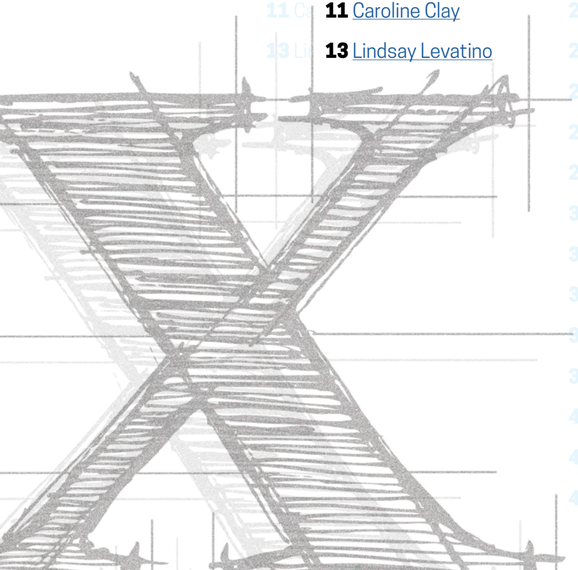

CHANGE'20
MADISON ENGINEERING
A Year of Good Through Innovation, Research, and Design

CONTENTS



CHANGE+MAKERS

A few weeks ago, my oldest daughter found a baseball and a couple gloves and asked to play catch. If nothing else, a pandemic can draw a family closer. As we enjoyed our first time at this, it dawned on me how quickly she improved her throwing and catching. It was partly her gifts at mastering physical activities, but mostly her ability to watch how I was throwing and catching. Seeing is so helpful in how we observe, plan, predict, and respond to new situations.

But what about situations we can't see? Our human experience is limiting, biasing our thoughts and actions around the human scale — physical dimensions proportioned to human bodies, and timescales relevant to human lives.

The grand challenges of today, though, are often at physical scales much smaller or bigger, whether they be hard-to-see viruses or hard-to-see planetary systems, and operating at time scales beyond our routine, whether blindingly fast artificial intelligence evolution, or multigenerational socioeconomic trends. These opportunities require more than our sight and other senses, they require what some call the "mind's eye," a uniquely human talent to imagine, understand, and solve.

How do you learn to see beyond your senses? Three ways come to mind.

Start with curiosity about the world around us. That begins with engaging all our senses, but even more difficult, engaging our discomfort. Opting into different experiences expands reality. Together this builds a wealth of evidence to draw upon, nourishes the imagination, and expands solution possibilities.

Second, get a broad education, in college but also throughout life. Whereas specialization prepared people after the industrial revolution to be a "cog in the machine" doing focused work well, it also results in narrow perspectives. People with breadth and the ability to think in systems will be needed to make connections between emerging needs and new responses. This requires an understanding of technology as well as the humanities, systems and details, complexity and simplicity.

Third, shift perspective from me to us. Each day provides opportunities to create value for others; this service mindset keeps the imagination looking for needs, and along the way provides powerful motivation during the hard work needed. Working on projects that matter, getting solutions out to the world, learning what worked and didn't, then doing it again, is paramount for lasting impact.

Our future is one of disruption, many happening at the same time. The power of engineering is in recognizing change as an opportunity for creativity rather than pain to endure. And that's what drives Madison Engineering — a single degree program offering mastery in the universal skills of engineering through four years of projects on real complex systems, all while providing each student the means to personalize their education for a dynamic world. The project summaries in this book are examples of how our students are stepping into the voids that technological, societal, and environmental shifts create, and responding with engineering that innovates imaginatively for the future instead of wistfully for the past.

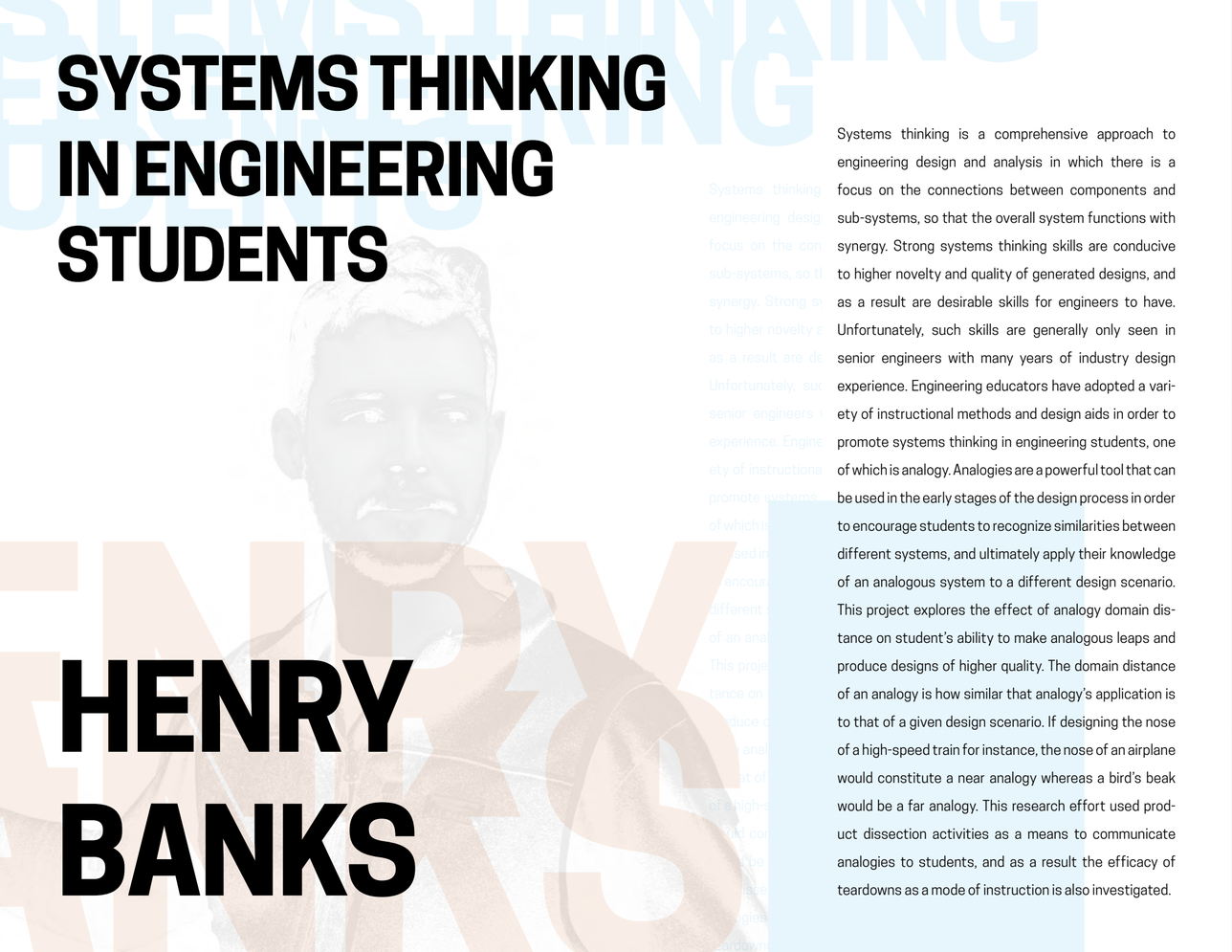
Changes are most certainly coming. Can you see them?

Kurt Paterson, Ph.D.
Head and Professor
James Madison University
Department of Engineering
Harrisonburg, Virginia USA
April 24, 2020


DISCOVER

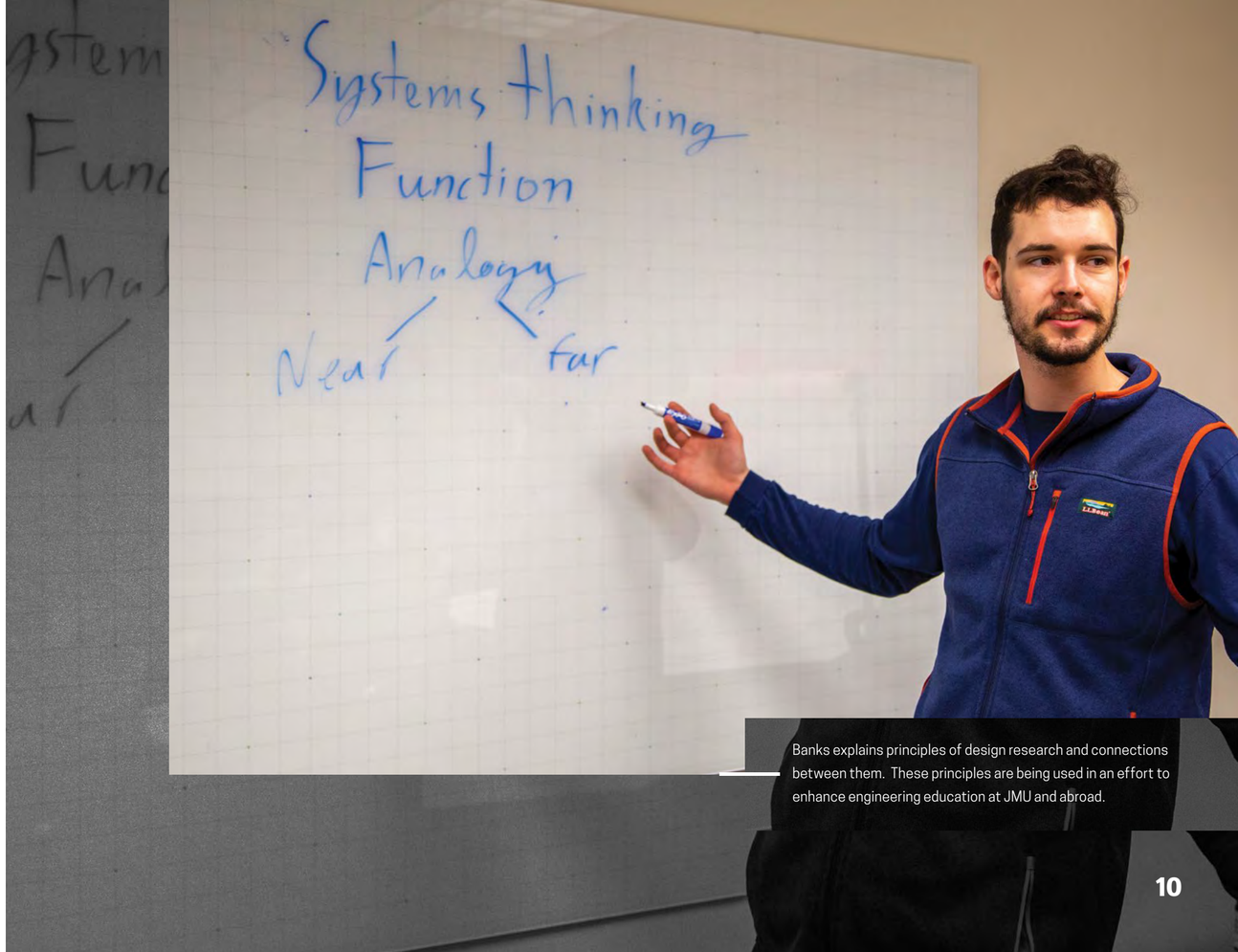

HONORS

SYSTEMS THINKING IN ENGINEERING STUDENTS



HENRY BANKS

Systems thinking is a comprehensive approach to engineering design and analysis in which there is a focus on the connections between components and sub-systems, so that the overall system functions with synergy. Strong systems thinking skills are conducive to higher novelty and quality of generated designs, and as a result are desirable skills for engineers to have. Unfortunately, such skills are generally only seen in senior engineers with many years of industry design experience. Engineering educators have adopted a variety of instructional methods and design aids in order to promote systems thinking in engineering students, one of which is analogy. Analogies are a powerful tool that can be used in the early stages of the design process in order to encourage students to recognize similarities between different systems, and ultimately apply their knowledge of an analogous system to a different design scenario. This project explores the effect of analogy domain distance on student's ability to make analogous leaps and produce designs of higher quality. The domain distance of an analogy is how similar that analogy's application is to that of a given design scenario. If designing the nose of a high-speed train for instance, the nose of an airplane would constitute a near analogy whereas a bird's beak would be a far analogy. This research effort used product dissection activities as a means to communicate analogies to students, and as a result the efficacy of teardowns as a mode of instruction is also investigated.



Banks explains principles of design research and connections between them. These principles are being used in an effort to enhance engineering education at JMU and abroad.

