAB INSTRUCTOR: Mohammad Rawashdeh

The Capstone Projects



John Albrecht
Associate Professor of Electrical
and Computer Engineering



Dr. Lalita Udpa
Professor of Electrical and
Computer Engineering

Presentation Schedule – Room 2205 Engineering Building, Second Floor

| Time | Team Sponsor | Project Title |
|------------|--|--|
| 8:30 a.m. | Great Lakes Controls & Engineering/ Panther Global Technologies | Orthopaedic Exercise Feedback |
| 8:55 a.m. | MSU Office of the Executive VP | Smart Parking Lots |
| 9:20 a.m. | ArcelorMittal | Safety Equipment for Barcode Scanner |
| 9:45 a.m. | Techmark | Impact Recording Device (IRD) |
| 10:10 a.m. | Techmark | Fruit & Vegetable Damage Detection Software |
| 10:35 a.m. | Whirlpool | Washer/Dryer Diagnostic Smartphone Application |

Presentation Schedule – Room 2250 Engineering Building, Second Floor

| Time | Team Sponsor | Project Title |
|------------|-------------------------------|---|
| 8:30 a.m. | MSU RCPD | Prosthetic Arm Control System |
| 8:55 a.m. | TI/MSU RCPD/MSU Demmer Center | Precision Pointing Device for the Blind |
| 9:20 a.m. | GM | Electric Car Noise System |
| 9:45 a.m. | ECE Dept. | Home Automation Educational Platform |
| 10:10 a.m. | MSU | Maskless Lithography System |
| 10:35 a.m. | NeEWS Lab | A Solar Powered Network of Internet of Things |

ECE 480 Senior Design

ECE 480 is required of all electrical engineering or computer engineering majors at MSU. It prepares students for the workplace, or for graduate school, including:

- putting into practice the technical skills learned in the classroom, on industrially sponsored team projects, under faculty guidance, doing open-ended design, giving them experience in teamwork, project management, product life cycle management, intellectual property, accommodation issues and entrepreneurship,
- polishing their communication skills – individual and team – on proposals, reports, résumés, evaluations, posters, web pages, and oral presentations, and
- requiring each student to complete four individual hardware/software laboratory assignments.

Team sponsors are local and national, including ArcelorMittal, General Motors, Great Lakes Controls & Engineering, MSU Demmer Center, MSU Electrical Engineering Department, MSU Office of the Executive Vice President, MSU Resource Center for Persons with Disabilities, NeEWS Lab, Panther Global Technologies, Techmark, TI, and Whirlpool.

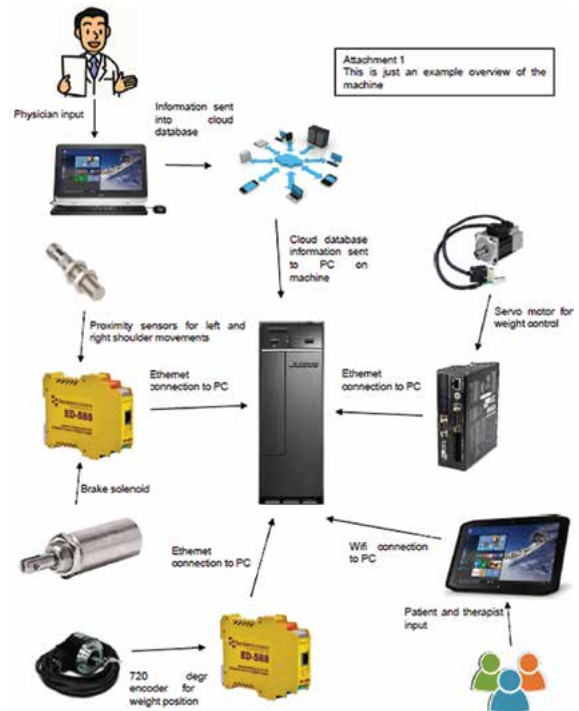
Great Lakes Controls & Engineering, LLC Panther Global Technologies Orthopaedic Exercise Feedback

Great Lakes Controls and Engineering, LLC, partnered with Panther Global Technologies, is interested in developing a shoulder exercise feedback system to add onto an existing therapy machine. They are looking for a reliable system to track patients' therapeutic progress as well as to ensure that exercises are performed correctly. The purpose is to implement this in everyday therapy to ensure superior results in comparison to today's methods.

The control system will consist of a number of components. A servo unit will be implemented to control the fly weight, enabling the weight resistance of the exercise to be modified. Meanwhile, an encoder will be used to communicate to the system the distance by which the machine has moved. To ensure the exercise is performed correctly, a brake solenoid will enable or disable movement of the machine depending on requirements. Also, proximity sensors will determine whether or not full movement has occurred.

Through a secure website, the therapists will be able to prescribe custom therapy routines and upload them to a database. The patient will have an interactive touchscreen application attached to the machine to log into his or her secure account. After logging in, he or she will be prompted to complete the customized, prescribed routines. Upon completion, the record will be sent back to the patient's therapist, who can retrieve the information via the same secure website.

Successful completion of project goals will result in a functioning control system to ensure correct exercise operation, and provide continuous feedback.



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MSU Office of the Executive Vice President

Smart Parking Lots

Parking on MSU's campus is limited. Drivers often circle from lot to lot looking for spaces. Some faculty and staff are reluctant to leave campus during peak hours (lunch time) or to go to meetings for fear of losing their parking space.

MSU is interested in developing a smart parking solution that would provide real-time information on the number of spots available in each parking lot. This would allow drivers to target lots with open spaces and make other more informed choices about their commute on campus. Currently, there is a potential path for Smart Parking on campus in gated lots; however, it will involve a costly replacement of gate arms across campus. We wish to develop a lower cost solution that might accelerate the pace of deployment of a new parking system on campus and are interested in the students' views and ideas to address this problem.

Our team recognizes the struggle of finding an available parking spot on campus, especially during peak hours. We are committed to solving the problem of uncertainty through sensing technology and networking in order to inform drivers of the capacity in real-time. This will allow a driver to make an informed decision when targeting a parking lot, eliminating time wasted in searching for space.



MICHIGAN STATE
UNIVERSITY



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Michigan State University Office of the Executive Vice President Project Sponsor

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ArcelorMittal

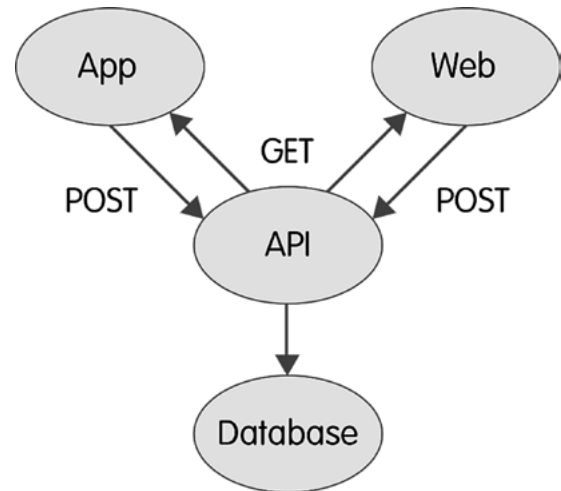
Safety Equipment for Barcode Scanner

ArcelorMittal is a Luxembourg-based multinational steel manufacturing corporation headquartered in Avenue de la Liberté, Luxembourg. It was formed in 2006 from the takeover and merger of Arcelor by Mittal Steel. ArcelorMittal is the world's largest steel producer, with an annual crude steel production of 98.1 million tons as of 2014. At such a high volume of manufacturing, regulations require ArcelorMittal to provide their employees access to a wide variety of safety equipment.

Current safety devices such as fire extinguishers and AEDs require periodic inspections which must be documented. In most instances, these inspections are documented at the location of the device on a paper record or attached tag. If that record is lost, so is the history of the inspections. Also, in many cases, there is no method to confirm that all required devices have been inspected as prescribed. Additionally, inspections such as these are often targets of audits. Auditors visit the locations of these devices to confirm inspections occur as scheduled; these audits could be more efficient if records were available electronically. Lastly, electronic confirmation of these inspections will alert responsible personnel of inspection failures.

Our team has developed an ecosystem in order to automate this process for ArcelorMittal. As a team, we accomplished our objectives by creating a mobile application to scan barcodes, and a responsive admin website to maintain and audit data. The mobile application uses open source barcode scanning libraries, and the website takes advantage of existing industry standard frameworks and communication protocols.

The database is developed using the standard SQL interface which allows easy integration with any enterprise database software. Overall this system was designed with the user at the forefront, constructing an environment that is easy for anyone to use.



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Jim Lang
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Techmark, Inc.

Impact Recording Device (IRD)

Techmark was founded in 1987 in Lansing, Michigan to provide advanced technology solutions to assist agriculture producers and companies around the world. Today the Techmark Impact Recording Device (IRD) is the world's leading tri-axial impact recorder.

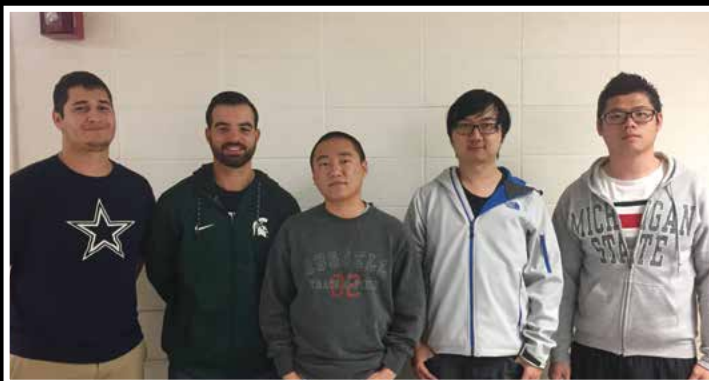
A 2013 study by Stellenbosch University suggested that up to 40% of produce may be affected by bruising. Produce that is bruised not only has a shorter shelf life, but also higher chance of disease in storage and lower overall quality. The IRD manufactured by Techmark offers an opportunity to monitor moments in harvesting and shipping where most bruising occurs.

The picture on the right depicts all of the IRD models Techmark presently provides. The design of the IRD limits the ability to make the IRD smaller than 2.25" in diameter. This currently works well for a wide range of fruits and vegetables such as apples and potatoes. However, this circuit design is simply too large to replicate smaller produce such as blueberries, strawberries, and tree nuts.

The goal of this project is to redesign the interior circuitry of the IRD to be 1" in diameter to accommodate the smaller produce. All circuitry components of the IRD will need to be changed and redesigned to fit the desired size limitations. The main components that the team will need to research and implement are a smaller microcontroller, accelerometer, and battery pack. Even though the circuit components will be very small, they still need to be durable and long-lasting.



TECHMARK, INC.
Technology from the ground up



Michigan State University

Team Members (left to right)

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Techmark, Inc.

Fruit & Vegetable Damage Detection Software

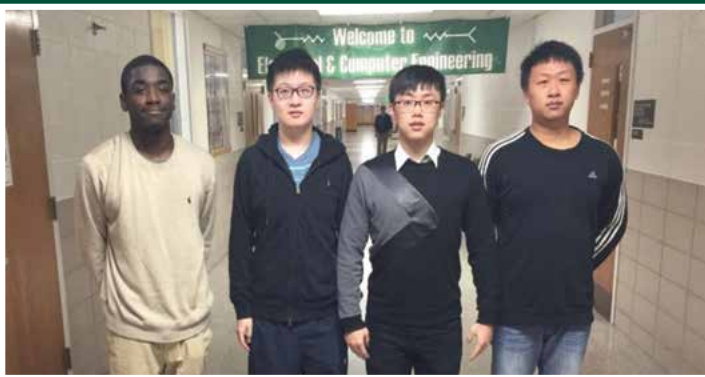
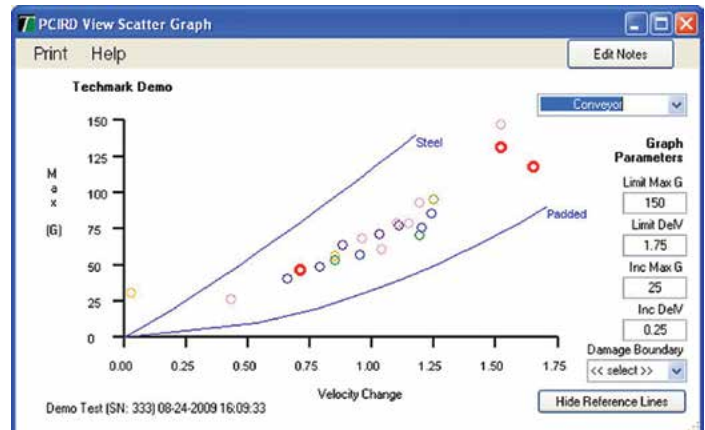
Techmark is a multinational agricultural technology company that provides advanced technology solutions to progressive agricultural producers and companies. Techmark produces impact recording devices that collect information on vegetables and fruit.

The Impact Recording Device (IRD) is stored with agricultural products in warehouses or trucks and records the force of impact and velocity change.

Since the IRD is placed with agricultural products during recording impact, the size of the IRD should be same as that of the product in order to ensure that the impact on the IRD is the same as that on the product. The current version of IRD is only able to test the impact on potatoes. In other words, the size of the IRD is related to the scale of product market. To expand the market of IRD, our team is working on developing a smaller IRD.