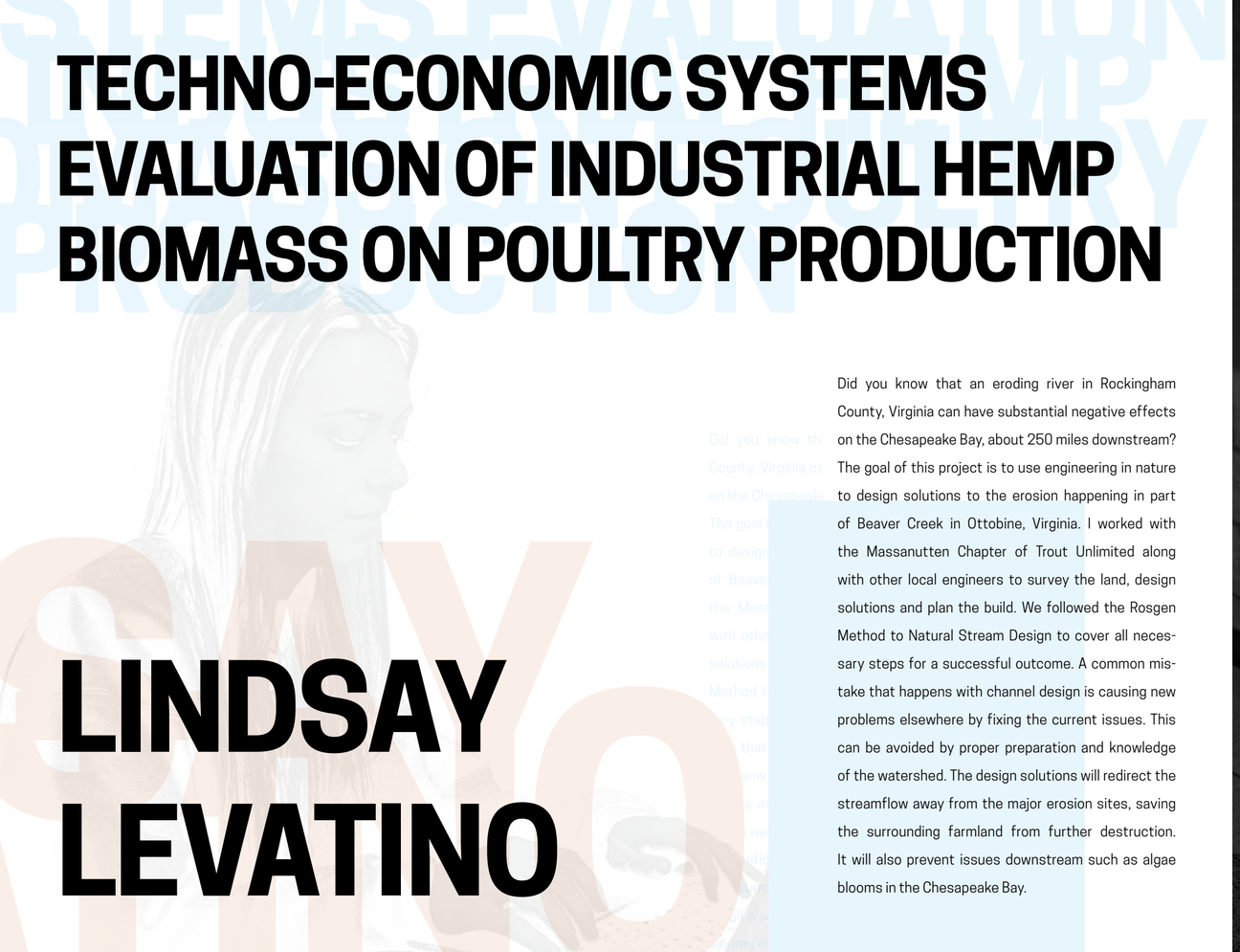
MAKING CHANGEMAKERS: HOW TO TRAIN AND MOTIVATE STUDENTS IN I&E PROGRAMS

CAROLINE CLAY

Over the last several years, the popular media has begun to popularize the phrase “changemakers,” saying that anyone from social activists to your next-door neighbor can be one. However, there has been relatively little research done on how these so-called changemakers are being formed. The first paper in this honors thesis uses a case study methodology to explore how a group of University Innovation Fellows learned, or failed to learn, to become changemakers. As a University Innovation Fellow myself, I was able to analyze the data through a unique lens of both an inside and an outsider. The second paper looks at the motivations and barriers to entry of undergraduate women in innovation and entrepreneurship (I&E) programs. The data from this paper came from interviews with 10 female JMU students who have participated in various I&E programs.

Clay works on her second thesis paper which investigates motivations and barriers to entry of women in innovation and entrepreneurship programs. Her first paper discusses the processes by which students learn to become changemakers.

TECHNO-ECONOMIC SYSTEMS EVALUATION OF INDUSTRIAL HEMP BIOMASS ON POULTRY PRODUCTION



LINDSAY LEVATINO

Did you know that an eroding river in Rockingham County, Virginia can have substantial negative effects on the Chesapeake Bay, about 250 miles downstream? The goal of this project is to use engineering in nature to design solutions to the erosion happening in part of Beaver Creek in Ottobine, Virginia. I worked with the Massanutten Chapter of Trout Unlimited along with other local engineers to survey the land, design solutions and plan the build. We followed the Rosgen Method to Natural Stream Design to cover all necessary steps for a successful outcome. A common mistake that happens with channel design is causing new problems elsewhere by fixing the current issues. This can be avoided by proper preparation and knowledge of the watershed. The design solutions will redirect the streamflow away from the major erosion sites, saving the surrounding farmland from further destruction. It will also prevent issues downstream such as algae blooms in the Chesapeake Bay.

Levatino is working to redesign part of the local Beaver Creek which is currently facing extreme erosion, damaging the surrounding land and causing problems downstream.


DESIGN


SENIOR

AGRICULTURAL APPLICATIONS: BUILDING AN EXPERIMENTAL AQUAPONICS SYSTEM

TEAM

Caroline Clay
Jamie Riley

ADVISING

Justin Henriques
Kyle Gipson

The Shenandoah Valley is home to four of the top five agricultural producing counties in Virginia. One of these five counties is Rockingham, which is home to Woods Edge Farm LLC, the client of the Agricultural Applications Capstone Team. The goal of this project is to redesign the aquaponics system at Woods Edge Farm, which is currently out of use. The team is investigating the suspended solids that the water settlement tank must remove. Aquaponics is a closed loop system in which water from fish tanks is used to water and nourish plants. The team began by investigating and analyzing the causes of the system's previous failure.

The first system component the team plans to address is the design of the sediment removal tank. The next step will be to improve the structure of the aquaponics system. The team has benchmarked and researched existing aquaponics systems and water settlement tanks as well as interviewed the client at Woods Edge, Mr. Calvin Nolt.

The team is measuring dimensions for the sprinklers in their aquaponics system.

The grow bed for the team's aquaponics system that when finished will house three different medias and be used to grow lettuce.

ANALYZING KARST FORMATIONS ON EAST CAMPUS

TEAM

Madison Gilmore
Kyle Inocco
Isabel Ledesma
Kathryn Nielsen
Clement Poole

ADVISING

Heather Kirkvold
R. Shane McGary

Most of the Shenandoah Valley morphology is due to the limestone that lies beneath it. Limestone is a carbonate sedimentary rock that can dissolve over time. When limestone is exposed to water and air, a chemical reaction occurs that creates carbonic acid. This acid corrodes the limestone around it and can form amazing karst features, including pinnacle weathering and caverns. However, construction on this type of subsurface can be challenging and potentially harmful to a building's longevity and safety.

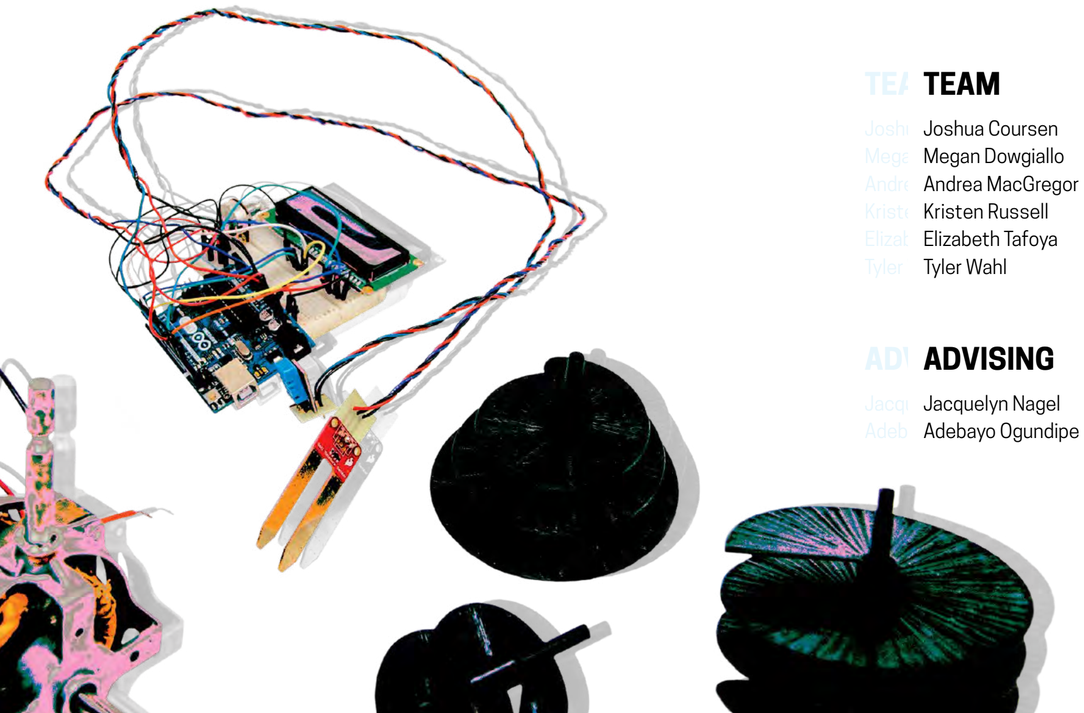
In May 2011, a sinkhole opened up at JMU near the Bioscience Building and Carrier Drive. Cracked flooring, gaps in the window panes, and raised footers above flooring within the ISAT/EnGeo building provide evidence of a changing subsurface under/around the buildings. These subsurface changes have the potential to develop into more serious structural damage in the future.

The goal of our Capstone project is to develop a risk assessment report for the ISAT/EnGeo/PhysChem buildings and the adjacent fields by examining land subsidence due to karst formations. Included in the methods used to complete the assessment of the subsurface is geophysical electrical resistivity tomography testing (ERT Testing). The risk assessment report will explain the current conditions of subsurface under the ISAT/EnGeo/PhysChem buildings. It aims to potentially quantify the risk associated with the subsurface conditions while offering a recommended mitigation technique(s). The purpose of our project is to ensure the safety of the public, maintain the longevity of the buildings, and create a baseline of the subsurface conditions for any future construction in the area.

The team is viewing a historical geologic map showing previous sinkholes on East Campus. This will aid in their understanding of the geologic features of the site and their impacts on future construction.

A satellite image of the ISAT/EnGeo/PhysChem building complex, where subsurface data collection took place.

BIO-INSPIRED AUTOMATED COMPOSTER



TEAM

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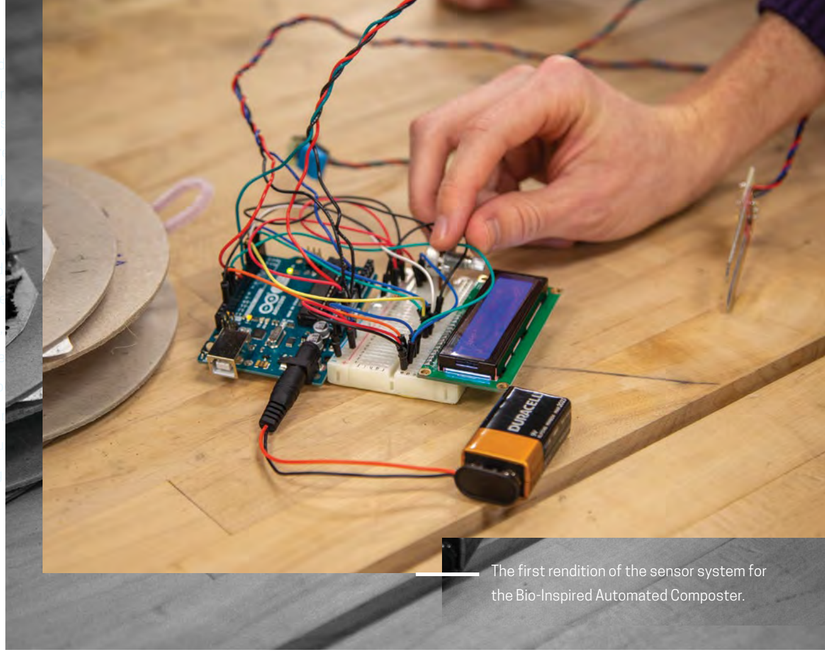
Megan Dowgiallo
Andrea MacGregor
Kristen Russell
Elizabeth Tafoya
Tyler Wahl

ADVISING

Jacquelyn Nagel
Adebayo Ogundipe

Humans and ecosystems around the world are suffering from varying temperatures in environments, rising sea levels, and increasing intensity of storms as a result of climate change. The amount of greenhouse gases throughout the atmosphere is one of the leading causes of climate change. An engineering process that simply looks at nature for solutions, also known as biomimicry, can be used as the forefront of producing and iterating innovative designs to mitigate the effects of climate change on the Earth. In this process, our team has explored biological functions which have changed through thousands of years of evolution to better suit themselves to their environments as an inspiration for modern problems. The process will be used for a product/service to combat the ever-growing threat of climate change.



The first rendition of the sensor system for the Bio-Inspired Automated Composter.

Auger prototypes, display sensors, and a 24V motor that have been used for concept testing and will soon be implemented into the Bio-Inspired Automated Composter.

CHUMBE ISLAND WATER ENERGY NEXUS

TEAM

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Preston Liverpool
Zachary Shipman
Carlee Smith
Joshua Williford

ADVISING

Adebayo Ogundipe

By 2030, it is estimated that the world will be facing a 40% water deficit. Small communities in developing nations struggle with energy and water needs more than in other, larger communities. Due in part to local geographic and geological properties, small islands have difficulty maintaining consistent sources of energy and clean drinking water.

Chumbe Island Coral Park (CHICOP) is a private nature reserve off the coast of Zanzibar dedicated to maintaining the unique coral and forest ecosystems of the area. In addition it serves as an educational nature park for children and adults alike. In order to fund conservation efforts for the island, the park hosts tourists and visitors, which in turn strains the island's current energy and freshwater systems.

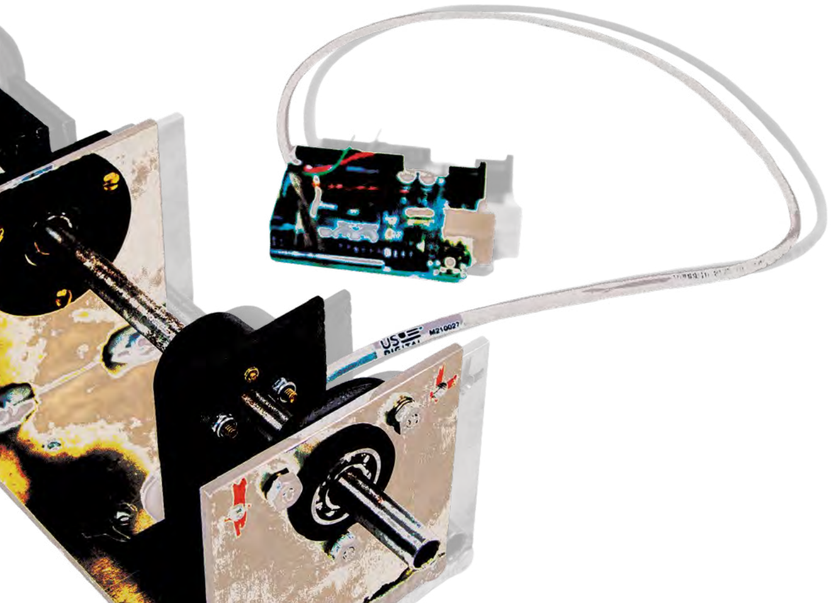
The interconnectedness and interdependence of water and energy systems is known as the Water-Energy Nexus. Our capstone project continues to focus on producing more energy for Chumbe Island's needs, thereby also alleviating their water shortage problem. Currently, most of Chumbe's energy is generated on the island using solar photovoltaic panels for electrical energy and solar thermosiphon systems for hot water needs.

The current Chumbe team continues to gain knowledge of the island's needs by computing total energy needs, power delivery needs and storage capacity needs, in addition to designing the primary and auxiliary systems to address these needs. Using Circuit Lab, the team has explored practical participatory while using user-centered design tools that have involved communities in the design process, as well as current and emerging appropriate and sustainable technologies.

The team working on testing the pump component of the Redox Flow Battery.

Chumbe Island's Visitor Center

COLLEGIATE WIND COMPETITION 2020



TEAM

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Joseph Carrico
Roman Cook
Jack McGeoghegan
Andrew Payne

ADVISING

Stephen Holland

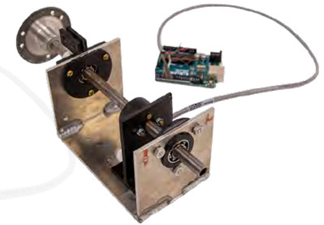
SPONSORS

US Department of Energy

Across the United States, wind energy could supply 10% of the nation's electricity by 2020 and that number is projected to increase 25% by the year 2035. The Department of Energy has established a competition that aims to prepare students to enter the industry for wind energy. Our project explores the design process behind constructing a fully functioning wind turbine that adheres to parameters set by the Department of Energy. For the turbine blades, the Q-Blade software was used to construct and test blades to determine possible power output and torque generation. From this, a three blade design was chosen with the specific airfoil still to be determined. The generator's performance was simulated using a simple model created in Excel, while several components were modeled in the SolidWorks CAD software and printed for construction.

The team evaluating the results of the angular velocity sensor on the Wind Turbine Nacelle prototype.

Wind Turbine Nacelle prototype that includes the shaft, disc brake, angular velocity sensor, and housing.



DRY RUN TRAIL DESIGN

TEAM

Beverly Boateng
Grace Carter
Ryan Cole
Christopher Santaniello

ADVISING

Bradley Striebig

SPONSORS

Trout Unlimited Embrace A Stream Program, Provost Grant award by James Madison University

No abstract submitted.

The water supply diversion dam, located on the border of Riven Rock Park, just 30 minutes west on Route 33, supplies Harrisonburg with about half its water supply every year. According to biologists from the Virginia Department of Game and Inland Fisheries and the Forest Service, the city-owned section of Dry Run, where the dam is located, also holds the largest population of wild brook trout south of Vermont. The users of Riven Rock Park and the surrounding Harrisonburg community may lack an understanding of why it is necessary for the area to be preserved for future generations. The Dry Run Trail Design Capstone Team will design panels and interactive platforms that inspire natural resource appreciation and education about the value of the Dry River and its watershed with respect to the Harrisonburg water supply, as well as why it is important to maintain the health of the Dry River Ecosystem. After several field trips, using GIS Online, the team has created a model of what the layout of panels and interactive platforms could be throughout the park and created prototypes of some of the possible interactive platforms. The team has also talked to teachers and individuals involved with the City to gain a better understanding of the limitations and attributes they should be sure to consider. They hope to end the semester by submitting components of their design to the City for approval.

Members Beverly, Chris, Ryan and Grace discussing edits for panels made for Riven Rock Park.

A closeup of the second draft of the Virginia Brook Trout panel.

IMMUNOSTAINING WELL-PLATE

TEAM

Sanarea Ali
William Armstrong
Johanna Enzmann
Nick Liberati
Tyler Machi
Theresa Montane
Nicole Morgan
Zaki Samady

ADVISING

Callie Miller

Many different scientists, studying all forms of tissues and cells, use the process of immunostaining. This process can be used to study a variety of subjects such as analyzing the formation of tumors or recognizing different forms of cancer. Traditional immunostaining practices involve the staining of tissue or cell samples with antibodies in order to visualize a targeted section under a specialized microscope and establish biological functions. A common problem among researchers utilizing the immunostaining process is the waste of antibodies and the lack of devices that allow for free-floating tissue samples. The problem is not only specific to our client, Dr. Mark Gabriele of the JMU Biology department, but is applicable to any researcher using immunostaining.

Our project will focus on the design of an apparatus that will minimize the amount of antibodies used to adequately stain tissue samples, saving researchers thousands of dollars. Our second objective is to create the apparatus such that it is able to maintain the tissues in the order from which they were cut, also known as serial order. In doing so, the client is able to create a three-dimensional representation of the studied brain through the use of computer software. The realization of the above-stated objectives has the potential to revolutionize the field of immunostaining because the same techniques performed by our client to analyze brain tissue can be applied to any type of tissue being studied.

A member of the team, Nick Liberati, applying a ceramic coating to an ABS plastic test sample for material testing. The results from the material testing will indicate materials with the lowest antibody affinity.

ABS plastic prototypes of two conceptual designs being analyzed for future development.

MULTISPECTRAL IMAGING TO INFORM VITICULTURE DECISION MAKING

TEAM

Ernest Benner
Dominic Coradazzi
Zachary DeBey
Justyn Girdner
Isaac Miller
Jacob Ortiz
Parth Patel
Brian Schieber

ADVISING

Justin Henriques
Jason Forsyth

SPONSORS

JMU X-Labs
Blenheim Vineyards

Agricultural fertilizers allow farmers to grow enough food to sustain our growing population; however, using these nutrients can have dangerous side effects on the environment. When too many of these nutrients are introduced to a body of water, they can cause massive algae growth which leads to water hypoxia, fish kills, and the presence of harmful bacteria.

Currently, there are no low-cost methods for monitoring eutrophication across an entire body of water over an extended period of time.

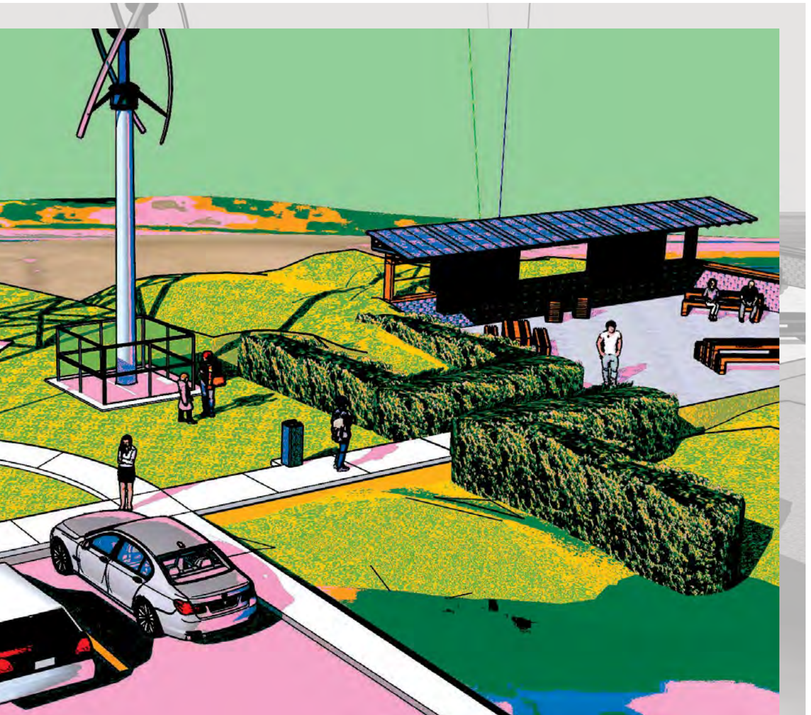
Our project seeks to address the issue of eutrophication in small bodies of freshwater by monitoring pond health characteristics from an aerial platform. To do this, our team is using a multispectral camera mounted on a drone to take pictures of the water and outlying land across five distinct bands, which will later be combined to calculate multispectral indices that can be correlated to pond health and fertilizer concentration.

Our team has created a process by which a drone will fly a preprogrammed flight plan in order to capture photos over an area of interest, and has devised a system for generating false-color images containing multispectral indices. Moving forward, our team is planning to learn more about identifying characteristics of water quality and pond health in order to validate which indices are appropriate for this approach.

The team reviews the most recent iteration of the SkyPrecision web application, a multi-functional website for displaying multispectral indices, GPS waypoints, and user notes.

DJI Phantom 4 Pro Drone and Micasense Altum Multispectral Sensor used to capture multispectral images for the capstone is on loan courtesy of JMU X-Labs.

PROJECT AEOLUS



TEAM

Carver Johnson
Robert McFaddin
Emerson Youtsey

ADVISING

Justin Henriques
Kurt Paterson

SPONSORS

Center for Sustainable Energy (CASE)

Coinciding with former James Madison University president Linwood Rose's commitment to advancing more sustainable practices at all levels, this student-proposed capstone focuses on engaging with the student body to generate a design that will provide lasting positive impact to JMU and the community. Simply put, Project Aeolus aims to develop an outdoor public space on East Campus that features a functioning vertical axis microturbine (VAM). This endeavor will simultaneously demonstrate how underutilized physical spaces can be optimized to provide for multi-functional purposes and how renewable energy sources such as vertical axis wind turbines are advantageous in urban settings. Partnered with the Virginia Center for Wind Energy, the project solution will offer educational and recreational opportunities, comparable to those performed through the Wind for Schools Program. Utilizing AutoDesk applications, such as AutoCAD and Revit, the team will develop an official site plan in conjunction with a final proposal document in order to actualize the design with facility engineers and JMU administration. Based upon logistical and administrative feasibility, the tentative conclusion is that the space will be located adjacent to the current Small Wind Training and Testing Facility located across Carrier Drive from Rose Library.

The team discusses wind data models to understand the technical feasibility of installing the DS-3000 VAWT on the East Campus of JMU.

Using the SketchUp software package, Project Aeolus developed a preliminary (Alpha) 3D model to better visualize and communicate the proposed expansion of the SWTTF.

REIMAGINING A PITCHING MACHINE

TEAM

Bernard Baird
Brady Fox
Daniel Green
Fox Semones
Adam Smith
Jason Souder

ADVISING

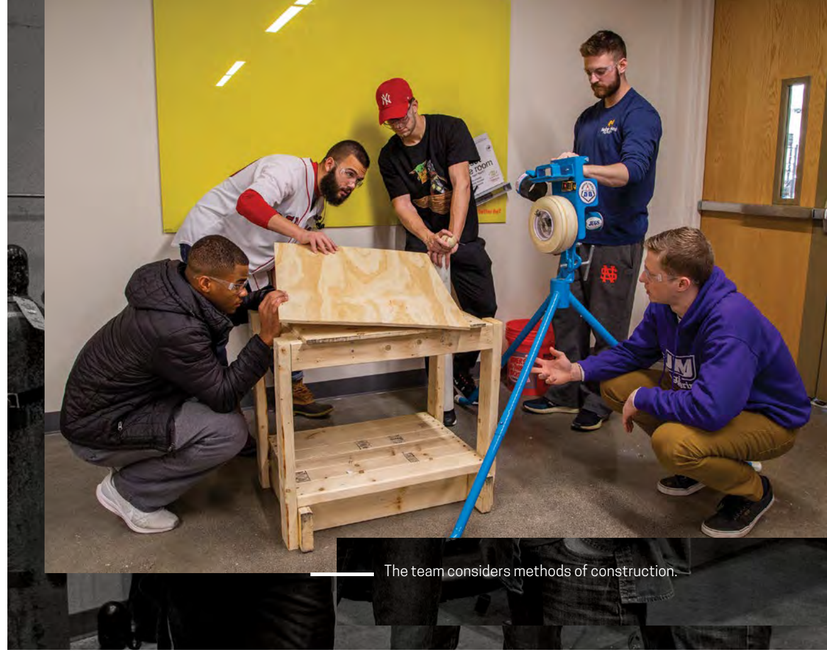
Jason Forsyth
Samuel Morton III

SPONSORS

Brian Koerner, PE from Engineering Solutions and Construction Management, PLC

No abstract submitted.