To reduce the size of the IRD, we built an adapter which contains a microcontroller and a charger. With this adapter, we were able to choose a smaller microcontroller in the IRD since the functions needed can be coded in the adapter.

The new design of product reduces the size of the IRD into less than one inch and enables it to work for small fruit, for example strawberries. In addition, the separate control on the adaptor simplifies updating a new generation of IRDs.



Michigan State University

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Techmark, Inc.

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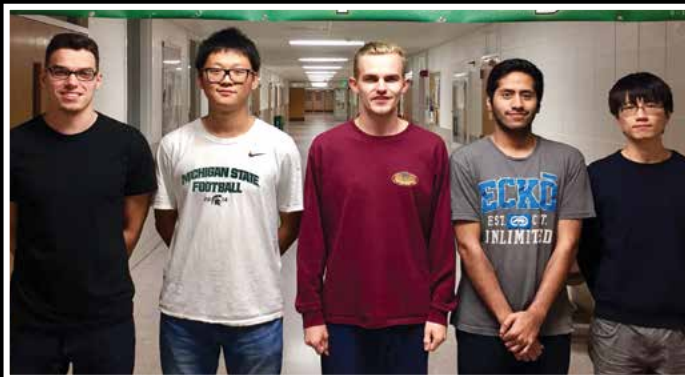
Whirlpool Corporation

Washer/Dryer Diagnostic Smartphone Application

Whirlpool is a renowned international appliance manufacturer, producing high quality products for homeowner and tenant communities around the world. Whirlpool wants to improve the responsiveness of its customer service by linking technicians with any technical demand in near real-time. Our team has been given the opportunity to develop a smartphone app that can automate the instruction manual experience or, if the customer prefers, provide direct information to a Whirlpool technician.

We have developed a camera-based method of communication between Whirlpool machines and smartphones. The overall objective is the creation of a smartphone application that can read and decipher error codes straight from a Whirlpool machine. By improving the customer service experience, this application provides a great amount of practical benefit for both the consumer and Whirlpool.

Most of Whirlpool's appliances are designed to have minimal user interfaces, typically consisting of a set of LEDs that display the status of the appliance. These LEDs are the main method of communication between the machine and the user and also between the appliance and a technician via a set of error codes. Our team improves upon the current one-on-one communication approach by designing a smartphone app and a communication protocol that sends error code information directly to the company and the user. In the successful prototype that uses a simulated LED matrix, the LEDs are blinking at a specified frequency visible to a smartphone camera. The app deciphers the LED error code sequence and sends the data to Whirlpool while simultaneously generating a user readable output. The user is then offered the option of scheduling a technician appointment at his/her convenience and both are well informed.



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Arnold Nunez
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Chaolun Huang
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Whirlpool Corporation

Project Sponsor

Michael Jakemeyer
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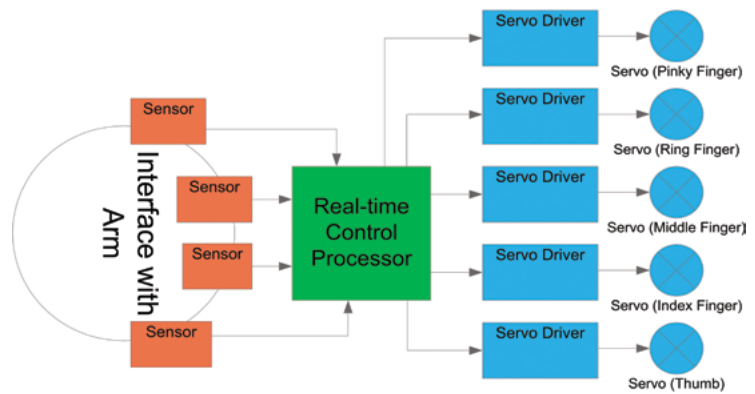
MSU Resource Center for Persons with Disabilities: Prosthetic Arm Control System

The Resource Center for Persons with Disabilities at Michigan State University is dedicated to providing assistance and advocacy for MSU students with disabilities. In the past few months, a MSU student and congenital amputee, Lee Cleaveland, has approached RCPD with a proposal for developing a lower-arm myoelectric prosthesis for his daily use. A component of the design of this arm has become the task of our Design Team.

Prior to contacting RCPD, Lee had researched custom bionic arms, but found these devices cost thousands of dollars and would not meet his needs. Lee began looking into other options and contacted RCPD for support who, in turn, contacted the ECE department with a proposal for a control system for a custom prosthetic designed by RCPD.

The team will begin by building a prototype arm with one degree of motion using 3D printing technology and low-cost consumer electronics. Each finger will be driven by a servo, which will be driven from motor drivers. A real-time processor will serve as the core of the arm, translating sensor input signals into signals to control the motor drivers.

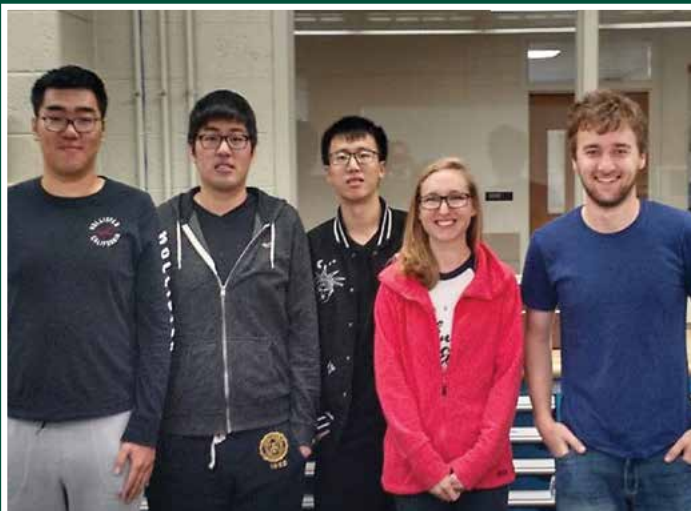
The goal of the design team is to construct the control system of a functional prosthetic arm as part of a complete, collaboratively-designed prosthetic. The control system will meet Lee's daily requirements, as outlined in the initial meeting, such as different hand positions, lifting, and grasping.



| | |
|-----------|---|
| Device: | Prosthetic Hand Control System – High-Level |
| Engineer: | Zach Farmer ECE 480 Design Team 7 |
| Date: | 10/6/2016 |
| Version: | 1.0 |

MICHIGAN STATE
UNIVERSITY

Resource Center for
Persons with Disabilities
Maximizing Ability & Opportunity



Michigan State University Team Members (left to right)

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MSU Resource Center for Persons with Disabilities Primary Project Sponsor

Stephen Blosser
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Other Sponsors

IronCAD
Michigan Department of Treasury
MSU College of Engineering
MSU Dairy Store
Texas Instruments

Collaborators

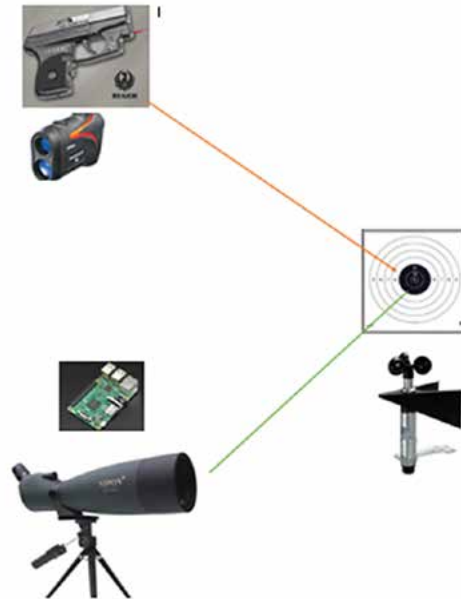
Stephen Blosser, Allison Burzynski,
Lee Cleaveland (Prosthetic
Beneficiary), Frank Luchini,
Matt Marshall

TI, MSU RCPD and MSU Demmer Center Precision Pointing Device for the Blind

The MSU Demmer Center is a shooting sports training facility that has both indoor and outdoor archery ranges, as well as indoor firearm ranges, where visitors can shoot up to .22 caliber pistols and rifles. In addition, the center offers Paralympic sport outreach for various activities including training blind individuals. The MSU Resource Center for Persons with Disabilities (RCPD) has reached out to the engineering program to develop a device to aid blind individuals in participating in recreational activities at the center, including archery and small caliber target practice.

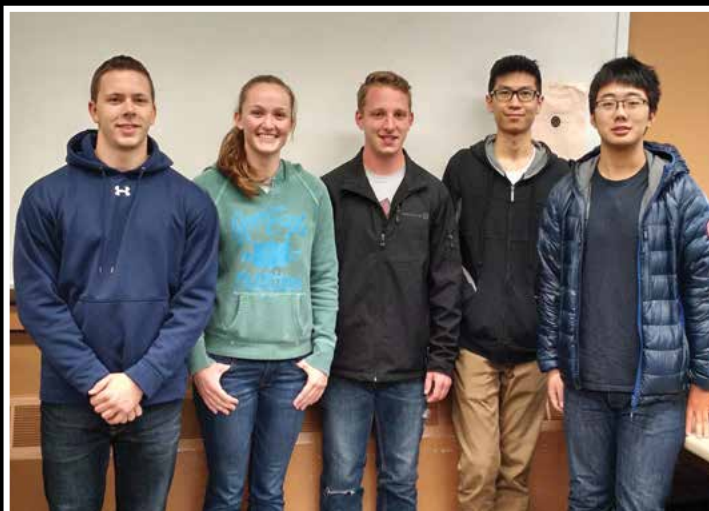
The current model was created by a group of ECE 480 students in the spring of 2016. This was developed with haptic feedback utilizing machine vision to determine distance from target. Through use of a Raspberry pi 2 and OpenCV, the system is able to vibrate motors in a wrist strap to allow the user to better aim their device.

The goal for this semester is to build on the system developed by the previous team and create an appealing and easy-to-use product. In order to accomplish this task, wireless haptic and audio feedback will be implemented. Software improvements will allow for easier and more functional use. Sensor enhancements will include wind speed, wind direction, and distance sensors that will allow the user to point at the target's bullseye.



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Resource Center for
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Maximizing Ability & Opportunity



Michigan State University Team Members (left to right)

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Demmer Center Project Contact

Michael Galella
East Lansing, Michigan

Project Facilitator

Dr. Fang Peng
East Lansing, Michigan

General Motors

Electric Car Noise System

By the year 2018, the NHTSA will require all automakers in the United States to comply with minimum sound requirements for hybrid and electric vehicles. This legislation is a result of the danger posed to pedestrians due to the lack of noise produced by moving hybrid and electric cars. The law states that a hybrid electric vehicle must emit a sound that resembles that of an internal combustion engine at a certain decibel level that can be heard by nearby pedestrians.

General Motors has responded to this legislation by implementing a basic speaker to emit sound from their electric vehicles, such as the Chevy Volt and Spark. The problem is that these current systems do not meet the level of innovation that General Motors desires. The sound emitted from these devices is not directional and is penetrating into the passenger area of the vehicle, thus compromising the expected quiet and comfort of the driver's experience. In addition, the loudspeakers currently used do not effectively deliver sound to nearby pedestrians.

General Motors has asked our team to develop a new kind of sound-emitting device that tackles these issues. The team has developed a piezoelectric speaker array that can be placed on the fascia of the vehicle. The speakers emit a frequency modulated ultrasonic tone consisting of an audio signal and a carrier signal. When these soundwaves hit an object, the signals mix and deconstruct into an audio-band signal that can be heard. The advantages are: piezoelectric speakers are much more directional than traditional loudspeakers, and the ultrasonic frequencies are easily damped by passive noise reduction techniques in GM vehicles.



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Dani Fernandez
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Austin Nolen
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Yunfan Ge
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GM

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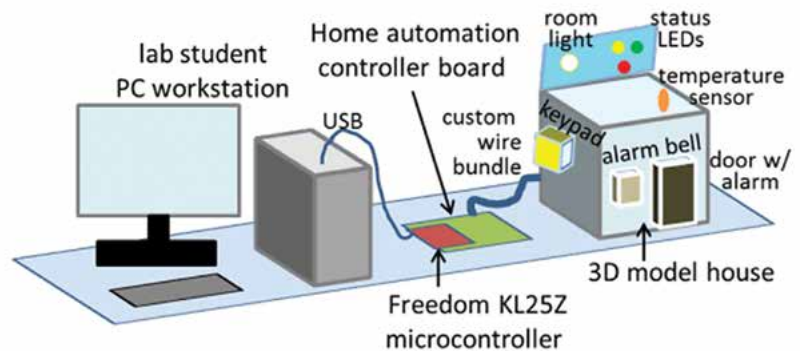
Dr. Selin Aviyente
East Lansing, Michigan

MSU Dept. of Electrical & Computer Engineering Home Automation Educational Platform

The MSU Department of Electrical and Computer Engineering has offered the opportunity to develop an educational platform utilizing a home automation model. Our challenge is to create a standalone, closed-loop, fully functional model home that will facilitate students' learning of analog-to-digital conversion in embedded systems labs. They require the controller board to use the Freedom KL25Z microcontroller, currently used in labs, to provide a relatively seamless transition in learning.