In baseball, it's hard for young catchers to develop skills necessary for the position outside of game situations; pitchers aren't developed enough at that age to truly help by focusing on specific locations, and coaches have different mechanics in terms of heights and velocities from their pitches. As a result, catchers don't get much practice due to the gaps in training from coaches, players, and a lack of an equipment. With this in mind, they are thrown into the position in live game situations and struggle with the fundamentals of catching. Not only can this incite fear in players, but this can discourage the player from wanting to keep playing the position or even the sport. This project explores the national problem within baseball of fearful players and lack of coaching tools to train catchers by looking to optimize a pitching machine for use with catchers. Most pitching machines are used for hitting, and while they can be used to pitch to catchers, the machines do not allow for the appropriate coaching environment. The solution will allow the coach to use the machine from a distance to maximize coaching time while the catcher can practice some necessary catching skills ultimately resulting in a tool that will not only build confidence within the position, but also improve their game.



The team considers methods of construction.

A prototype of the team's pitching machine.

SETH: STEM EDUCATIONAL TINY HOUSE

TEAM

Ashley D'Angelo
Andrew Farber
Alex Hasty
Gray Trotter
Samantha Wilkinson
Cole Young

ADVISING

Steven Harper

SPONSORS

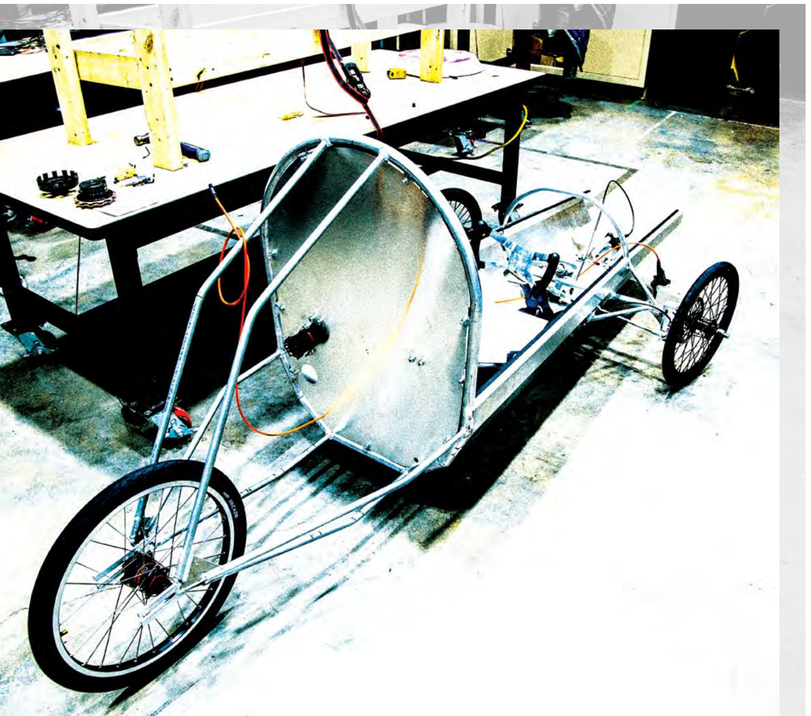
Steven Harper and Madison Academic Brewery

Have you ever wondered what STEM majors do in their careers and research? What if there was a way to travel around and show people exactly what happens behind the scenes in STEM related productions and teach people the science behind the things they see every day? Our team is focused on designing a STEM Educational Tiny House that is portable and modular to teach different target audiences about what we do. Our team specifically focuses on using a brewery system that was donated to us as a proof of-concept of the feasibility of this idea. In order to do this, our team took an old camper trailer and tore it down to the frame to repurpose it as an educational space. We then used our experiences in design classes and brewery classes to design a space that was intriguing and informational for our target audience. By using stakeholders' advice and knowledge, our goal is to attend festivals and breweries to teach audiences about STEM education through the brewing process. Through our efforts we hope to spark people's interest in not only the science around brewing, but in other STEM related topics.

The team is working on drilling holes in 2x4s to be bolted together to finish the floors under the advisement of Steven Harper.

The team along with Steven Harper working together on the trailer to finish framing the floors.

SHELL ECO-MARATHON: CHASSIS



TEAM

Sam Bowers
Tom Ferguson
Nick Pitorri
Joseph Potter

ADVISING

Robert Nagel
Robert Prins

SPONSORS

Shell

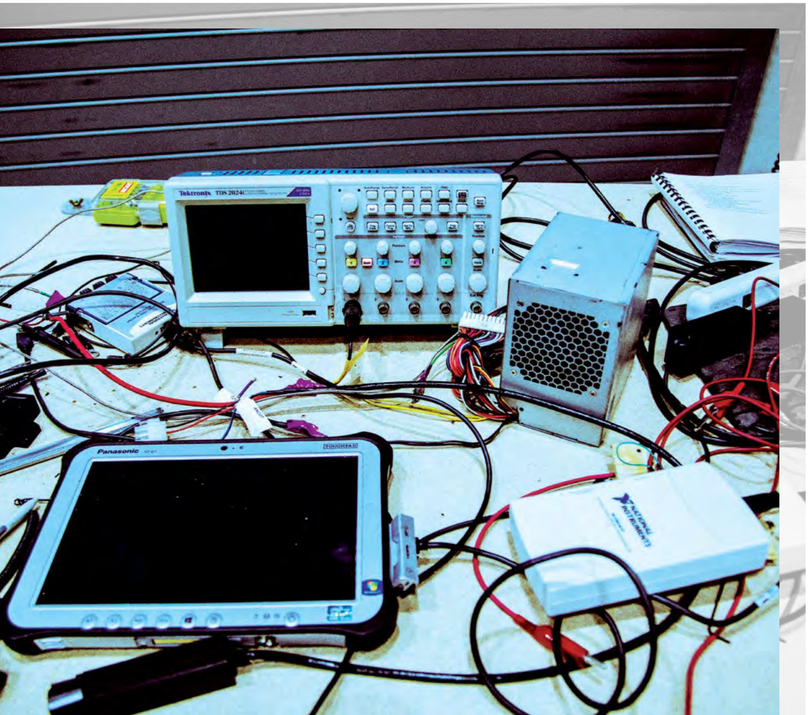
A twelve member engineering team has been divided into three sub-teams-chassis, data acquisition, and drive-train-in order to design and produce a vehicle for the 2020 Shell Eco-Marathon Competition. With fuel emissions on the rise, engineers have been working to identify the means necessary to reduce these emissions in today's automobiles. Our team is the Chassis Team and the chassis that we will design and construct will satisfy all rules and regulations set forth by the Shell Eco-Marathon Rulebook. Our goal is to set a competing score that will be an improvement from the 2018 team's recorded 187 MPG.

The chassis material was selected with a few things in mind. First, the chassis must to be able to support the load determined by the 2020 Shell Eco-Marathon Rulebook. In addition, we wanted to design a chassis that is lighter than the 2019 JMU Shell Eco-Marathon Competition team's chassis. With this in mind, we decided to use an alloyed metal that is stronger and more lightweight than the one on the previous competition vehicle. Through the use of Solidworks, we were able to validate material properties, and by doing so, were able to select a proper material in order to satisfy the necessary strengths needed. Also with Solidworks, the team designed a chassis that will satisfy our competition requirements, as well as run static load testing in order to simulate the expected loads that the chassis will likely experience at competition time. Ultimately we are expecting the chassis that we design to be respectively more light weight and more aerodynamic than previous JMU Shell Eco-Marathon Competition Teams' chassis.

The team is evaluating and testing the components within the chassis to ensure component functionality.

The team's rolling chassis that will be fitted with a drive-train and data acquisition systems for future competition in Sonoma, California.

SHELL ECO-MARATHON: DATA ACQUISITION



TEAM

John Hunter
Lindsay Levatino
Nick Lindenfeldar

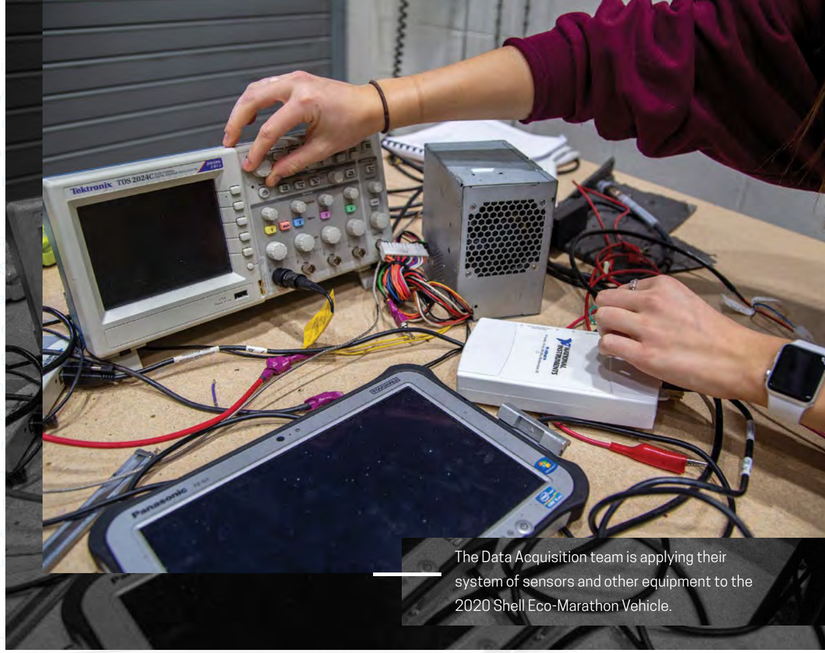
ADVISING

Robert Nagel
Robert Prins

SPONSORS

Shell

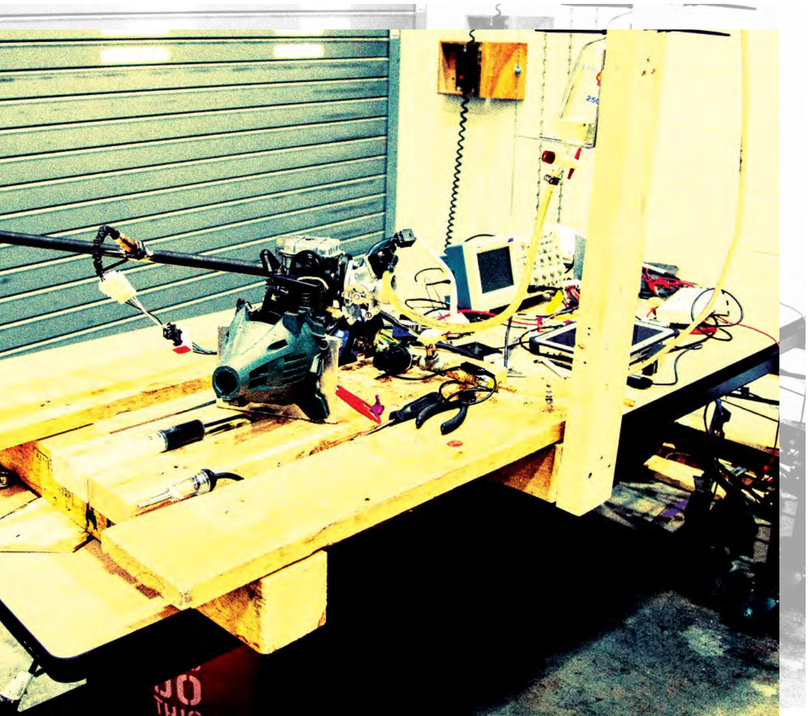
Every time you start your car and begin to drive, a vast network of sensors on your vehicle actively measure temperatures, pressures, and other phenomena. These sensors send data into your car's computer in order for your vehicle to run more efficiently and to provide the driver with information on the car's performance. Our project will design a system to measure and record various phenomena around the Shell Eco-Marathon car and interpret that data to help design the next iteration of the car. Using a data acquisition device and a Panasonic tough book, along with an array of sensors, and amplifiers, we designed a system that was installed on the 2019 iteration of the Shell Eco-Marathon Car. This system recorded data at the Sonoma Raceway in the 2019 competition. Analysis from the data collected assisted the chassis and drivetrain teams in making informed design decisions and is available for future teams utilization.



The Data Acquisition team is applying their system of sensors and other equipment to the 2020 Shell Eco-Marathon Vehicle.

This system will collect data from various parts of the vehicle that is designed to be the most fuel-efficient. The data is analyzed and used to make improvements to the car and for future teams to use.