The model home must be as true to life as possible using sensors, actuators, and other components that would typically be found in the home. Required components include at least two sensors, two actuators, necessary analog interfaces, the KL25Z microcontroller, 110VAC lighting, and a USB PC interface to provide status updates or alerts via email and/or text message. The model home will house all the required sensors and actuators, and provide a user interface to arm and disarm the system with user feedback via status LEDs.

The controller board will provide all necessary power supplies, transformers, and an optional battery backup power supply. Test algorithms pre-programmed on the KL25Z microcontroller will demonstrate all the functionality of the model home. Programming and interfaces are designed such that sensors, actuators, and the programing itself can easily be added, removed, or modified to provide a variety of learning modes.



MICHIGAN STATE UNIVERSITY

Department of Electrical & Computer Engineering



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Joseph Thom
Charlotte, Michigan

Sean Irwin
Grosse Ile, Michigan

Evan Jakovac
Wyandotte, Michigan

MSU ECE Dept.
Project Sponsor

Professor Andrew Mason
East Lansing, Michigan

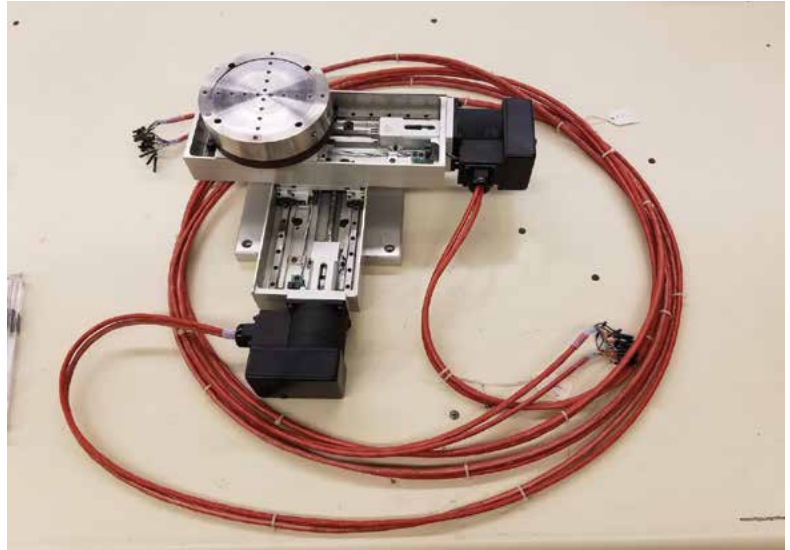
Michigan State University

Maskless Lithography System

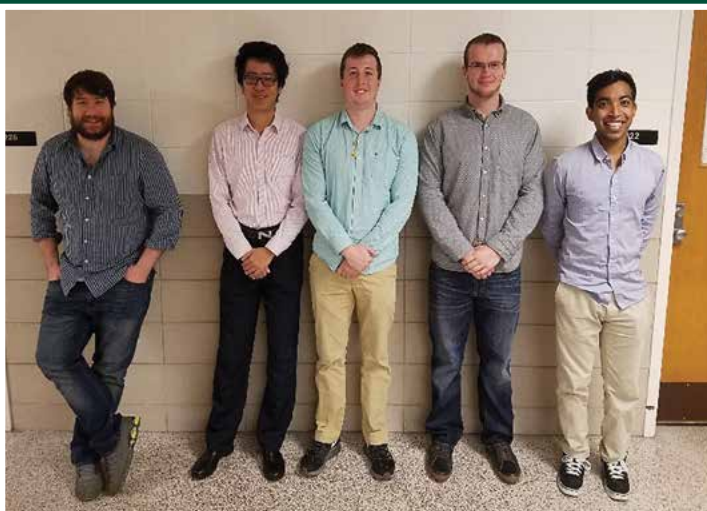
Michigan State University is interested in developing a maskless lithography system. They have tasked our team with developing a production unit to be used for research and teaching. The ECE Cleanroom presently has a standard mask aligner. With a maskless lithography system, students could have the flexibility of changing the lithography patterns rapidly without the added costs associated with purchasing additional masks.

The main objective of this project was to create a system that takes CAD and Bitmap files and engraves silicon on a rotation stage. The rotation stage can move in the X-Y-Z direction and can vary dynamically through software. The system will be able to print on a 4x4 inch wafer and has a beam width of less than 50 microns.

The system connections are housed within an aluminum enclosure. It is controlled by the user through a MACH 4 interface that interacts with the rotation stage and UV light. The microcontroller also handles all the computation of the UV light in order to manage intensity and duration. Successful completion of the project will result in a lithography system that is able to engrave CAD images on a silicon wafer.



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Clayton Dewitt
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Josh Kern
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Saichetan Nalamolu
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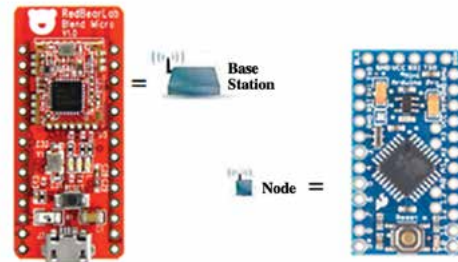
NeEWS Lab

A Solar Powered Network of Internet of Things

The Networked Embedded & Wireless Systems Laboratory (NeEWS) at Michigan State University focuses on finding solutions to upcoming communication problems that will greatly affect the world. With Industry 4.0 becoming ever more prevalent, taking measurements of something in the field is becoming increasingly more expensive due to the amount of work necessary to connect sensors to stationary power sources. The NeEWS Lab needs an expandable hardware platform that can be controlled and utilized remotely, using only energy harvested from sunlight. This platform will provide a solution to the problem and enable wireless sensing using only sunlight.

A customized hardware platform that can be upgraded and expanded will be developed, as well as accompanying software that will connect all of the platforms together to perform measurements in the most energy efficient manner. The energy efficiency will be achieved through implementing a novel SDN for IoT networking protocol that minimizes energy consumption while allowing continuous sensing.

A working system would consist of a base station and as many nodes as are necessary to perform all of the sought-after measurements. Bringing more nodes into the system and moving them from location to location will be seamless. The networking stack solution that will arise from this research will be useable as a framework upon which other future Internet of Things applications can be built and foster further innovations in this growing field.



Michigan State University
Team Member

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Holt, Michigan

NeEWS Lab
Project Sponsor

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Graduate Student Mentors

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Feng Dezhi
Faezeh Hajiaghajani
Brandon L. Harrington
Rui Wang

Design Day Awards Spring 2016

Electrical & Computer Engineering Prism VentureWorks Prize & Winners, Spring 2016

The Prism VentureWorks Prizes, are awarded each semester to the most outstanding teams in the Electrical and Computer Engineering Senior Capstone Design Course, as judged by a panel of engineers from industry. A team with members from both ECE and another engineering major (mechanical engineering, for example) is also eligible, if the team's project is administered through ECE 480. The prizes are sponsored by Prism VentureWorks, a Boston-based venture capital firm, and Mr. William Seifert, an ECE alumnus, who is a partner in that firm. The faculty and students of Electrical and Computer Engineering are very grateful for this generous support.

Prism VentureWorks First Prize: Great Lakes Controls & Engineering Aeroponic Control System for Efficient Growth

Left to Right:

Saleh Alghamdi, Jacob Jones, Patrick Pomaville,
Justin Fecteau, Samuel Metevia



Prism VentureWorks Second Prize: MotionControlShop.com IntelliMotor

Left to Right:

Barend Ungrodt, Joe Stephan, Angelica Minissale,
Theo Chupp, Chans Head



Prism VentureWorks Third Prize: ArcelorMittal Conveyor Transfer System for Coils

Left to Right:

Haojun Wang, Ruowan Ji

Not pictured: Mark Zatorski, Yun Lou, Jiawei Wu





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MICHIGAN STATE UNIVERSITY



Thanks to Dean Craven, TechSmith's Chief Technical Officer
for 10 years of challenges and 20 exciting capstone projects
educating and inspiring a new generation of computer scientists.



ME 371 Mechanical Design I

Michael Lavagnino
Academic Specialist
Department of Mechanical Engineering

Thrills for Pre-collegiates: Mechanisms that Fascinate, Captivate, Stimulate and Entice

Teams of students were required to design and manufacture mechanisms that would thrill an audience of pre-collegiate students. The constraints imposed upon this assignment were that each mechanism must incorporate at least one linkage, one gear set and one cam-follower combination. These engineering marvels will be demonstrated and displayed with a complementary poster explaining the subtleties of each mechanism. The ME 371 teams will also be interviewed and rated by the pre-collegiate students. The most highly-rated team will be awarded the Sparty Plaque, which was designed and fabricated by students at Holt Junior High School over a decade ago.

Teams and members: Section 1

Team 1

Payton Bauman
Lexi Baylis
Patrick Kelly
Eric Lindlbauer

Team 2

Megan Beisser
James Garrett
Hunter Gvozdoch
Bram Parkinson
Jason Sammut

Team 3

Jon Andrejczuk
Geena Duff
Phillip Erickson
Mitchell Pollee

Team 4

Matthew Auvenshine
Lance Frahm
Cody Lysher
Scott Michael
Reed Williams

Team5

Yamen Almahmoud
Luke Boulter
Matthew Cassiday
Jeffrey Pattison

Team 6

Andrés Garcia
Grant Gooch
Jason Kim
Jacob Richter

Team 7

Paul Ferraiuolo
Marissa Meaney
Jason Moll
Jeri Sutter

Team 8

Kelly Patterson
Robert Schmit
Kayla Starr
Aryka Thomson

Team 9

Darren Harnden
Jacob Smyth
Kathryn Stimetz

Team 10

Megan Friedrich
Justin Suh
Colby Williams
Jiaji Zhang

Team 11

Christian Genord
Jack Kuerbitz
Tyler Sloan
Gino Wickman

Team 12

Zachary Engen
Syunsuke Hata
Christian Luedtke
Kanshu Mori
Hang Zhao

Team 13

Mitchell Holt
Austin NicholSEN
Heather Raymor
Nicholas Wojno
Carly Wolf

Team 14

Ruichen Li
Byeong Park
Taojun Wanyan
Yitan Zhu

Team 15

Meredith Jonik
Jean Klochko-Bull
Daniel Middleton
Laura Nye

Teams and members: Section 2

Team 1

Chris Brenton
Charlie Guidarini
Owen Middleton
Chase Quencer

Team 2

Colton Knopf
Kyle Raden
Thomas Robertson
Tyler Smith

Team 3

Nicholas Flannery
Nathanael
Ginnodo
Ian Lindsley
Zachary Sadler

Team 4

Zach Lapinski
Melissa Oudeh
Vince Rende
Rebecca Reneker

Team5

Lindsay Hoard
Trey Pfeiffer
Matthew Walz

Team 6

Thomas O'Brien
Nick Santi
Patrick Sharp
Andy Stamm

Team 7

Bridget Anderson
Anxhelo Lalaj
Nicole Stanley
Amad Wahib
Michael Williams

Team 8

Abdullah Boshgeia
Ziqing Cao
Nor Mohdnoor
Hassan Olaiwat
Michael Vanbemmelen

Team 9

Leo Calaj
Brandon Jett
Do-Hyung Kim
Tracey Nguyen

Team 10

Ryan Loveland
Maria Osinski
Justin Slagter
Brant Toback

Team 11

Yurun Gu
Jiajun Lu
Zexi Peng
Lingfeng Wang
Oliver Xu

Team 12

Manea Alhammadi
Omar Alhammadi
Adnan Alhuwait

Team 13

Muhammad Djafri
Nicholas Raterman
Brendan Webberly

Team 14

Logan Kincaid
Austin Klump
Hoa Nguyen
Nathan O'Sullivan

Team 15

Roobin Arbab
Tanner Ellens
Jacob Wilson



ME 412 Heat Transfer Laboratory

Dr. Neil Wright
Associate Professor of Mechanical Engineering

Birthday Candle Powered Desalinator

Water scarcity is a significant problem in many areas of the world. It affects wealthy nations and developing ones. Many areas rely on desalinization plants to provide fresh water from brackish or sea-water. This semester, the ME 412 design project is to design a system to produce as much fresh water as possible from a 0.6M saltwater source with only the power of several birthday candles.

While the device may be simple, the concepts and analysis behind the project are challenging. Calculating: 1) the amount of energy that is available from burning the candles (paraffin is C_nH_{2n+2} with n unknown), 2) the convection and radiation heat transfer to the boiler, with its real-world geometry, and 3) the efficiency of the condenser represent some of the challenges. The accuracy of the prediction and the quality of the test plan are keys to a good grade, even if producing the freshest water with the lightest and least expensive device is the priority for the competition.