SHELL ECO-MARATHON: DRIVETRAIN



TEAM

Henry Banks
Rachael Frost
Peter Nielsen

ADVISING

Robert Nagel
Robert Prins

SPONSORS

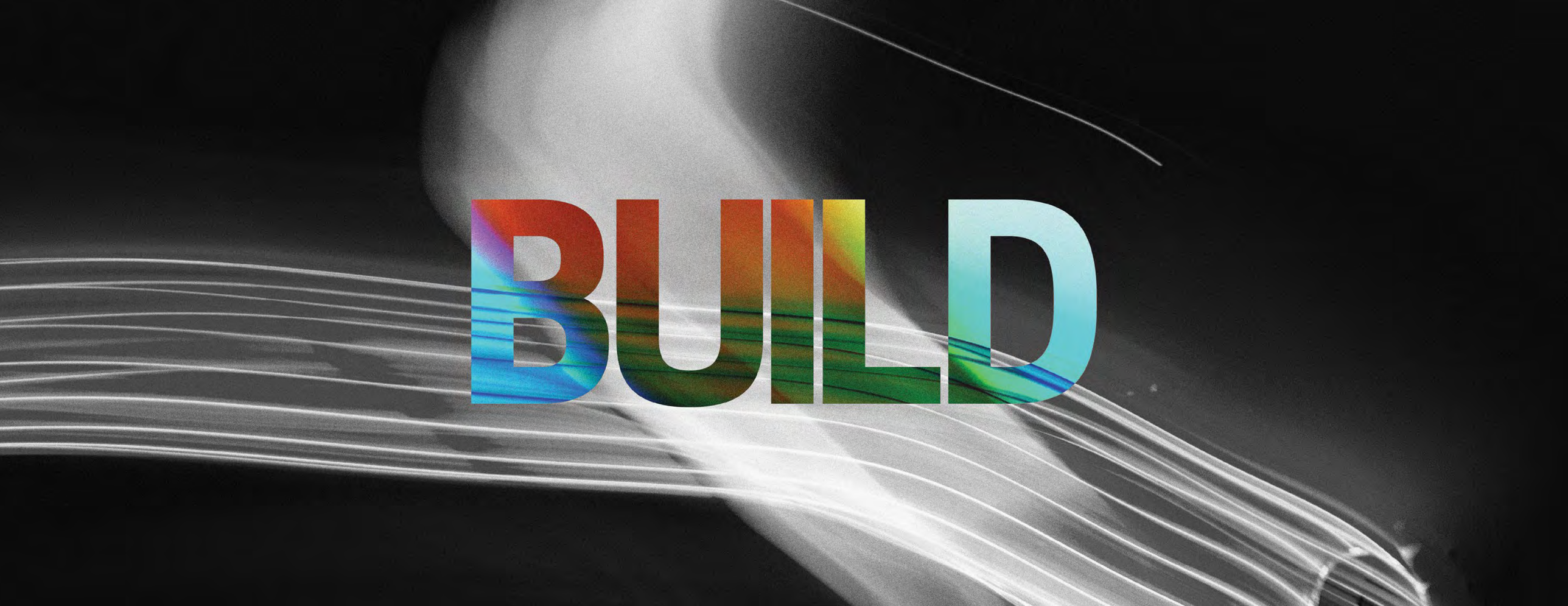
Shell
Alumni
Friends
Family members

In today's large and rapidly growing world, the means and infrastructure we use for transportation must not only get people from point A to B safely, but should do so in a sustainable way. Unfortunately, this is not the case. Currently there are an estimated 1,706.7 million barrels worth of oil reserves throughout the world, reserves that at the current rate of consumption, will be depleted in a little over 48 years. Furthermore, petroleum consumption accounts for roughly 30% of all greenhouse gas emissions, which drive the man-made climate effect.

Accordingly, the third iteration of the Shell Eco-Marathon competition aims to help combat climate change as well as foster automotive design skills to help usher in a new generation of transportation engineers. More specifically, the drivetrain will look to past iterations of the Eco-Marathon capstones for inspiration on designing and developing a drivetrain that achieves superior fuel economy for the 2020 competition vehicle. Our team will work in tandem with the Chassis and Data Acquisition teams to ensure a seamless integration of these sub-systems as well as a vehicle that will achieve superior fuel economy at the 2020 competition.

The team assembles the new wiring harness and fuel system up to the Ryobi 30cc engine sitting on the engine mount.

Complete engine setup set up for testing purposes before installing in the chassis of the vehicle.


BUILD


JUNIOR

ASSESSING INTRINSIC FOOT MUSCLES

TEAM

Nathan Carney
Niko Droukas
Shannon Karabaic
Bre McLaughlin
Morgan Uhlick

ADVISING

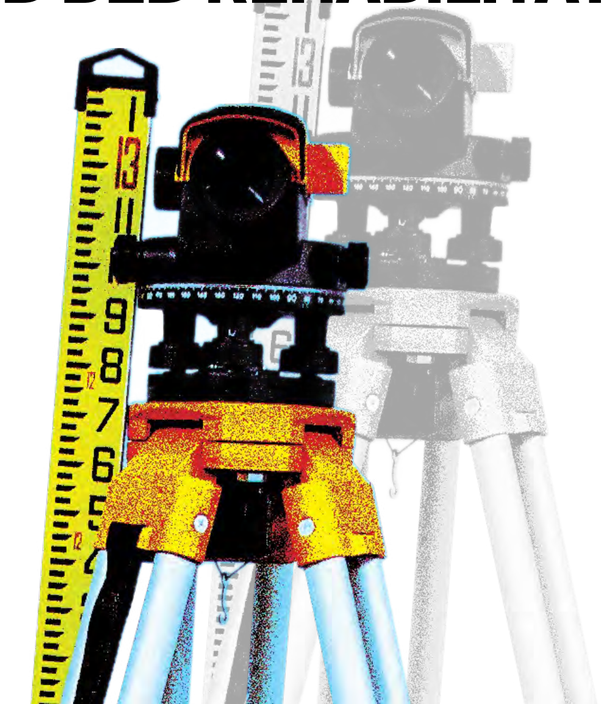
Jason Forsyth
Roshna Wunderlich

Around the world, thousands of diabetics and elderly people suffer from weak intrinsic foot muscles causing them foot pain, poor balance, and loss of mobility. There is currently no favored method for professionals to test the intrinsic foot muscle strength of these patients. This project explores the ability to use force sensors and foot immobilization to create an accurate and efficient way to measure the intrinsic foot muscle strength. Using SingleTact brand sensors combined with an Arduino Uno, we were able to calculate different force outputs with given weights, as well as human toe forces. Our tentative conclusion is that two subsystems will be needed to achieve our goals: a sensing method (physical sensors and data collection) and a housing to immobilize the foot during testing.

Team members testing and analyzing previously made housing apparatus.

SingleTact sensor used to measure and determine Intrinsic Foot Muscle strength in our clients.

BRIDGES OVER MOSSY CREEK TEAM A: CREEK BANK AND BED REHABILITATION



TEAM

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Marcos Piggott
Devin Smith
Jack Williams

ADVISING

Bradley Striebig

SPONSORS

Brian Trow
Mossy Creek Fly Fishing
& Trout Unlimited

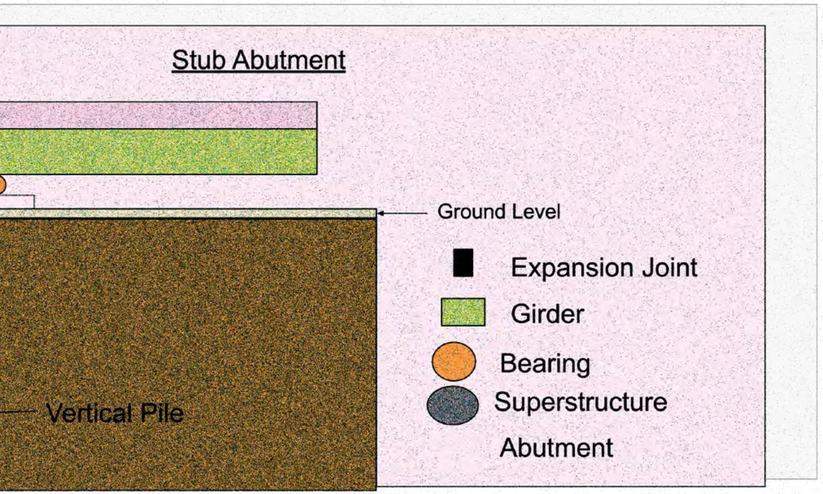
Nestled away inside of the Shenandoah Valley is one of Virginia's premier fly-fishing destinations, otherwise known as Mossy Creek. Within the last five years, the waterway has experienced a monumental flooding event which washed away previously made footbridges. This project examines the current environmental conditions of the creek as well as explores potential methods of creek-bank stabilization and restoration. The team hopes to hand off a topographical surveying report to the other sub-teams to designate a location to build. Through extensive background research in the fields of stream bank restoration and rehabilitation, the team has compiled sufficient information necessary to compose a surveying plan. Balzer and Associates provided a surveying workshop in which team members were trained on basic surveying equipment and procedure similar to that which will be implemented in the field. Using RIVERMorph® software, all data gathered from surveying Mossy Creek can be analyzed and produce a two-dimensional plan and profile view of the creek. Completion of this capstone will provide relevant experience in our fields of interest and will bring the fly-fishing community of Mossy Creek one step closer to once again enjoying their passion.

The team is assembling components of the Surveying Equipment Package, preparing for initial testing of functionality before heading to Mossy Creek.

The team's fully assembled sight level with tripod supports, carrying case for the sight level, and measuring rod used for the topographical surveying of Mossy Creek.

BRIDGES OVER MOSSY CREEK
TEAM B: FOUNDATIONS, ABUTMENTS AND SUPPORTS

Concepts



TEAM

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Ryan Lesniak
Jack Lindberger
Conor McNicholl
Holden Tasillo

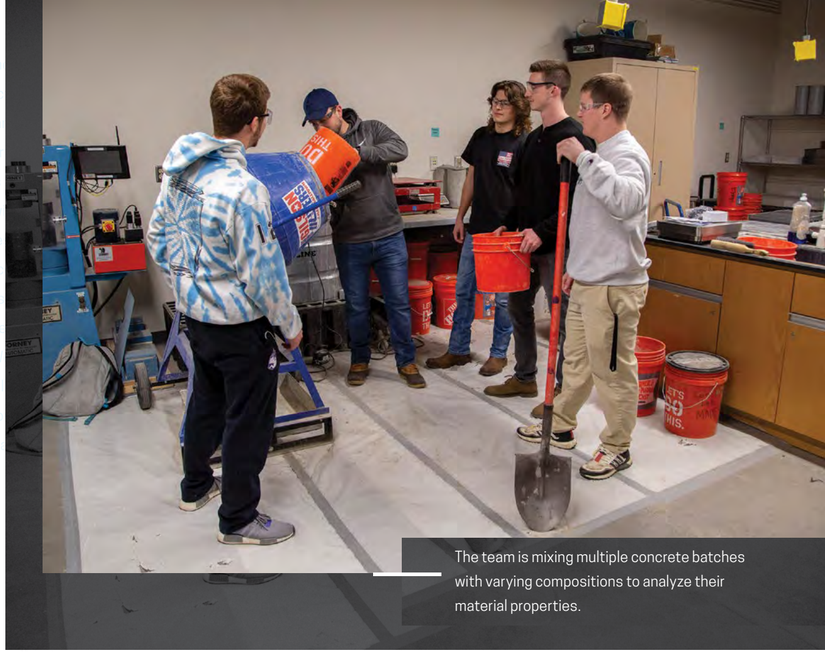
ADVISING

Daniel Castaneda

SPONSORS

Brian Trow
Mossy Creek Fly Fishing & Trout Unlimited

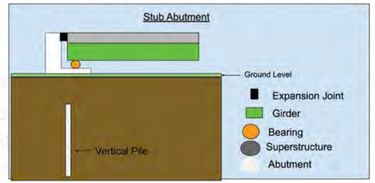
Mossy Creek in Augusta County, Virginia is known as a prominent fly-fishing destination that attracts people from all over. This project explores how we can design a feasible bridge that can withstand a 500-year flood and avoid washing downstream like the previous ones. Our portion of the design is the abutments that will support the superstructure. We have spent time researching different abutments, bridge designs, and codes and standards that apply. A key aspect that is essential to being successful is following the appropriate steps to ensure all our requirements are fully met. We are currently in the conceptual phase where we will begin to design different abutments and examine how we can integrate it with the bridge superstructure team.



The team is mixing multiple concrete batches with varying compositions to analyze their material properties.

This diagram represents the concept of a common abutment system that the team may use to create more detailed designs.