Competition Schedule

| Time | Team # | Station | Team members |
|-------|--------|---------|--|
| 8:00 | 1 | A | Rachael Acker, Sanders Aspelund, Mark Cogo, Andrea Vedrody |
| | 8 | B | Jared Abood, Matthew Hitch, Stephen Moye |
| 8:20 | 9 | A | Andrew Boyer, John Ellbogen, Brandon Fortman, Kevin Lalko, Evan Weider |
| | 2 | B | Alexander Gerding, Christine Hampton, Paul Heeder, Scott Matthews |
| 8:40 | 19 | A | Alyssa Bartlett, Shane Frakes, Trevor Herrinton, Christopher Slamp |
| | 24 | B | Alexander Friedman, David Jagow, John Lefevre, Kyle Moeller |
| 9:00 | 5 | A | Daniel Busch, Joseph Genoa, Shane Hessling, Elizabeth Schaepe |
| | 18 | B | Andrew Benson, Michael Gaduski, Trevor Gilmartin, Sahem Marji |
| 9:20 | 3 | A | Abigail Livingston, Darby Spiegel, Morgan Weber, Abigail Wulf |
| | 10 | B | Joseph Brooks, Wesley Dorin, Richard Tran, Aaron Urbonya |
| 9:40 | 11 | A | Ryan Juntunen, Zhaoqiang Mi, James O'Connor, Zhongyu Shi |
| | 13 | B | Mark Becker, Ryan Boutet, John McLaughlin, Nathaniel Noel |
| 10:00 | 14 | A | Alexander Ho, Shiyao Liu, Andrew Morgott, Eric Olsen |
| | 16 | B | Zachary Dutcher, Avinash Dutt, Yu He, Kendra Martin |
| 10:20 | 20 | A | Herbert Darrow, Kyle Foco, Matthew Gagnon, Shuowei Geng |
| | 22 | B | Waithera Chege, Danielle Heger, Ian Mular, Louis Yun |
| 10:40 | 21 | A | Cody Bradford, Christopher Churay, Erik McGuire, Daniel Riggs |
| | 4 | B | Joshua Dewys, Jacob Neubecker, Joshua Neubecker, Michelle Samalik |
| 11:00 | 23 | A | Sagar Dungal, Martin Dwornick, Karan Ghuman, Zachary Graves |
| | 12 | B | Hanis Hashim, Sara Knoedler, Jiajun Lu, Jennie Parrish |
| 11:20 | 15 | A | William Kelly, Jack McDougall, Yu Sang, Tyler Stricker |
| | 17 | B | Qiren Gao, Abigail Henning, Maryrose Jakeway, Andrew Wandor |
| 11:40 | 6 | A | Yuzhou Gu, Yewei Jiang, Wesley Lanigan, Jiajun Liu |
| | 7 | B | Matthew Hart, David Meleca, Shangyou Zeng, Haonan Zhou |



ME 471 Mechanical Design II

Dr. Patrick Kwon
Professor of
Mechanical Engineering

Deployable Bridge

The goals of this project are to design, build and test a scaled-down version of a deployable bridge. The bridge system before the deployment must fit inside a box (10"L x 10"H x 15"W), which will be mounted onto the table with only four bolts. The bridge will be deployed with the

input from the motor to reach as long as possible while minimizing the deflection at the end of the bridge, the total system mass, and cost. To test the stiffness, the bridge will be loaded with 50 lbs at the end of the bridge, and the vertical deflection is measured at the end of the bridge.

Competition Schedule

| Time | Team | Station | Team Members |
|-------|------|---------|--|
| 8:30 | 1 | A | Alec Czanderna, Jacob Huver, Matthew Norman, Jonathan Ristola, David York |
| | 1 | B | Alexander Athens, Evan Cummings, Cody Lange, James O'Connor, Anna Sommerfeld |
| 8:40 | 2 | A | Steven Collareno, Mitchell Heinz, Kathleen Noblet, Michael Reynolds, He Yan |
| | 2 | B | Troy Baertson, Elizabeth Davidson, Devon Leasher, Jacob Overla, Yuanyuan Wang |
| 8:50 | 3 | A | Brian Clark, Marissa Grobbel, Tyler Nicolay, Raymond Renaud, Troy Willmer |
| | 3 | B | Tyler Bauder, Sarah Egbert, Shiyao Liu, Austin Payne, Zirui Wang |
| 9:00 | 4 | A | Martyna Cieslak, Thomas Griffith, Michael Mcatee, Kristian Rego, Sarah Whitney |
| | 4 | B | Mhna Bawzieer, Tyler Ellsworth, Xiaonan Liu, Matthew Pottebaum, Yi Wei |
| 9:10 | 5 | A | Simba Chidyagwai, Kevin Glime, Ian May, Tess Reed, Mark Vanpoppelen |
| | 5 | B | Kyle Benedict, Tianyuan Gu, Shayne Maguire, Michael Rasmussen, Ashley Wilkey |
| 9:20 | 6 | A | Pranay Chaturvedi, Andrew Franko, Matt Marsh, Jalaj Prakash, Hoi Ho Hawke Suen |
| | 6 | B | Brenna Bolton, Joseph Hartford, Saul Makanga, Gray Ritchey, Brian Wingate |
| 9:30 | 7 | A | Oscar Castro, Karl Fischer, Jiayi Li, Jacelyn Pozniak, Matt Strzalkowski |
| | 7 | B | Joshua Borton, Carly Head, Xinyu Mao, Joseph Rombach, Lei Xu |
| 9:40 | 8 | A | Jennifer Carmichael, Anthony Ethridge, John Lefevre, Michael Popielec, Sarah Sonego |
| | 8 | B | Andrew Hieber, Bijan Masrouri, James Ryan, Tianhang Xu |
| 9:50 | 9 | A | Caleb Calfa, Tobin Egger, Jacob Khodl, Trevor Ploucha, Joseph Snay |
| | 9 | B | Andrew Brockman, Rachael Kain, Kevin Mccarty, Michelle Samalik, Jonathan Zofchak |
| 10:00 | 10 | A | Brennen Burns, Angela Dobrzelewski, Jonathan Katt, Amanda Pfutzenreuter, Daniel Setili |
| | 10 | B | Abdullah Alluhaidan, Daniel Burchart, Cody Kelly, Zhaoqiang Mi, Jacob Schoenborn |
| 10:10 | 11 | A | Thomas Baldwin, Jacob Depierre, Mark Johnson, Brooke Otterbein, Yu Sang |
| | 11 | B | Conner Archey, Stephen Camilletti, Thomas Kobak, Hai Nguyen, Zhongyu Shi |
| 10:20 | 12 | A | Allison Bakka, Zachary Decker, Leah Iseler, Zachery Osisek, Andrew Roach |
| | 12 | B | Kalie Collins, Austin Krauss, Yuchen Ni, Richard Simon |

Weigh Team Projects (8:00 a.m. - 8:30 a.m.)

Break (10:40 a.m. - 10:50 a.m.)

Semi-Final Competition (10:50 a.m. - 11:00 a.m.) – #3 vs. #4

Final Competition (11:00 a.m. - 11:10 a.m.) – #1 vs. #2

The Capstone Projects



Dr. William Resh
Professor of Mechanical Engineering

Presentation Schedule – Engineering Building, Room 1202

| Time | Team Sponsor | Project Title |
|------------|---------------------------------------|--|
| 9:00 a.m. | MSU Adaptive Sports & Recreation Club | Athletic Walker |
| 9:30 a.m. | Steelcase | Overhead Conveyor Hang Fixture Stabilization |
| 10:00 a.m. | General Motors | Directional Speakers and/or Systems |
| 10:30 a.m. | Hitachi | QFN Solder Joint Robustness |
| 11:00 a.m. | Packsize | Corrugate Laser Cutting and Creasing |
| 11:30 a.m. | Ingersoll Rand - Trane | Custom Air Handling Unit Panel |
| 12:00 Noon | Ingersoll Rand - Trane | Externally Mounted Impeller Exhaust Hood |

ME 481 Mechanical Engineering Design Projects

ME 481 is a required course for mechanical engineering majors at MSU. The course provides students with a team-based capstone design experience in which they:

- use the technical expertise, communication skills, and teaming methodologies they have learned throughout their mechanical engineering curriculum, together with their creativity, to solve real world problems,
- collaborate with practicing engineers to address problems sponsored by industry,
- develop new products or redesign existing products to reduce costs or enhance reliability and functionality,
- interact with large, medium, and small companies in the automotive, defense, aerospace, consumer products, and agricultural industries, and with US government agencies.

We gratefully acknowledge the support of this semester's project sponsors: ARaymond, ArcelorMittal, Bosch, Environmental Protection Agency, Fairmount Santrol - Alpha Resins LLC, Michigan AgrAbility, Ford Motor Company, General Motors LLC, Hitachi Automotive Systems Americas Inc., Ingersoll Rand - Trane, Marathon Petroleum Company, Meritor, MSU Adaptive Sports and Recreation Club, MSU Formula SAE Team, Packsize, Steelcase, Tenneco, Inc., and Whirlpool Corporation.

MSU Adaptive Sports & Recreation Club

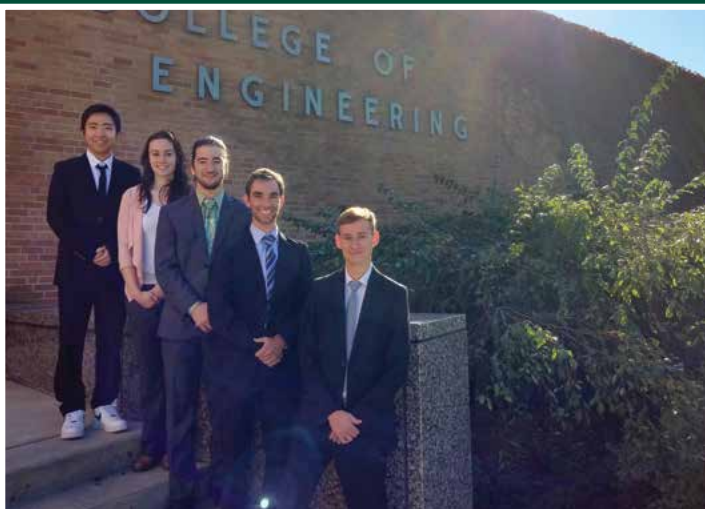
Athletic Walker

The MSU Adaptive Sports & Recreation Club is an organization that provides a welcoming environment and exercise resources to people with physical disabilities. The goal of this project is to create a safe, durable, and ergonomic posterior posture walker that easily moves with the user during a sports application. This device is intended to be used by persons with partial control over their lower limbs. The adaptive walker can be used on a variety of surfaces such as a track, turf, and a basketball court. The intent is to allow users to utilize their full body when exercising, rather than being constrained to a wheelchair. The team worked closely with members of the adaptive sports team to gather input and target key issues with current walkers. The main focuses of the new design were ergonomic handgrips, a foot shield for the back wheels, and a quick switch to lock/unlock the front wheels. These unique concepts combined to allow a safe but adaptive environment.



MICHIGAN STATE
UNIVERSITY

Resource Center for
Persons with Disabilities
Maximizing Ability & Opportunity



Michigan State University

Team Members (left to right)

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Rachael Acker
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Steven Ward
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Paul Heeder
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Zack Dutcher
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MSU Adaptive Sports & Recreation Club

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Steelcase

Overhead Conveyor Hang Fixture Stabilization

Steelcase is the world's largest manufacturer in office, health, and education furniture. The company's products and services create spaces that amplify the performance of people, unlocking their human promise. For more than 100 years, Steelcase has worked with leading organizations to provide great experiences for their people.

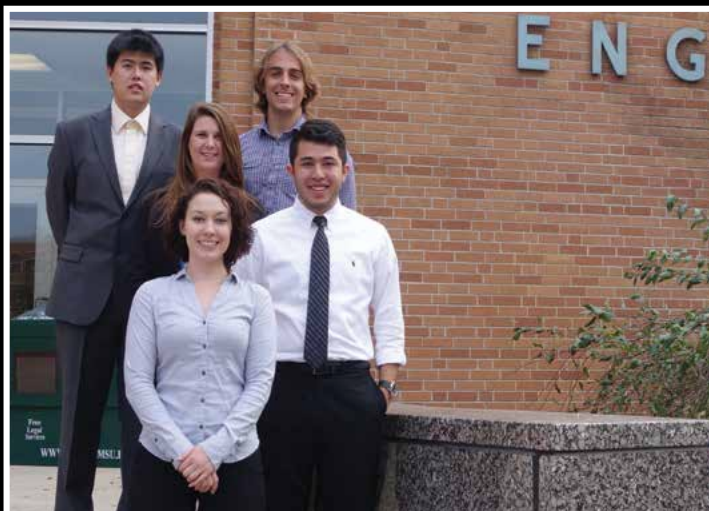
Currently, Steelcase is seeking to convert its powder paint shops to robotic painting in order to achieve improvements in quality and powder transfer efficiency and to meet increasing skill requirements.

The main factor that hinders a conversion stems from the robot's inability to effectively paint due to swaying of the products moving through the booth. This swaying is caused by vibrations in the system that can lead a part to make contact with the nozzle of the paint gun as well as result in accuracy errors when painting.

For this project, the group delved into solutions that helped stabilize the swaying motions in the parts to their required tolerance. The idea of an eddy current damping station in order to stabilize the parts was proposed, and the team was asked to begin the steps into development of the design. Plans towards development were addressed to prove conceptually which ideas could be produced. Accomplishing this required modeling of the system mathematically, determining which items were necessary to be purchased, optimizing the placement of these items, and lastly demonstrating this system with a scaled-down model to prove the dampening effects.



Steelcase



Michigan State University

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Steelcase

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General Motors LLC

Directional Speakers and/or Systems

General Motors has a growing line of electric and electric-hybrid vehicles. Electric vehicles are nearly silent when in operation because of the lack of an internal combustion engine. While this is a selling point to the drivers of the vehicles because they prefer a silent cab, it can cause an issue to people outside of the car. If the vehicle is nearly silent, it can be dangerous to pedestrians because they might not be aware of the presence of the car.

The objective of this project was simple: develop a noise generation system to project noise outward from the car at a specified frequency and decibel level in order to make aware the presence of the car to the environment. Simultaneously, the noise created by our system must also be cancelled in the cabin of the vehicle so that the driver experiences a nearly silent ride.



Michigan State University

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Alyssa Bartlett
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Trevor Herrinton
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General Motors LLC

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Hitachi Automotive Systems Americas, Inc.

QFN Solder Joint Robustness

Hitachi Automotive Systems Americas, Inc. manufactures and markets a broad range of electromechanical and electronic automotive products for all major automotive original equipment manufacturers. Based in Farmington Hills, Michigan, Hitachi has historically been synonymous with safety, quality, growth, and continuous improvement.

As vehicles become increasingly computer based, automotive companies are asking for smaller circuit boards that have greater capabilities and remain robust to harsh vehicle environments. As a response to these requests, Hitachi Automotive Systems and other electronics suppliers are switching their electronic components to Quad Flat No-lead (QFN) devices in order to save space. These QFN components are soldered to the circuit board but have smaller leads than the standard leaded devices. The smaller leads on the QFN devices are cracking when the heat sinks, which are under the circuit boards, deflect vertically during thermal loading.

Our team created, organized, and carried out a test to determine which heat sink cross-sectional area will allow for the most vertical deflection of the heat sink before QFN failure. The design team ran finite element analysis alongside mechanical testing to simulate the thermal load, quantifying the stress distribution. The internal stress values of the board at the location of the failure can be used to predict failure in other Hitachi PCBs and in future electronic controller design.

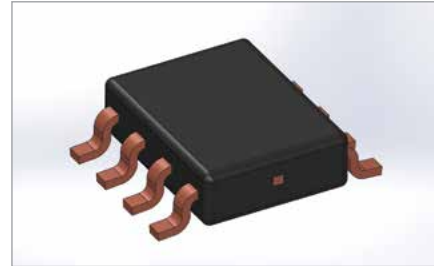


Fig. 1 Typical Gull-wing Leaded device

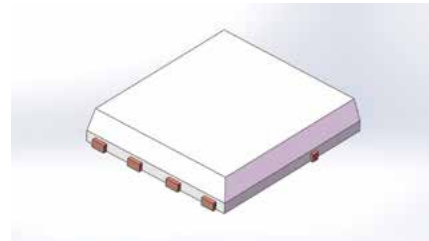
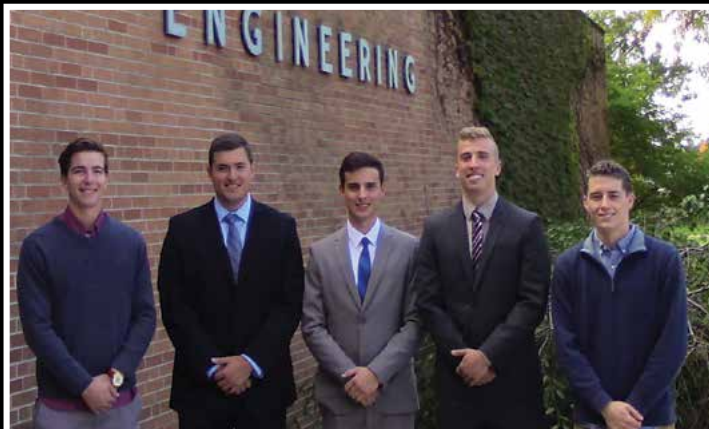


Fig. 2 Leadless device

HITACHI

Inspire the Next



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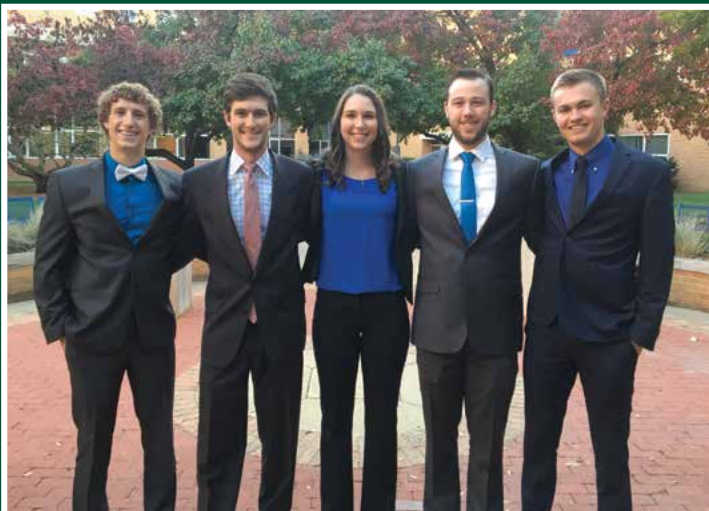
Dahsin Liu
East Lansing, Michigan

Packsize

Corrugate Laser Cutting and Creasing

Packsize is the world leader in on-demand packaging, providing customers with the ability to create the right sized, custom box on the fly. This is accomplished by utilizing machines designed and manufactured by Packsize. These machines cut and crease corrugated cardboard into the right size and configuration for the customer's specific needs. With this technology, their customers reduce shipping costs, use less corrugated material, minimize void fill (air pillows, packing peanuts, etc.), reduce or eliminate premade box inventory, optimize warehouse space, reduce labor, and increase environmental sustainability. Packsize wishes to increase their machine capabilities even further through the use of laser technology.

Our design team was tasked with looking at laser effectiveness in relation to corrugated material. This project required the team to research different types of lasers and their capabilities. The design process began with understanding the different laser parameters to design better tests for identifying the laser's ability to cleanly and effectively cut and crease corrugate. Packsize helped the group obtain a laser and corrugate samples for testing. The group used process design to develop tests that analyze the significance of laser power, speed of cutting, and other parameters. The group executed its tests, analyzed the results and optimized the laser settings. This was done through an iterative process to best identify the effectiveness of cutting and creasing corrugate. Throughout this project, the team focused on safety as a critical design and testing factor.



Michigan State University

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Packsize

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Ingersoll Rand - Trane Custom Air Handling Unit Panel

Trane, a brand of Ingersoll Rand, produces high-quality air handling units (AHU) for industries such as health care, education, government, etc. They have been offering custom AHUs with high performance in air leakage and casing deflection for over 20 years; however, they would ideally offer more flexibility to customers seeking a cost-effective option. Because of this, Trane is losing to competitors such as Leibert, Silent-Aire, Energy Labs, and Haakon, who offer flexibility by producing AHUs for customers seeking less robust designs compared to Trane's.

Our design group benchmarked the AHU industry to determine the best approach to designing an alternative cost competitive panel for Trane while keeping a class-A certification. Working closely with Trane's product engineering, marketing, and customer service, they further developed the design and determined the desired target cost for the new panel.

Utilizing finite element analysis (FEA) software, ANSYS, we analyzed cost-cutting designs based on load and certification requirements provided to us by Trane. Our design group produced two final design alternatives in Siemens NX and presented them, along with FEA studies, to Trane for its consideration. With a cost competitive alternative to its custom AHU, Trane will spearhead the market and once again become the leading custom AHU manufacturer in the industry.



TRANE®



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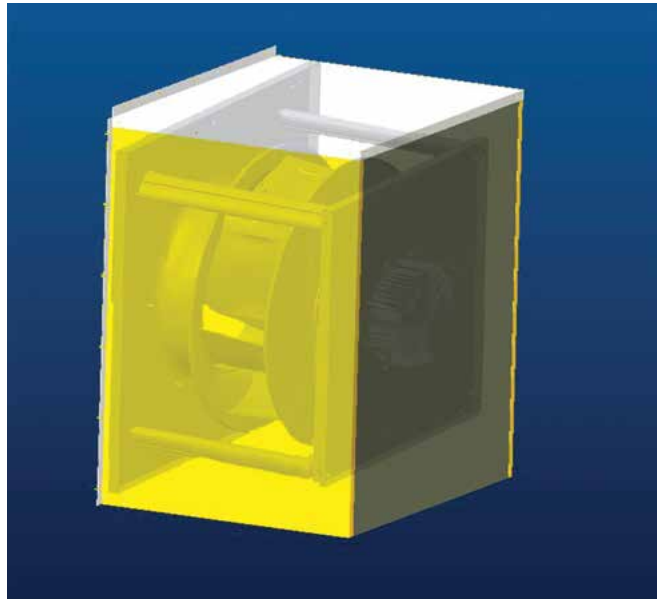
Ingersoll Rand - Trane

Externally Mounted Impeller Exhaust Hood

Trane Inc. is a subsidiary of Ingersoll Rand Inc. located in La Crosse, Wisconsin. It is a world leader in air conditioning systems, services, and solutions. Trane offers a wide range of energy-efficient systems including heating, ventilation, and air-conditioning. Trane's CSAA product line features various sizes of industrial air handlers designed to clean, filter, dehumidify, heat, and cool commercial buildings with superior performance, industry-leading efficiency, and tailored specifications to satisfy the unique demands of each customer.

Trane has been utilizing motorized impeller fans for multiple applications in its CSAA line, and these fans can be used for its return air systems as well as its supply air systems.

In the current design, the impeller fan is mounted internally, which increases the overall size of the unit. Our team's objective was to create a reduced overall length exhaust fan design for the two different size options of CSAA air handlers. The motorized impeller exhaust fans were externally mounted to a foam-injected two-inch parallel panel. The project includes two alternative designs for the fans depending on the unit. An exhaust hood was designed to cover the fan and was tested by our team.



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Danielle Heger
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Evan Weider
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The Capstone Projects



Dr. William Resh
Professor of Mechanical Engineering

Presentation Schedule – Engineering Building, Room 1220

| Time | Team Sponsor | Project Title |
|------------|---------------------|--|
| 9:00 a.m. | Tenneco | Characterization of Phase Change Materials |
| 9:30 a.m. | Bosch | Test Fixture for BLDT Diesel Pumps |
| 10:00 a.m. | Hitachi | BNA Lash Study |
| 10:30 a.m. | Meritor | Optimized Axle Carrier Structure |
| 11:00 a.m. | Ford | Driveline Joint Friction |
| 11:30 a.m. | Marathon | “Pig” Transmitter Functionality |
| 12:00 Noon | Michigan AgrAbility | Tractor Step Bracket |

Mechanical Engineering Design Program

Mechanical engineers make the world move and provide the energy for it to do so. One goal of the MSU Mechanical Engineering Program is to educate engineers who are prepared to lead, create, and innovate as their professional or graduate careers evolve. The Mechanical Engineering Design Program is the key element of the curriculum that supports this goal. There are five required design courses in the program which provide our students with eight hands-on team-based, ‘design, test and build’ projects, and numerous opportunities to practice and refine their written, oral, poster, and video presentation skills. The Design Program in Mechanical Engineering has attracted national recognition on many occasions and helps to distinguish the ME program as one of the best in the country.

The ME faculty who supervised ME 481 design teams this semester are: Seungik Baek, Gary Cloud, Alejandro Diaz, Abraham Engeda, Brian Feeny, Farhad Jaber, Dahsin Liu, Al Loos, Norbert Mueller, Ranjan Mukherjee, Dan Segalman, Rod Tabaczynski, Brian Thompson, and Sharon Xiao.

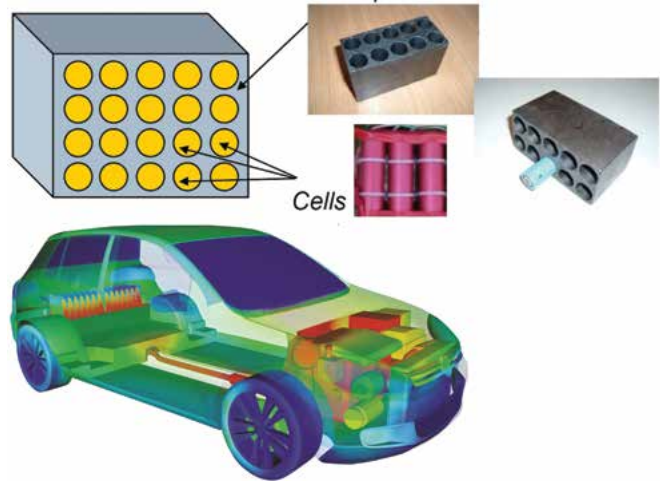
Tenneco, Inc.

Characterization of Phase Change Materials

Tenneco, Inc. is a global company leading in the designing, manufacturing, and distribution of automotive clean air and ride performance products. Tenneco's vision is to pioneer global ideas for cleaner air and smoother, quieter, and safer transportation. A breakdown of the company's clean air business includes reduction and control of criteria pollutants, greenhouse gases, and acoustic noise.

With the increasing need to make automobiles more efficient, losses of energy through heat have the possibility to be recovered and used in different areas of a vehicle. Our design team worked on the research and testing of Phase Change Materials (PCM) in a Hybrid Electric Vehicle (HEV) battery cooling system. PCMs are substances with high latent heat capacities which allow for absorption and storage of energy at a constant temperature. These materials can hold more thermal energy between phase changes, which make them great materials to capture energy and transfer it for use in other areas of an automobile.

We identified PCM materials that can be used to capture heat emitted from a HEV battery system, a means to ensure proper energy transfer to and from the PCM, as well as efficient transfer of the PCM stored thermal energy to various chosen applications in the vehicle.