Preliminary Concepts



BRIDGES OVER MOSSY CREEK TEAM C: BRIDGE DECK AND SUPERSTRUCTURE

TEAM

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Ian Howell
Jack Leary
Wyatt McCabe

ADVISING

Heather Kirkvold

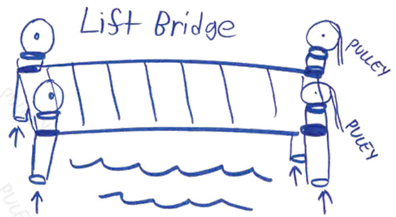
SPONSORS

Brian Trow
Mossy Creek Fly Fishing & Trout Unlimited

Bridges bring people together by allowing us to travel to places otherwise inaccessible. Humans have been building bridges for thousands of years and some amazing examples stand as marvels of engineering and industry. A local waterway in the Shenandoah Valley, Mossy Creek, has recently experienced extreme flooding events. These unexpected floods destroyed makeshift bridges which previously allowed local fly fishermen to access both sides of the creek. Team Bridging Connections (Mossy Creek Team C) was founded to address this problem by exploring topics within civil and structural engineering. They are responsible for contributing the bridge deck and superstructure to a bridge design in conjunction with teams A and B that will span across Mossy Creek and be able to safely withstand rapid flood waters. Preliminary concepts include dynamic bridge designs that move out of the way of flood waters using mechanics or static bridge designs engineered to withstand the flood. Some dynamic designs being considered are a drawbridge, a vertical lift bridge, and a swing rotation bridge.

Team brainstorming preliminary concepts.

Preliminary concept sketch of lift bridge.



BUILDING LATRINES IN TANZANIA

TEAM

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Jordan Jones
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ADVISING

Adebayo Ogundipe

SPONSORS

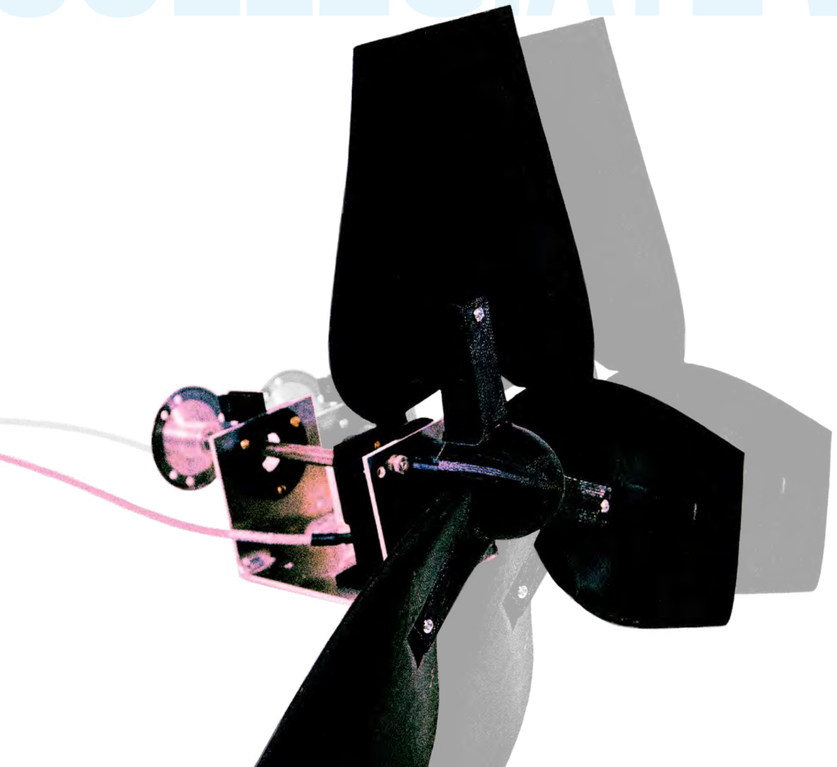
MSABI

Ifakara, Tanzania is known as "a place you go to die." This is a reference to the historically high amount of disease in the area. The water supply in Ifakara is contaminated by bacteria from human waste that has leaked from the latrines into the groundwater. The bacteria in the water is capable of making one sick and could possibly result in death. This project focuses on stopping bacterial contamination of the water supply in Ifakara, Tanzania before it reaches the groundwater. We are going to redesign the latrine experience (basin, structure, latrine, and hygiene) to prevent future contamination of the water supply. Using knowledge from team members and conducting research, we have been able to better understand the culture in the community and the current latrine designs being used in the area of interest. The community is unwilling to boil water or use filters, and there is a naturally high water table that makes it challenging to properly construct the latrines. We are currently in the concept generation phase and will be testing prototypes to refine the final solution.

The team is reviewing photos of existing latrines in Ifakara, Tanzania. They are doing this to identify failure points in the existing designs and begin concept generation.

This is a photo of MSABI, a Non-Governmental Organization in Tanzania that focuses on water treatment and sanitation. They are constructing a latrine for community members in Ifakara.

COLLEGIATE WIND COMPETITION 2021



TEAM

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Raymond Benner
Tre Bright
George Funk
Brady Monroe
Nathaniel Ray
Leith Rayes
Jaclyn Riddiford

ADVISING

Stephen Holland

SPONSORS

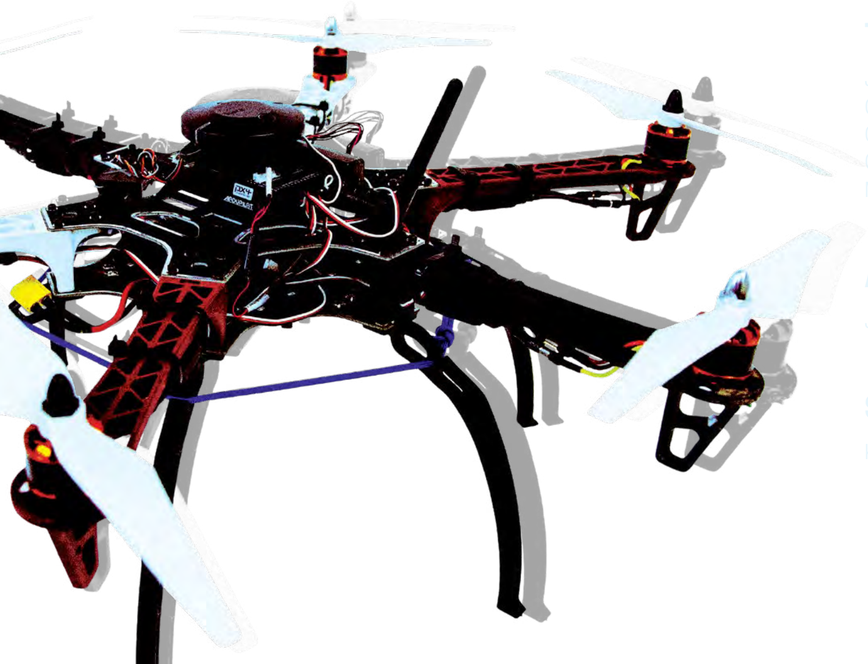
US Department of Energy (DOE) and National Renewable Energy Laboratory (NREL)

Wind energy could supply 35% of the nation's electricity by 2035, according to the U.S. Department of Energy, creating a dramatic rise in the demand for educated personnel and new solutions applicable to the renewable energy field. To address this predicted issue the Department of Energy hosts a competition each year in which they invite a select number of schools to design, build, and test a small-scale wind turbine which resembles a real-world solution for the growing energy demand. Using analytical and physical models, along with help from the senior Collegiate Wind Competition team, our team has begun developing concepts for the electrical, mechanical, and software systems of wind turbines.

The junior team analyzing their blade design to correspond with the generator and circuit subsystems.

One of the many rotor prototypes for a vertical axis wind turbine designed by the Collegiate Wind Competition Capstone team.

DETECTING CHANGES IN ALGAE GROWTH USING MULTISPECTRAL IMAGING



TEAM

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Cailyn Lager
Charles Seaver
Mark Vakarchuk

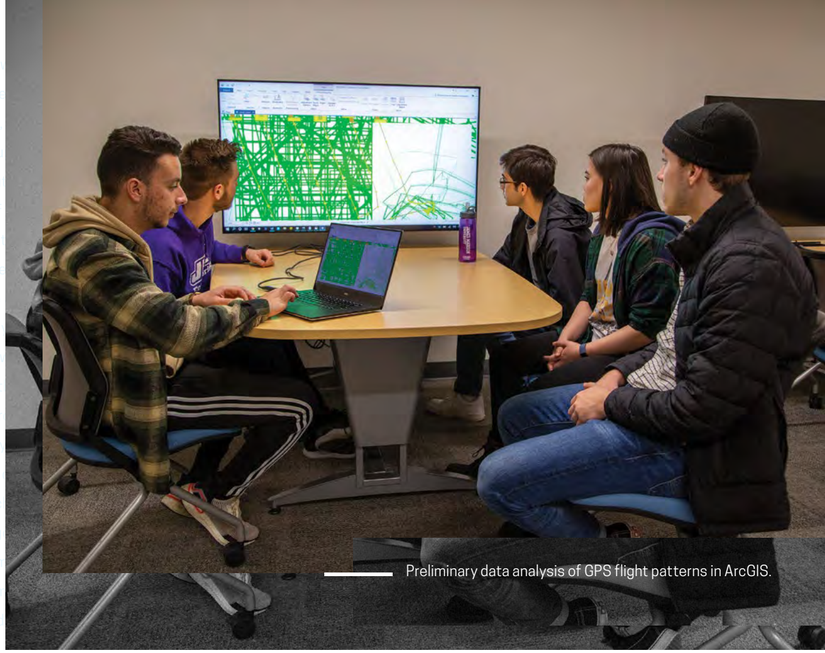
ADVISING

Justin Henriques

SPONSORS

Ken Benson

Ever since people started farming and growing food they have looked for ways to increase crop yield. Many modern farmers use fertilizer, primarily nitrogen-based fertilizers that plants soak up to repel bugs and increase crop yield. However, about 60-90% of the fertilizer is washed away in runoff polluting streams, rivers, lakes, and oceans. High nutrient-rich bodies of water from fertilizer runoff promote the rapid growth of algae, called algae blooms. As the algae die, bacteria in the water eat the algae and deoxygenate the water, leading to the death of animals within the bodies of water. This project showcases the development of an unmanned aerial vehicle (drone) that would be able to quantify the health of a body of water, inspired by Dr. Henriques' humanitarian desire to approach environmental issues with new technologies to better understand the environment. The goal of this project is to capture meaningful data from multispectral imaging of bodies of water and determine the likelihood of eutrophication being present due to the change in algae growth.



Preliminary data analysis of GPS flight patterns in ArcGIS.

First iteration drone built from a DJI model kit.

RE-PURPOSING SILICON DIOXIDE MANUFACTURING WASTE

TEAM

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Arthur Ashe
Sahm Azizi
Fitz Curran
Ronan Higgins
John Young

ADVISING

Kyle Gipson

SPONSORS

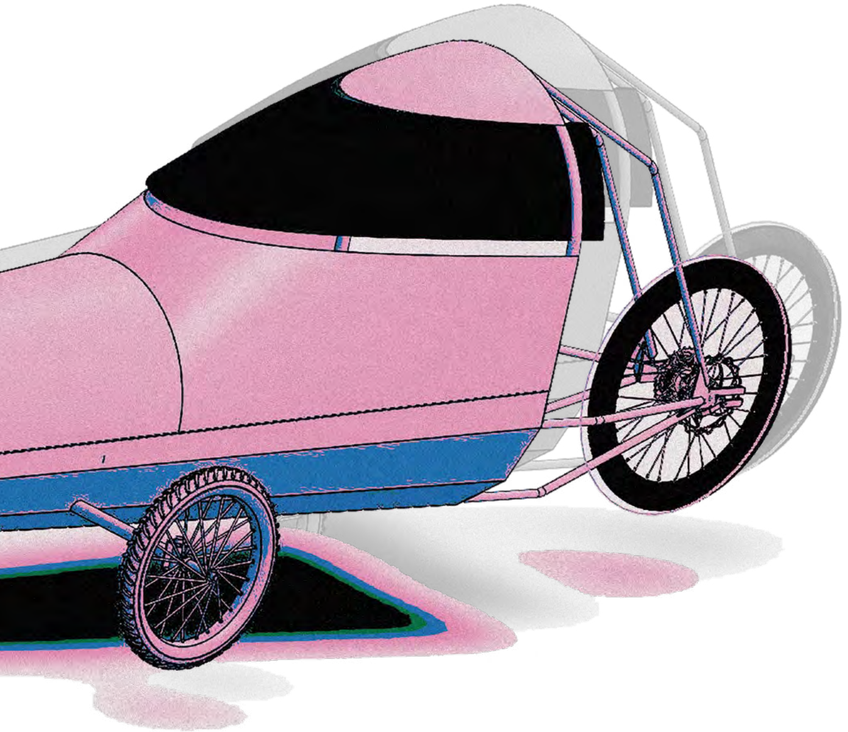
W. R. Grace & Co.

Silica, also known as silicon dioxide, is a highly refined and processed sand that can be used in various applications from sand blasting to toothpaste. W.R. Grace & Co., a chemical manufacturing company, has an approximated 95% yield, meaning 300,000 pounds of silica waste is generated each month from their facility. This "waste" comes from a variety of forms of silica that happen to not meet the pharmaceutical or food grade quality specs required by their clients, but still has many useful properties. Currently, it is sent to landfills for disposal. Working with W.R. Grace, SiOsix is working towards designing a product, process, or system that will allow for the useful properties of their manufacturing waste to be repurposed.

Team SiOsix analyzing the properties and specifications of waste silica by creating an aqueous solution. Understanding the properties of the waste will guide the team in exploring its potential uses as a new product.

Amorphous silica (SiO_2) waste produced at the W. R. Grace K1 Plant in Curtis Bay, Baltimore, Maryland. Samples like this will be used to develop alternative uses for a portion of the waste produced each day from the K1 Plant.