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Bosch

Test Fixture for BLDT Diesel Pumps

The Bosch Group is a leading global supplier of technology and services. The company employs approximately 375,000 associates worldwide (as of Dec. 31, 2015) and generated sales of \$78.3 billion in 2015. Its operations are divided into four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods, and Energy and Building Technology. The Bosch Group comprises Robert Bosch GmbH and its roughly 440 subsidiaries and regional companies in some 60 countries. If its sales and service partners are included, then Bosch is represented in roughly 150 countries.

The Diesel Systems group at Bosch supplies high pressure cylinder pumps to their customers as part of the common rail fuel system. As part of the release testing a bearing load drive torque (BLDT) measurement must be completed. This requires strain gauges to be installed on the driveshaft of the pump. Once the pumps are instrumented, it is imperative pumps be tested on a fuel system bench prior to being installed on a test engine. This is especially true on BLDT pumps as the strain gauges are extremely sensitive and prone to failure.

The project being completed by the MSU Capstone team will increase the efficiency of testing BLDT instrumented pumps by reducing test bench down time and reducing the risk of fuel contamination. It will also provide a higher quality of testing as some instrumented pumps that cannot currently be tested on our benches, will now be able to be tested insuring the pumps are properly instrumented prior to being installed on an engine.



BOSCH
Invented for life



Michigan State University

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Saad Bahbishi
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Bosch

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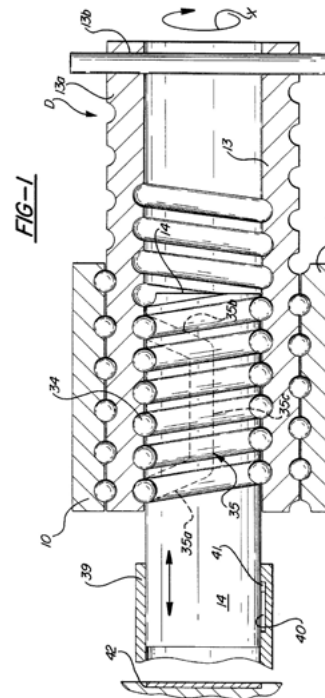
Hitachi Automotive Systems Americas, Inc.

BNA Lash Study

Belt-Drive Electric Power Steering (BEPS) is replacing the older hydraulic steering pumps. BEPS offers many advantages; BEPS is lighter than the hydraulic steering system and it does not require power from the engine. This leads to an overall increase in the vehicle's performance and fuel economy. Additionally, BEPS provides more freedom in defining the performance characteristics to better match the target vehicle. For example, the same gear could be used in a truck and a sports car.

As shown in the diagram, the rack has a groove, or thread, in which sit the ball bearings located inside the ball nut assembly (BNA). The ball bearings do not fit perfectly within the grooves where lash greater than 30 microns is undesirable. If there is no lash, there will be increased friction; while a lash too high will facilitate noise conditions.

The goal of the project was to directly measure the lash between the BNA and the rack. In order to do so, the team needed to prevent the BNA from rotating while moving the rack back and forth. The movement of the BNA was measured via a laser or force cell measurement system.



HITACHI

Inspire the Next



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Andrew Boyer
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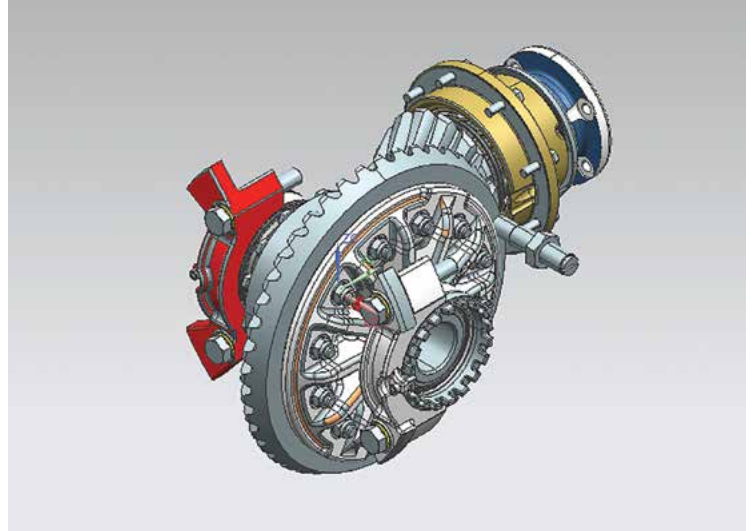
Rodney Tabacaynski
East Lansing, Michigan

Meritor

Optimized Axle Carrier Structure

Meritor is a global leader in advanced drivetrain, mobility, braking, and aftermarket solutions for the global commercial vehicle and industrial markets. With the goal of meeting the customers' needs, Meritor strives to develop innovative products that provide superior performance, energy efficiency, and reliability.

In an effort to reduce the cost and weight of the carrier structure on the rear drive axle of trucks, Meritor is looking to implement a thrust bearing to counteract the gear forces directly, where the loads are applied by the pinion gear onto the ring gear. During overload conditions, the pinion gear faces some deflection, which is inefficiently absorbed by the carrier structure. With a thrust bearing implemented, the load will be directed to the carrier structure directly through this device. The point that this force enters the carrier structure is known, therefore allowing the carrier structure to be optimized to absorb the desired amount of force with the least amount of material. This result decreased the weight of the carrier structure, decreasing costs and increasing fuel efficiency. The improved carrier structure and thrust bearing also decreased the deflection of the pinion gear, decreasing the wear on the pinion and ring gears and increasing lifespan and performance.



Michigan State University

Team Members (left to right)

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Pedro Garcia (*Sponsor*)

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Meritor

Project Sponsors

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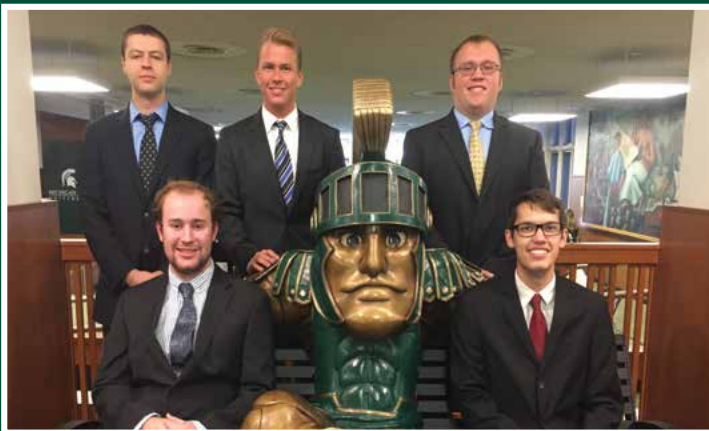
Norbert Mueller
East Lansing, Michigan

Ford Motor Company

Driveline Joint Friction

Ford Motor Company is one of the largest automotive manufacturers in the world with large markets in Europe, Asia, and North and South America. Headquartered in Dearborn, Michigan, Ford produces some of the most dependable and long-lasting vehicles. To ensure that the company remains competitive in the increasingly competitive auto industry, Ford engineers are designing their products with the “Go Further” mentality. To improve the driving experience, Ford’s Powertrain NVH Research and Development department partnered with Michigan State’s engineering department. Ford is currently unsatisfied with their ability to model friction in their Computer Aided Engineering models and is working with Michigan State University to develop a device capable of identifying the dynamic friction losses in their driveshaft joints. Ford can use the results from this project to significantly reduce development times and costs in the future.

The test fixture that Ford requested will be able to accurately measure articulation torque vs the angle of the joint in real time and produce hysteresis plots. The fixture will be able to apply various articulation speeds and torques on the shaft while filtering out possible noise in the data due to the mechanical properties of the system.



Michigan State University

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Ford Motor Company

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East Lansing, Michigan

Marathon Petroleum Corporation

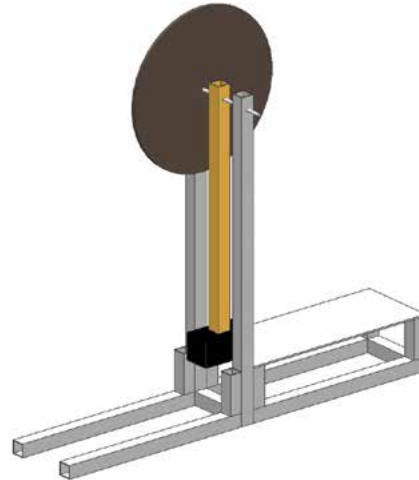
“Pig” Transmitter Functionality

Pig tracking devices have been found to fail during nitrogen purges of pipelines. Several failure modes were hypothesized. The design team investigated the effects of temperature and force on Pig Transmitter functionality through the use of experimental methods. These failure modes were examined because they were identified as the most probable causes of failure.

To determine the effects of temperature on the tracking devices, the conditions of the pipeline were simulated. A transmitter was placed into an insulated chamber and cooled. Throughout the experiment the amplitude of the transmitter signal was measured against the temperature of both the air in the chamber and the surface temperature of the device. The data was then analyzed to determine the temperature at which the transmitter failed.

The forces present on the tracking device during operation were reproduced to determine the effects of force on transmitter functionality. An impact test was performed directly on the transmitter. The force applied to the transmitter was increased with each trial of the experiment. During testing, the amplitude of the device signal was again monitored to determine the force at which failure occurred.

By receiving and interpreting results from these tests, Marathon can determine why their Pig Transmitters are failing and implement a design to correct the issue, making their Pigs more reliable.



Marathon Petroleum Corporation



Michigan State University

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Brett Hewitt (*Sponsor*)

Marathon Petroleum Corporation

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Findlay, Ohio

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Findlay, Ohio

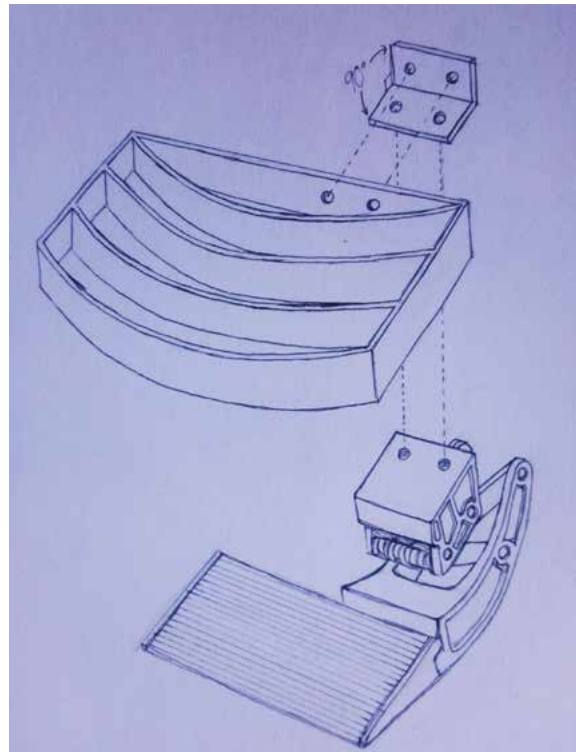
ME Faculty Advisor

Dashin Liu
East Lansing, Michigan

Michigan AgrAbility Tractor Step Bracket

Michigan AgrAbility provides services to farmers with disabilities, illnesses or aging conditions. It develops farming tools, equipment, and methods to allow farmers with disabilities to continue their productive work and lifestyle.

Farmers with physical limitations to their legs have a very difficult time climbing the first step of tractor ladders. The first step to a tractor is especially high off the ground, usually 22 inches. This large distance causes strain on these farmers. In order to account for this, commercially available folding bed steps can be used to eliminate this large distance. The goal of this project was to fabricate a bracket that secures the bed step to the bottom step of a tractor ladder. This allows for farmers to easily climb on the tractor as well as resolve the need of the first step being high from the ground.



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Seungik Baek
East Lansing, Michigan

The Capstone Projects



Dr. William Resh
Professor of Mechanical Engineering

Presentation Schedule – Engineering Building, Room 1300

| Time | Team Sponsor | Project Title |
|------------|-------------------|--|
| 9:00 a.m. | Tenneco | Liquid Gas Separator |
| 9:30 a.m. | EPA | PEMS Flow Meter Calibration |
| 10:00 a.m. | ARaymond | Surface Geometry Coefficient of Friction Study |
| 10:30 a.m. | Whirlpool | Interchangeable Grid for Ice Cube Cutting |
| 11:00 a.m. | ArcelorMittal | Preliminary Steel Sample Rapid Cool Box |
| 11:30 a.m. | Fairmount Santrol | Innovative Bulk Packaging |
| 12:00 Noon | Pratt and Miller | FSAE Carbon Fiber Suspension |

Mechanical Engineering Design Program Awards

The Mechanical Engineering Design Program makes three project awards on Design Day. The most significant award is the Thomas Alva Edison Design Award—a medal—given to each member of the ME 481 Capstone design team that produces the most outstanding technical design project. This award considers the team's performance over the duration of the project, their presentations, the project solution, and prototype quality.

A second ME 481 Capstone award is given to the team that gives the best technical project presentation. The importance of communication of scientific and engineering ideas cannot be understated, and it is for this reason that we make the ME 481 Project Presentation Award. Award winners will typically have built an impressive prototype which forms the basis for a very clear and effective presentation of the project background and its solution, often incorporating live or video demonstrations of its functionality.