SHELL ECO MARATHON STRATEGY TEAM



TEAM

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Francis Chval
Alejandro Mastrapa
Jordan Prax
Mark Rodriguez

ADVISING

Robert Nagel
Robert Prins

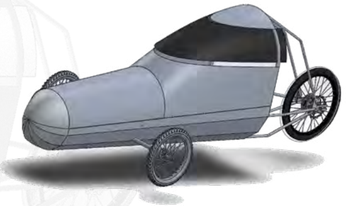
SPONSORS

Royal Dutch Shell

"Strategy without tactics is the slowest route to victory. Tactics without strategy is the noise before defeat"- Sun Tzu. The Strategy Team believes this quote embodies its purpose in differentiating itself from prior teams through an analytically-focused driving strategy for the competition and vehicle system redesign. Although it may not be a linear strategy, we need to dissect and apprehend various components of the fuel-efficient vehicle to assemble a mathematical model. Its purpose is to enable users to closely predict how their vehicle will behave while on the competition racetrack. Furthermore, the model provides a strategic step for future teams in the JMU Shell enterprise to become knowledgeable with aspects of the vehicle and make informed design decisions.

The strategy team is analyzing the flow of information in the drivetrain model on Simulink.

The team's first complete CAD model prototype of the fuel-efficient vehicle chassis. It will be incorporated in the Simulink interface to analyze the performance of the vehicle.



SPENT GRAIN RECOVERY SYSTEM

TEAM

Peyton Dudley
Conner Feit
John Gardiner
Collin Kenney
Chris Smith

ADVISING

Samuel Morton

SPONSORS

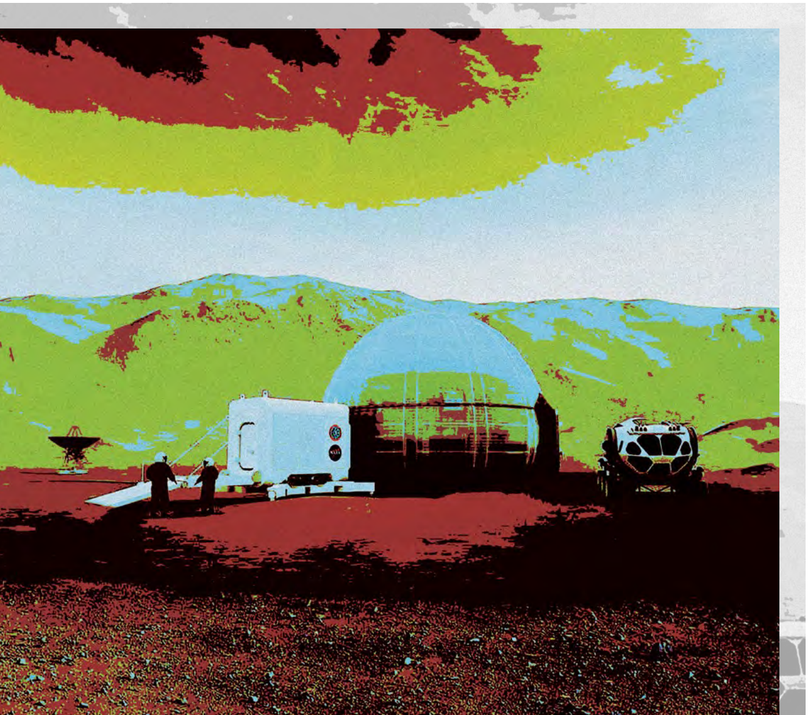
Pale Fire Ale

Brewers' spent grain is the main by-product of the brewing industry making up about 85% of the total by-products generated. Due to its high fiber and protein content, spent grain could have a variety of uses including animal feed, human feed, and composting. This project explores how a system can be made for small scale breweries (less than 465,000 gallons of beer brewed per year) to utilize their spent grain for a financial profit. The reason that the team is focusing on small-scale breweries is often the spent grain is either given away to farmers or thrown out. When thrown out, the brewery may have to pay disposal costs and we hope to eliminate this problem by adding value to the waste product they produce year-round. Larger breweries, such as Coors, already have a system in place to sell their spent grain to a third-party company. Our goal is to scale this system down in a way that will benefit small-scale breweries. Our main stakeholder is Pale Fire Ale here in Harrisonburg. Working closely with them has provided us with access to spent grain as well as stakeholder feedback through the design process.

The team working on a presentation for their design review panel.

Spent Grain

SUSTAINABLE GREENHOUSE ON MARS



TEAM

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Javier Rodriguez
Zechariah Somers
Tanna Walters
Lawrence Marfo

ADVISING

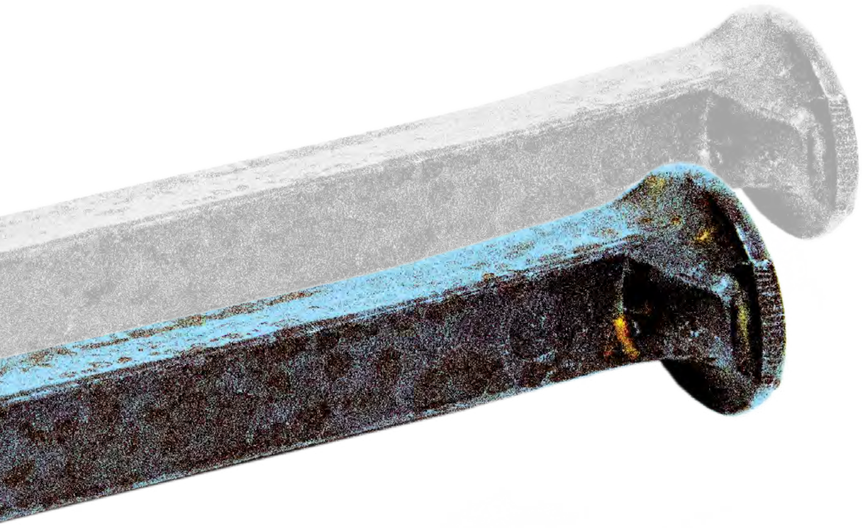
Justin Henriques
Adebayo Ogundipe

With the current state of the world, there is more of a need to expand our inhabitable space. This being the case, we have turned our interest to the skies and beyond. Our focus has turned to the most likely candidate, Mars. In the early 2030's, NASA plans to send astronauts to explore the terrain and start the colonization of Mars. To maintain life on Mars, it is essential to sustain the health and well-being of these explorers. Enter the greenhouse. Our project is to design an Earth-like atmosphere in a controlled environment on Mars where crops can grow and thrive. Join us as we show you what it takes to be MadE in Space.

The team is drawing iterations of a Martian Greenhouse to lay the foundation of the project.

Ice House: NASA's proposed housing unit for astronauts living on Mars which complements the greenhouse design.

TRAIN OF THOUGHT



TEAM

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Trevor Kraeutler
Zach Wenzler
Adam Zahorchak

ADVISING

Jacquelyn Nagel

From January 2010 to November 2019, derailments have cost railroad companies over $350,000,000 in damages in addition to the costly environmental remediation cleanups and injuries. The State of Virginia is home to many small scale railroads that have less than a total of 100 miles of track between destinations.

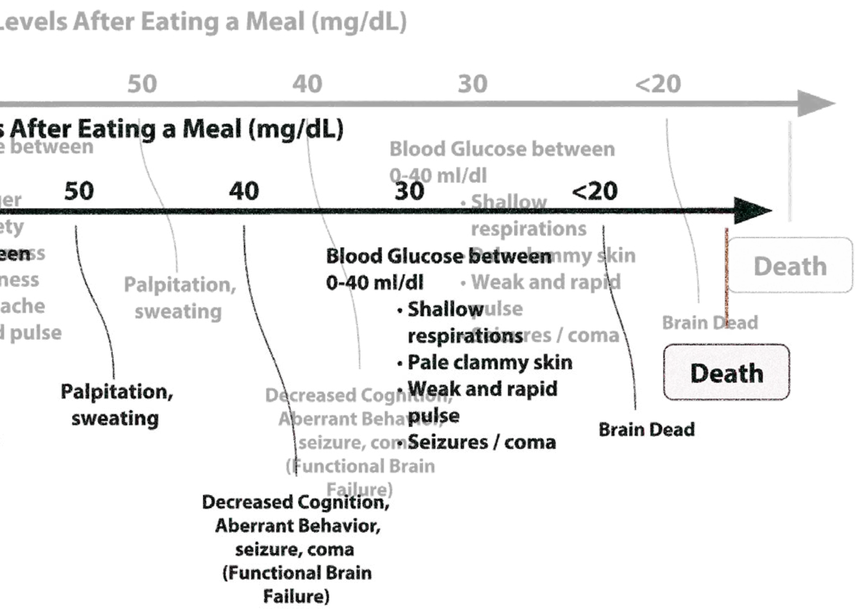
Many of these small scale railroads do not have the resources to autonomously inspect their railroads and cannot afford the cost of large scale railroad inspection equipment along with the resources needed to run these inspection systems. The team has an ultimate goal of preventing or severely decreasing the likelihood of train derailment by focusing on the detection of surface level defects on rails which will have an impact on all railroads while also helping the local short line railroads.

By creating an inspection system for all railroad companies, they can more accurately and precisely find surface level defects than current manual inspections. The team has worked with industry experts to understand what the most common and dangerous surface level defects are and have explored different methods of detection. Our tentative conclusion is that an autonomous inspection system using machine learning focused on surface level defects of rails is capable of identifying defects that may lead to derailment. The system will identify and alert users to dangerous levels of rail damage while providing a cheaper inspection alternative for smaller railroads.

Team meeting on track to make design decisions.

Railroad spike given by SVRR and used to communicate effectively as a large team.

USING VITAL SIGNS TO DETECT NOCTURNAL HYPOGLYCEMIA



TEAM

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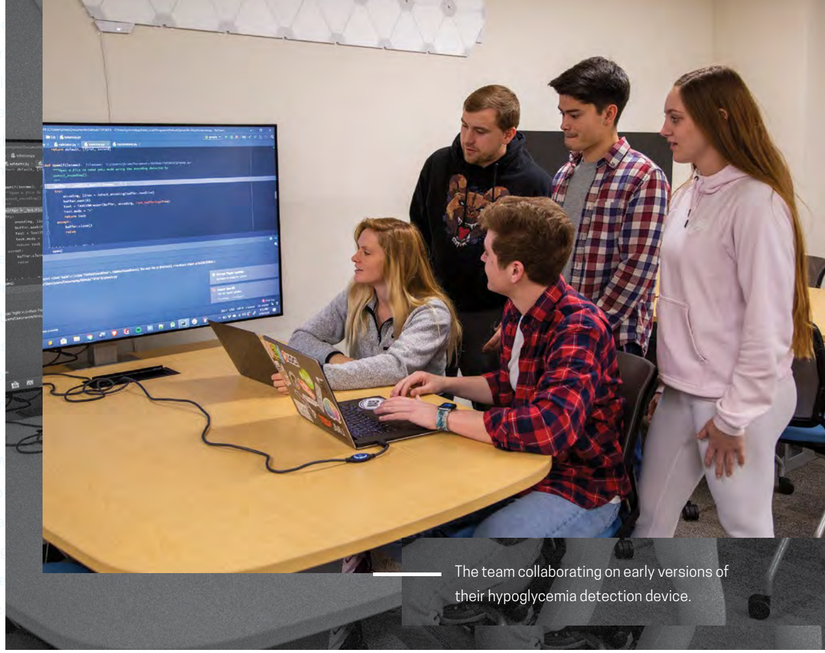
MacKenzie Gring
Ashley Vayo

ADVISING

Shraddha Joshi
Jason Forsyth

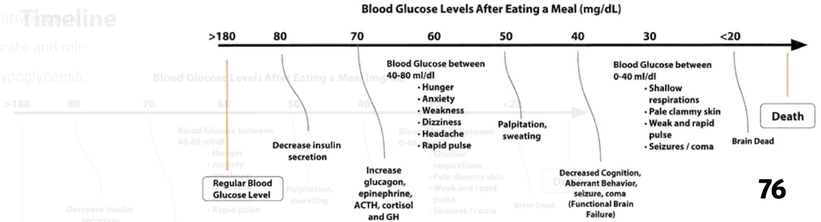
Over 34 million Americans, or 10.5% of the population, have diabetes and about 1.5 million Americans are diagnosed with diabetes every year. Hypoglycemia is often reported to be one of the most feared complications of diabetes, specifically the ones that occur during sleep. Nocturnal hypoglycemia can be dangerous because an individual is unlikely to recognize symptoms or wake up during an episode. It may result in physical injury, poor quality of life, impairment in cognitive function, seizures, and even death. Our project identifies opportunities to improve the detection of the onset of nocturnal hypoglycemia by measuring the changes in vital signs associated with hypoglycemia. We have identified that changes in body temperature, blood pressure, heart rate, shakiness, and sweating are correlated to a hypoglycemic episode. We plan to develop a non-invasive device that is capable of continuously measuring these vital signs while the user is sleeping. The device will detect any changes in the user's vital signs and then determine if these changes correlate to nocturnal hypoglycemia. If this correlation occurs, the device will awaken the user from sleep and alert them that they are experiencing the beginning of nocturnal hypoglycemia. The device will be an alternative way of detecting hypoglycemia without the use of measuring blood glucose levels. Our tentative conclusion is that this device will be more accurate and reliable in detecting the onset of nocturnal hypoglycemia.