The ME Design Program also presents the Leonardo da Vinci Machine Design Award to the winners of its ME 471 Machine Design competition. The specific design problem and criteria for this competition change from semester to semester.

Tenneco, Inc.

Liquid Gas Separator

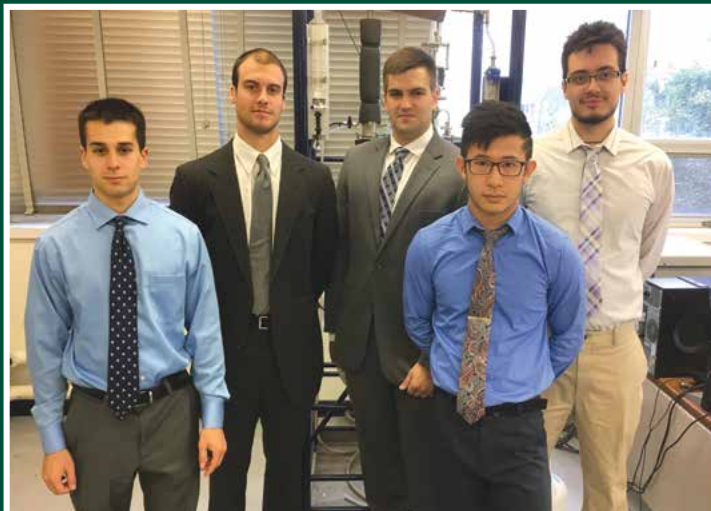
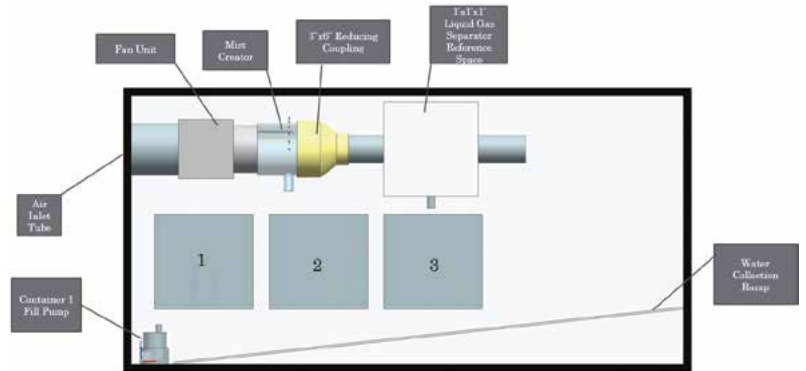
The problem to be solved for Tenneco, Inc. was to create a new concept idea and prototype for a liquid gas separator (LGS). A benchtop testing rig was also to be created to test the efficiency of the LGS.

Applications for an LGS include exhaust gas recirculation condensers, HVAC, refrigeration, A/C, and kitchen ventilation systems. In all applications, it is useful and necessary to separate the contaminants from the inlet airflow.

Our focus for the LGS was the EGR application. While considering the high pressures and temperatures of an EGR and other constraints, we operated our LGS prototype at room temperature and lower pressures.

Our solution process included a literature review of LGS methods in the market, brainstorming, choosing best design, analyzing the design using models/calculations, optimizing, and building a desktop demonstrator. For the desktop demonstrator, there needs to be a method of supplying the saturated air/vapor mixture into the inlet of the LGS. A pressure of around 1 bar was required.

An optimal LGS will have both a low pressure drop and high efficiency (rids air of moisture). The goal for this project was to create innovative methods for separating liquid from an air/vapor mixture and creating an efficient way of testing and qualifying the LGS.



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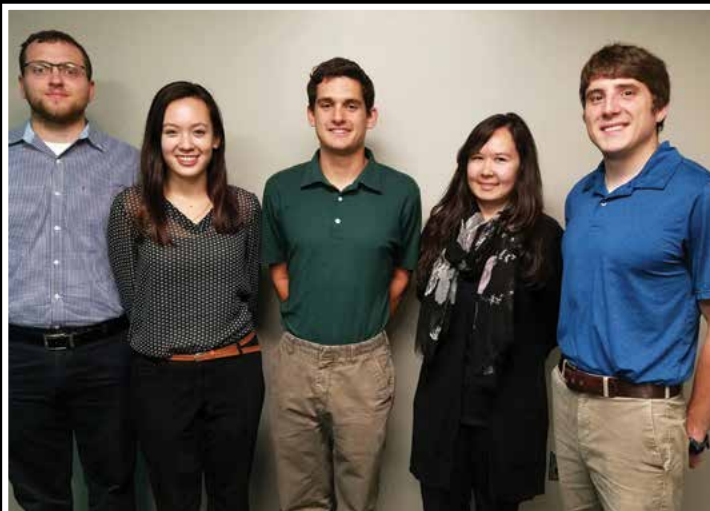
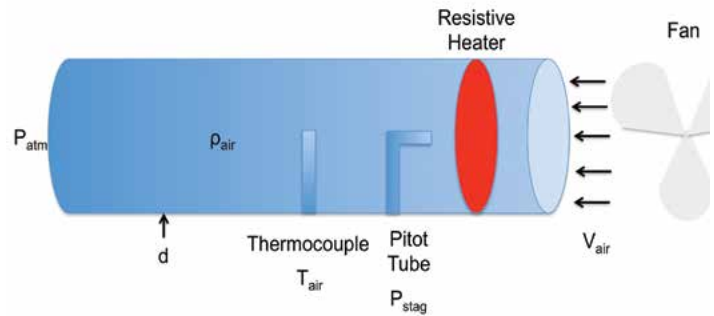
Environmental Protection Agency (EPA)

PEMS Flow Meter Calibration

The mission of the Environmental Protection Agency is to protect human health and the environment. The EPA is responsible for maintaining and enforcing national environmental laws dealing with land, air, and water pollution as well as hazardous waste, endangered species, and other issues. The Ann Arbor National Vehicle and Fuel Emissions Laboratory is responsible for the complete range of tasks required to provide the necessary laboratory testing and support services to verify that Federal Emission Standards are met.

One way to test vehicle emissions outside of the lab is by collecting data using a Portable Emission Measurement System (PEMS). The flow meter attached to the PEMS unit needs to be calibrated frequently to guarantee accuracy; the EPA currently does not have an in-house method to do this. Instead, the EPA must physically send their flow meters back to the manufacturer in order to have them calibrated. This process can take up to two weeks, leaving the EPA short of flow meters, and costing them time and money. The EPA hopes to remedy this problem by developing a device that allows for in-house flow meter calibration.

Our design team constructed a fully functioning prototype based on specific operating points obtained from previous PEMS data. Testing conditions simulated exhaust temperatures and flow, and NIST traceable instruments will ensure reliability. The desired prototype is also portable. A manual detailing construction, operation, and maintenance of the prototype was included for the EPA.



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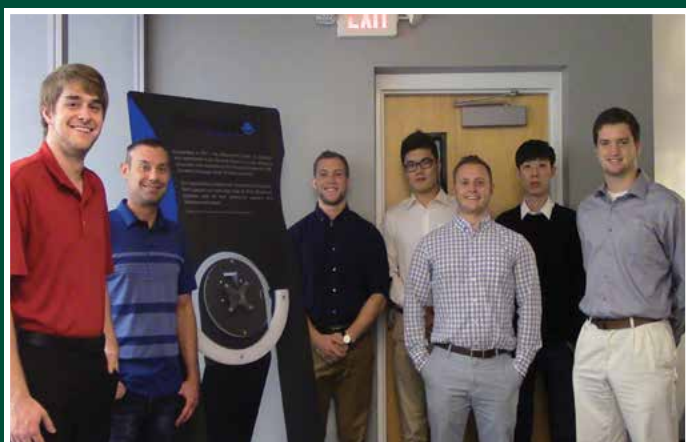
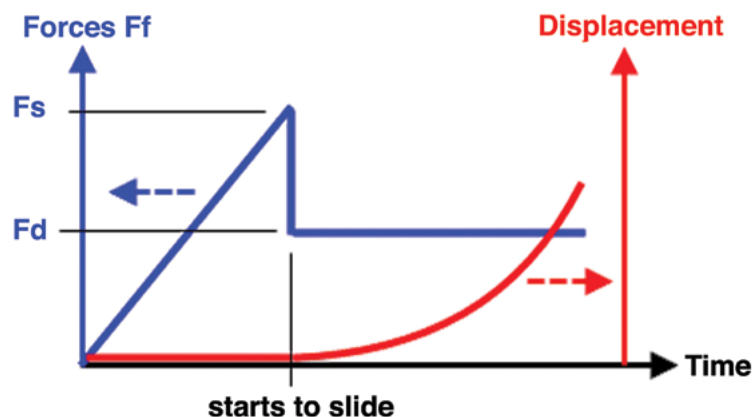
East Lansing, Michigan

ARaymond

Surface Geometry Coefficient of Friction Study

ARaymond is a global company that specializes in the design and manufacturing of fasteners and bonding agents for multiple industries. ARaymond's products range from creating biodegradable fasteners for plants in greenhouses to industrial/commercial fasteners for photovoltaic modules.

ARaymond is currently investigating the relationship between surface geometry and the resulting coefficient of friction between two surfaces. In-depth knowledge in this correlation will lead to advancements in ergonomic design for ARaymond's products. The team designed and built a testing system to help find these correlations with many different geometries.



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Whirlpool Corporation

Interchangeable Grid for Ice Cube Cutting

Whirlpool Corporation is a Fortune 500 manufacturer of household appliances, headquartered in Benton Harbor, Michigan. It produces under-counter icemakers for use in homes and small businesses. These icemakers are state-of-the-art and produce completely clear ice, free of sediment and air bubbles.

To form the ice in these icemakers, water flows onto an angled plane in very thin layers until a slab of ice is formed. From there, it is dropped onto a grid, which is comprised of heated wires. These wires melt through the slab of ice to create cubes of identical size and shape.

In order to reach a new market, a grid has been created to produce ice of different shapes that can be changed by the consumer. Some of these shapes are stars, circles, or triangles. In the future, seasonal shapes might be produced as well. Because this is a new product, the icemaker had to be retrofitted in order to be able to easily exchange the grids. Ergonomic constraints were a major factor in considering the interchangeability of the grid system in order to be able to accommodate for consumers with disabilities or physical limitations.



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ArcelorMittal

Preliminary Steel Sample Rapid Cool Box

The ArcelorMittal Burns Harbor location is the second largest steel making facility in America. Products manufactured at this plant include hot and cold rolled steel, hot-dipped galvanized sheet, etc. Along with supplying the automotive market, ArcelorMittal also provides steel products for the appliance, construction, and distribution industries. The Burns Harbor location acts as an excellent highway and railroad epicenter for the 5 million tons of raw steel it produces annually.

An important standard for the company is to ensure consistency in the quality of their steel. Preliminary steel samples are formed and retrieved from one of three Basic Oxygen Furnaces (BOF) to determine the chemical composition. These samples must be cooled quickly before testing commences. The current solution calls for a metallurgical process known as quenching, where water can enter through microscopic voids in unformed samples. When these “bad” samples are tested on the Optical Emissions Spectrometer (OES), an electric arc vaporizes the water embedded in each sample. Mixed with graphite dust, water clogs the OES and can result in up to two hours of idle time.

The goal of this project was to find an effective system that would rapidly cool samples and, in turn, reduce inaccuracies/faults in the OES. Utilizing convective cooling, the updated process uses a high powered air blower to lower sample temperatures to 20 °C (room temperature) in under 30 seconds.



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Fairmount Santrol – Alpha Resins LLC

Innovative Bulk Packaging

Fairmount Santrol is a leading provider of high-performance sand and sand-based products used by oil and gas exploration and production companies to enhance the productivity of their wells. The company also provides high-quality products, strong technical leadership, and applications knowledge to end users in the foundry, building products, water filtration, glass, and sports and recreation markets. Its products are delivered around the world and, as such, the products must be shipped in packaging that will protect the products from a variety of climates. Upon delivery, the products will be stored in the customer's industrial facility without climate control for an unknown amount of time.

The project required research and development of an alternative bulk package that is able to be reused or repurposed to maintain the company's zero landfill policy across its 30+ facilities. Additionally, the new bulk package must prevent moisture from contaminating the product, while also being heat resistant to prevent the product from fusing into a large lump, which requires rework. The new bulk package will prevent or reduce the need for product rework, while also being reusable and inexpensive.



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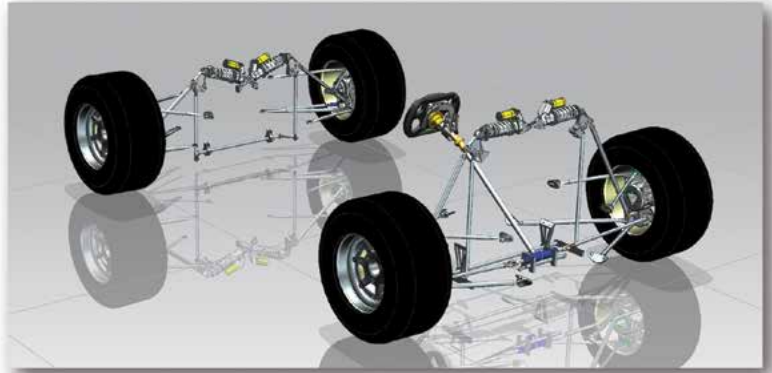
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Pratt & Miller Engineering

Formula SAE Carbon Fiber Suspension

Formula SAE (Society of Automotive Engineers) is the largest collegiate design competition in the world, which challenges students to design, manufacture, and test a small, open-wheel racecar. The Formula SAE Team has partnered with Pratt & Miller Engineering (PME). PME, founded in 1989, is an engineering firm that focuses on professional motorsports and advanced technologies. PME currently develops Corvette Racing, the most successful team in the history of the American Le Mans Series. With their advancements in motorsports, the company expanded into a full engineering firm with over 300 employees. They now serve customers in the defense, automotive, and power-sport industries.

With the support of PME, improvements to the Formula SAE vehicle were made by developing a carbon fiber suspension system. The objective was to design, manufacture, and validate a composite suspension to reduce the mass of the 2017 vehicle. This process involved performing structural analysis on the linkages while utilizing finite element analysis to design the laminate schedule of each link. Bonding strategies were researched and implemented to properly bond aluminum inserts inside the optimized carbon fiber links. The aluminum inserts house spherical bearings, which allow for proper suspension articulation. Overall, the suspension system must be able to withstand the loads generated at the tire, while being as light as possible.



**PRATT &
MILLER**



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Project Sponsor

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Design Day Awards Spring 2016



SPRING 2016 ME 481 THOMAS ALVA EDISON UNDERGRADUATE DESIGN AWARD

The Thomas Alva Edison Award for the best overall technical design project was awarded to a team that designed, built, tested and made measurements of dynamic friction in drive-shaft joints in a project sponsored by Ford Motor Company and supervised by Dr. Dan Segalman.

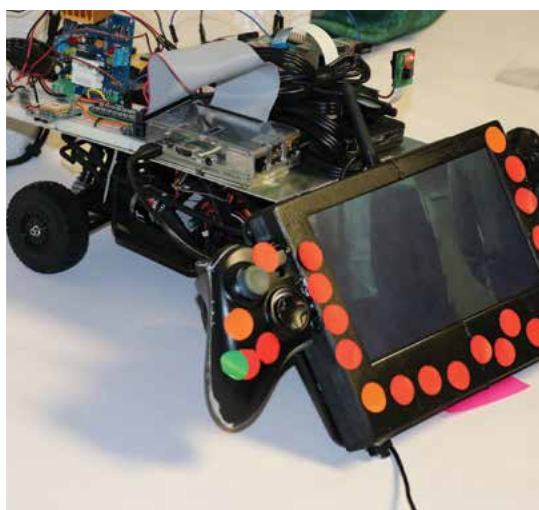
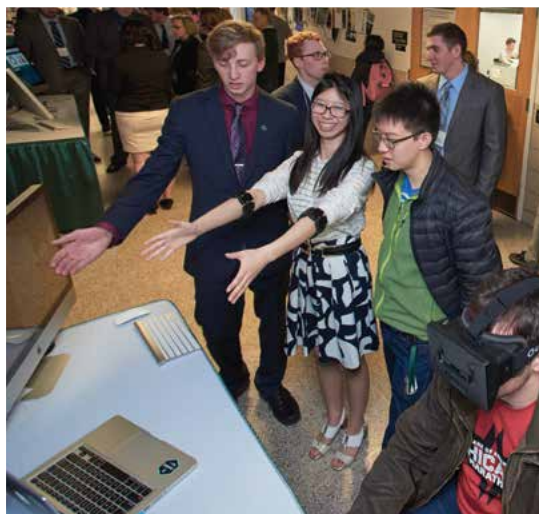
Left to right: Eric Bargiel, Matthew Klooster, Shaoyu Han, Eric Buday, Lindsay Clark and Max Dunigan

SPRING 2016 ME 481 PROJECT PRESENTATION AWARD

The Award for Best Presentation of a design project goes to the designers of an automated spray painting line that uses eddy current damping to stabilize the parts to be painted. The project was sponsored by Steelcase and supervised by Dr. Brian Feeny.

Left to right: Zhi Hong Phuah, Prateek Prasad, Paul Miller, Zhanying Hu and Horitsu Kubata





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ME 491 International Humanitarian Engineering



Dr. Brian Thompson
Professor of Mechanical Engineering

W.H. Welch, MD (1850 - 1934) founder of the School of Public Health at Johns Hopkins University in Baltimore, Maryland, wrote, 'It is a well-known fact that there are no social, no industrial, no economic problems which are not related to health.'

Doctor Welch's insightful remark buttresses and sustains the vision of an international educational initiative launched over a decade ago when box ovens, heated by solar thermal energy, were developed for Tanzanian families. The subsequent International Humanitarian Engineering Program, which has featured projects in Guatemala, India, Kenya, Peru and Zambia was born of hope and ignorance, sustained by good fortune and steadfast determination, and consummated by accomplishments that were unimaginable at the genesis.

However, upon reflection and further cogitation, the rapid growth of this program appears to be almost inevitable because authentic messy interdisciplinary semester-long humanitarian projects motivate and accelerate undergraduate learning much more poignantly than traditional hypothetical academic classroom exercises. This profound learning is manifested by the creation of ergonomically refined pedal-pumps for irrigation; human-powered farm implements that improve harvest-yields; domestic water-purification devices; and solar-dehydration structures that reduce post-harvest losses in fruit crops.

The fabric of this design-intensive interdisciplinary ME 491 course is woven from a thread of ideas on humanitarian societal development that addresses the pressing needs of the 80 percent of the world's population living on

less than US \$2 each day, intertwined with a second orthogonal thread comprising a triumvirate of fundamental ideas on interdisciplinary problem-solving processes, entrepreneurship, and the diffusion of innovations that are relevant to every single nation sharing our small planet. This warp and weft of interlaced fibers constitute the tapestry describing the solution strategy for solving the biggest challenge confronting humanity today: the very survival of the species.

Students enrolled in this enthralling ME 491 course are the visionaries and the bold ones. The dreamers and the doers. The explorers and the discoverers. The achievers and the magicians.

But these risk-takers must maintain paradoxical balances. They are committed to the traditional engineering practice of creating revolutionary new products that enhance the lives of the poor, yet they display personal panache; they are prepared to stand steadfastly alone, clinging tenaciously to their own personal convictions, yet they are willing to unite philosophically because of their commitment to teamwork; and they are relentlessly driven to create waves of positive change in international marketplaces, yet they are also cognizant of social, cultural, and ethical responsibilities. Yes, this is indeed a complicated convoluted cerebral conundrum!

So at this Design Day, pause to review the spectacular innovations created by these ME 491 students. Converse with them, marvel at their dedication to serving the poor, the marginalized, and also the under-represented at the base of the socio-economic pyramid.

USAID: Modular Motorized Threshing Platform for Rural Zambia

Zambia is classified as a Least Developed Country and struggles with malnutrition and poverty. For their basic food, legumes are dense in micronutrients and protein, and when paired with maize, allow for a complete nutritional balance. Small and medium-scale farms in Zambia's northern region produce the majority of the legumes that are consumed by Zambia. Conventional harvesting methods for legumes involve labor intensive threshing by hand that leads to low production rates. Adam Lyman, the team's project collaborator, has previously implemented a mechanized legume thresher system that is powered by a bicycle. This system is excellent for small, resource-limited farms that are looking to improve legume production. However, medium sized farms are in need of a motorized system to meet the demand of their more substantive harvest. Pairing the current thresher with the modular motorized platform will enable farmers to increase their production rate to upwards of 100 kg per hour.

When designing the modular motorized platform, the team considered design specifications unique to Zambian resources and culture, including cost, transportation, energy sources, and many others. System compatibility was a major factor because the motorized platform needed to work harmoniously with the current bicycle-powered legume threshing machine. Selection of the energy source ultimately determined the overall design of the system. Extensive research was done for both solar powered and internal combustion engine systems.

This prototype will be utilized to motorize a variety of otherwise manual farm equipment. Implementation of the modular motorized platform will allow small-scale farmers to increase their crop yield while saving on precious resources such as time and labor.



MICHIGAN STATE UNIVERSITY | Global Center for Food Systems Innovation



USAID
FROM THE AMERICAN PEOPLE



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Global Center for Food Systems Innovation

Project Collaborator

Adam Lyman
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USAID
Project Collaborator

USAID: Zambian Peanut Farming - Human Powered Thresher

Zambia is populated by 15 million people and 60 percent live in poverty. The nation's primary activity is agricultural production and this endeavor employs 85 percent of the workforce. Over 74,000 metric tons of groundnuts are produced annually by small- and medium-sized farmers, despite female farmers manually threshing only 1kg of nuts each hour. In order to enhance this productivity, and each family's income, the team developed a human-powered device that threshes 100kg of peanuts each hour.

It is crucial to be able to visit the area of interest to meet the people the device will be servicing. However, as this was not feasible for the class, we have a collaborator, Adam Lyman, who is a Michigan State alumnus and is currently in Zambia. He serves as our eyes and ears in delivering a better understanding of the dominant culture and its people.

Ultimately, the team needed to “design and manufacture a modular peanut threshing machine that could be used by small-scale farmers in Zambia to de-shell and separate peanuts from their husks.” The nut is currently threshed manually by the farmers, which can cause long-term damage to the farmer's hands. It is essential to not damage the nut when the shell is broken apart; the nut must come out “whole” (not split in half or cracked). In doing so, the team can not only impact the professional lives of the farmers but also impact their personal lives. The group expects the thresher to assist the female farmers in focusing on education, health and family issues rather than having to sacrifice their bodies and lives that are currently devoted to purely threshing.



MICHIGAN STATE UNIVERSITY | Global Center for Food Systems Innovation



USAID
FROM THE AMERICAN PEOPLE



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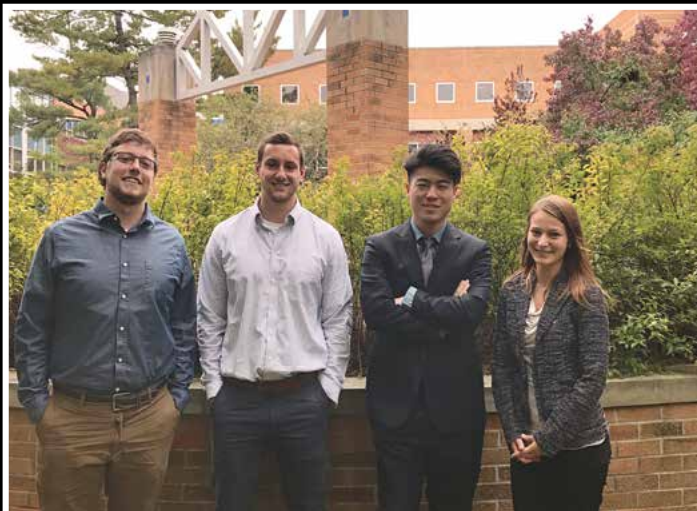
Adam Lyman
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USAID
Project Collaborator

The Indian Government's "Clean India Mission": Human-Powered Trash Collector for Urban Streets

Roads in India are frequently cleaned by brooms and other handheld devices. This is inefficient because of the amount of time it takes and the undesirable health effects such as dust inhalation, the dehydration of the operators, bacterial infections causing vomiting and diarrhea, malaria, skin disease, and typhoid. More so, problems involved with effectively picking up trash include the weather conditions, which can be extremely hot and also rainy during the monsoon season.

Recently, the Indian government has launched an initiative known as the "Clean India Mission," which has set the goal to have India clean by the date of Mahatma Gandhi's 150th birthday in 2019. Due to this mission statement, there is a need for a more efficient and healthy way to collect the trash in the form of a device attached to a human pedal-powered tricycle. Safety and health are of great concern, so the device allows the operator to pick up the trash and place it into a temporary storage unit without actually touching the trash. In order to navigate the sometimes rough terrain on the roadways in India, the device is durable and stable. This manually-powered street-cleaner will provide a much more efficient and sanitary means of cleaning the streets of India, thereby assisting in the progression of the "Clean India Mission."



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Nutri-Fresh Farm & Agri-Hub

Kenya: Human-Powered Water Pump

As Margaret Mead so wisely stated, “Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has.” One of the most important issues that must be changed is the current water crisis throughout large regions of our planet. Currently, 748 million people worldwide do not have access to high-quality, potable water. A vast majority of these underprivileged people live in Africa.

In Kenya, most families must walk many miles each day just to gather water from unsanitary sources such as stagnant mud holes. Woman and children are the main workforce for this exhausting, dangerous task. Gathering and using this water generally leads to numerous health issues caused by water-borne diseases such as dehydration, diarrhea, and many other possibly fatal illnesses.

Our team developed a device that efficiently retrieves water from boreholes and other natural water sources. The goal was to improve the health of local people by reducing the time and energy required to gather water, as well as to improve the quality and amount of water available to them. Considering that electricity may not be available and gas powered devices are expensive, the pump is human-powered. It is capable of retrieving water from depths up to 100 feet and is able to move a minimum of 200 liters per day. Achieving this goal will not only provide a steady source of water for Kenyan families, but all the benefits that come with it such as a cleaner home and enhanced personal hygiene, healthier and more fruitful gardens, more hydrated domestic animals, and more time in the day for activities such as schooling for the children.



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Kathleen Noblet
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Simon Wachieni
Thika, Kenya

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