The team collaborating on early versions of their hypoglycemia detection device.

A visual aid showing some of the team's preliminary research.

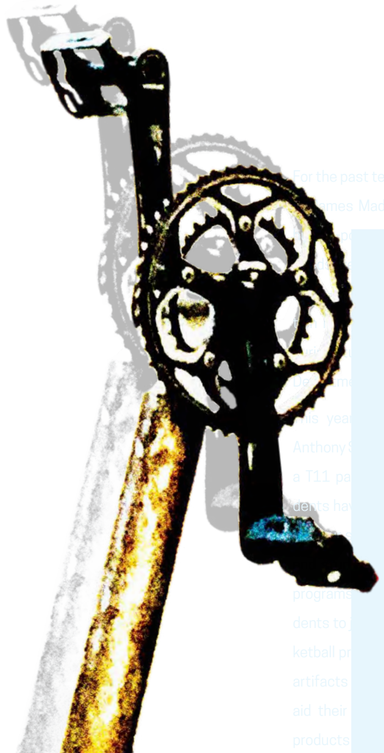
Timeline




REDESIGN


SOPHOMORE

HUMAN-POWERED VEHICLE DESIGN



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Alexandra Davis
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Cameron Funk
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Jack Gavin
Hunter Goodman
Sofiya Gorban
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Jake Hinkle
Ben Hoare
Camden Hollowell
Brenham Howard
Garrett Hutson
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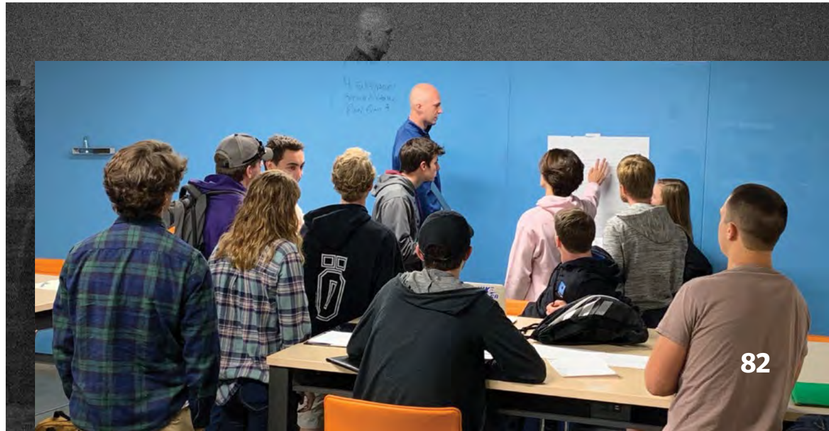
Kyle Lewis
Jenna Lindsey
Jack Lochary
Jeremy Lunn
Abby Maltese
Ban Mansoor
Andrew McHale
Erik McIntosh
Jacob Messner
Stephen Mitchell
Ryan Motta
Zach Mountjoy
Evelyn Munsterman
Elizabeth Olchevski
Matt Paredes
Jack Peot
Nicole Peterson
Tommaso Piccorossi
Matthew Porchetta
Nicholas Pumpelly
Wesley Quill
Jadon Rabon
Kelly Riggan
Gray Roisch
Kelly Sadel
Jake Schmank
Colby Schneider
Trace Scordo
Andrew Sklavounos
Andrew Smith
Katie Smith
Charlotte Solak
Zac Somers
Jack Stephenson
James Stopa
William Sullivan
Brian Sweet
Tyrees Swift-Josey
Gavin Tomchick
Nick Tsoleas
Morgan Uhlick
Mark Vakarchuk
Dylan Varghese
Amy Veihdeffer
Johnna Verry
Tyler Webster
Zach Weller
Austin Zicafoose

For the past ten years, sophomore engineering students at James Madison University work to design and build human-powered vehicles for a community member with needs very different from their own. This year-long, client-based, design project is interwoven with instruction in a two-course design sequence generally taken during students' second year in the Madison Engineering Department.

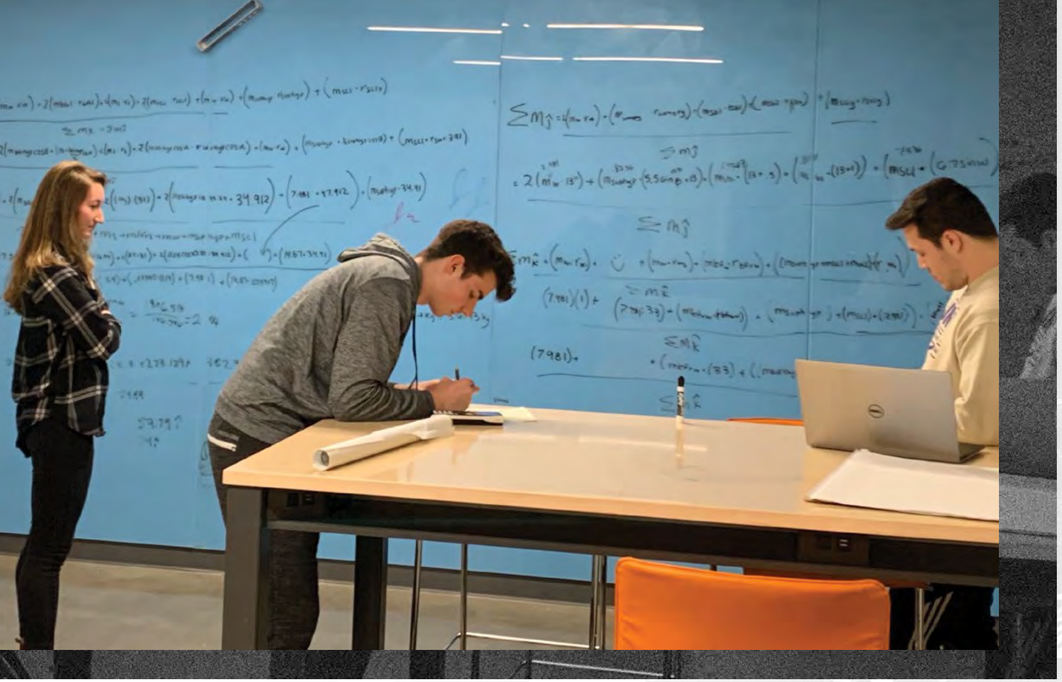
This year our students have been designing for Mr. Anthony Strieff to understand his needs as a person with a T11 parallelization. Through these two courses, students have learned directly from Anthony as he has visited our students in the Madison Engineering classroom and studio spaces, been available on campus through programs such Overcoming Barriers, and invited our students to join him and his teammates for wheelchair basketball practices. Students have developed engineering artifacts to guide their process, test assumptions, and aid their design process toward creating rideable final products for Anthony to test.

Each year, while the theme for the project remains the same, the designs vary greatly as each client's needs and requirements are different. The overarching goal is to expose the students to an experience that transcends the classroom, and in the process, not only teach the students design, but also, that they are part of a larger complex system where their decisions and actions as an engineer can (and likely will) influence others.

This course project transcends the scheduled class time, requiring students to meet outside of the class with the client, coordinate with the machine shop, fabrication shop, and work with Mr. Les Welch of East Coast Bicycle Academy to learn the fundamentals of bicycle mechanics. For this project, the impact truly is on our community.



HUMAN POWERED VEHICLE DESIGN



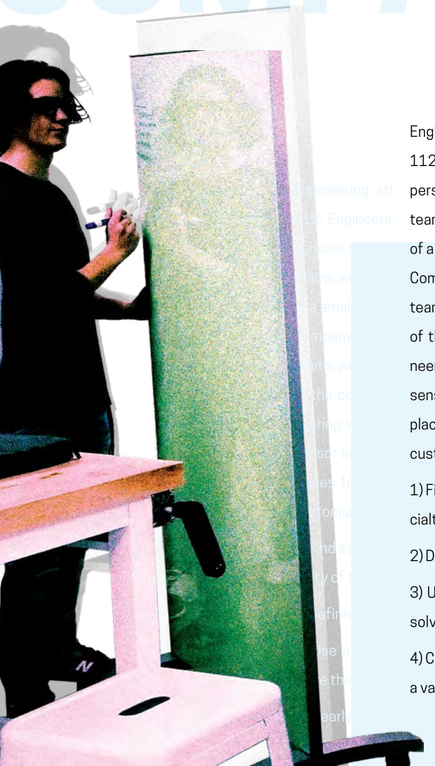
HUMAN-POWERED VEHICLE DESIGN

HUMAN-POWERED VEHICLE DESIGN


DELIGHT


FIRST YEAR

FICTITIOUS CONSULTANCY COMPANY, INC.



ADVISING

Kyle Gipson
Jason Forsyth
Daniel Castaneda

Engineering students in the first-year course ENGR 112: Engineering Decisions formed into teams of 4-5 persons as part of a semester-long project. The student teams were prompted to envision themselves as part of a small group of engineers for Fictitious Consultancy Company, Inc., located in the Shenandoah Valley. The teams were encouraged to leverage the specialization of the company which is developing customized engineering solutions in the deployment of environmental sensor systems to measure conditions in hard to reach places for its clients. Each team embarked on highly customized journeys to:

1) Find a problem in the world that is relevant to the specialty of the company;

2) Define the relevant engineering problem to be solved;

3) Use appropriate tools to investigate and potentially solve the problem; and

4) Clearly communicate the milestones of the project to a variety of stakeholders.

In doing so, student teams had opportunities to blend their own passions and interests with engineering content grounded in the human-centered design process, the Stanford school design thinking model, engineering fundamental analysis, and analytical and physical prototyping skills.

STUDENTS

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Dylan Gnagey
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Zachary Neal
Jack Nordstrom
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Finn Otto
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Aaron Ringer
Elliott Rodgers
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Alejandro Sanchez
Aaron Sanford
Hailey Sauvageau-Shlaffer
Josh Savage
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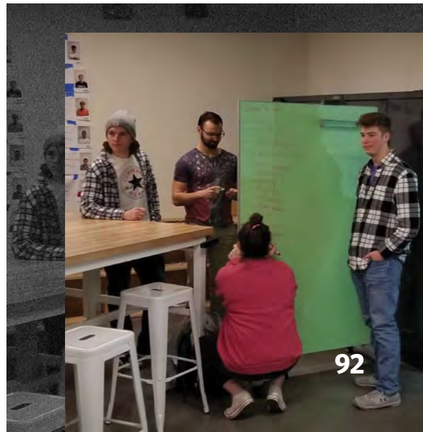
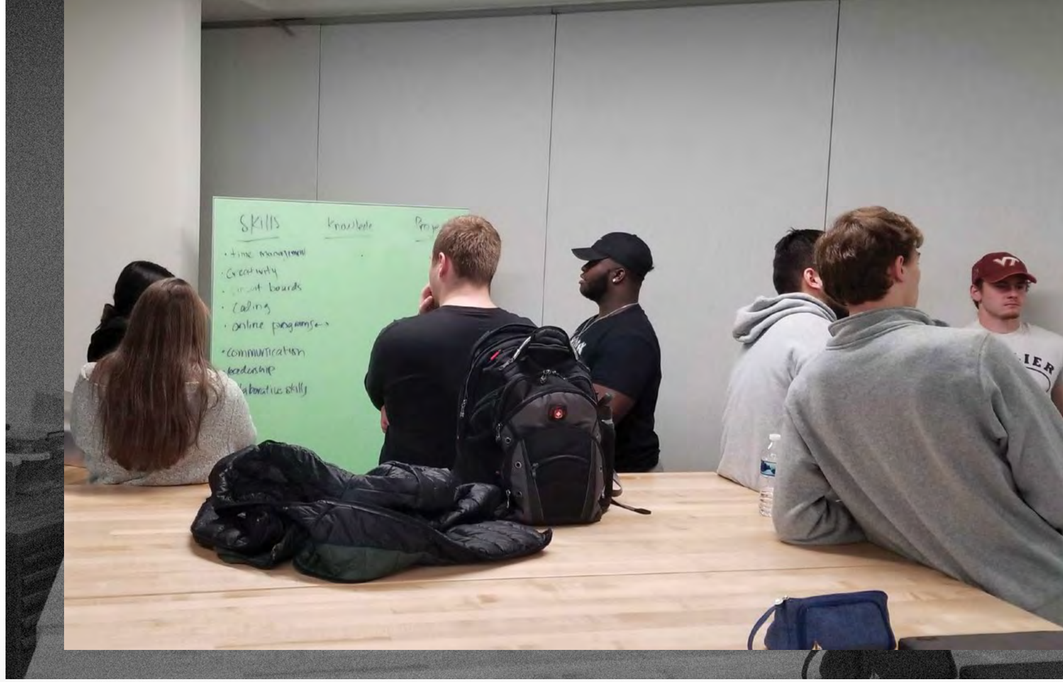
Ryan Ulmer
Nick Van Tol
Tricia Wang
Mary Wari
Thomas Wasylenko
Sean Wertheim
Jack Williams
Justin Williams
Zach Wynn
Sherinne Zhang
Alexander Ziemke



CONSULTANCY



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AN EXCERPT FROM “CHANGES” *BY DAVID BOWIE*

I watch the ripples change their size

But never leave the stream of warm impermanence and

So the days float through my eyes

But still the days seem the same

And these children that you spit on

As they try to change their worlds

Are immune to your consultations

They’re quite aware of what they’re going through

Ch-ch-ch-ch-changes

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