XCHANGE '22

MADISON ENGINEERING

A Year of Good Through Innovation, Research, and Design


JMU
Department of
Engineering

DISCOVER

This was another tough year that took physical and mental tolls on all of us. Nevertheless, we persevered and gradually found and adjusted to new possibilities. One thing that remains a part of us is the collective resolve to always finish the work we start.

We are ending the year with a strong display of what makes our program unique; the quality and diversity of project and research work that our students do and the innovative solutions they create. The past few years have reinforced the fact that adaptability and innovation will continue to be winning mindsets for a sustainable future. This is why we do what we do.

Kintsugi is the ancient Japanese art of repairing broken pottery in a way that makes it better. This method celebrates fractures and breakages as part of the object's unique history by not hiding or disguising them. This is a very apt motif for this year as we continue to celebrate our themes of resilience and overcoming. We have emerged better than ever.

BAYO OGUNDIPE PH.D.

Department Head
Department of Engineering

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DESIGN

HONORS

ASPECTS OF A MAKING CENTERED COMMUNITY: A DIVE INTO WHAT HAPPENS WHEN A SHIFT TO ONLINE LEARNING DISRUPTS THE FAMILIAR

HONORS STUDENT

Kelly Sadel

ADVISING

Dr. Robert Nagel
Dr. Melissa W. Aleman

READERS

Dr. Robert Nagel (JMU)
Dr. Melissa W. Aleman (JMU)
Dr. Julie S. Linsey (Georgia Institute of Technology)

The rapid onset of COVID-19 created a need for an immediate adjustment of longstanding, in person experiences. With classes, labs, and projects moving online, the student experience and community within an engineering department adjusted to fit the current situation. Four research questions found study:

1) What are the differences between students' accounts of engineering learning before and after the onset of remote instructions due to the COVID-19 pandemic?

2) What are the key themes in students' accounts of their experiences learning about engineering and making following the onset of remote instruction due to the COVID-19 pandemic?

3) What are the key features of a making community that are important to undergraduate students in an engineering program?

4) How do students account for changes, if any, in the making community after the onset of remote instruction due to the COVID-19 pandemic?

Through focus group interviews, student experiences were gathered and analyzed in order to understand student perceptions of the impact of COVID-19 on the engineering community and the students' learning experience. Insights include how students adapted to the online learning environment throughout the evolution of the pandemic, what aspects of community translated into the online learning environment, and how students felt the pandemic impacted their learning and undergraduate experience.

ACOUSTIC MODELING OF THE ROCKET FLAME TRENCH AT WALLOPS ISLAND FLIGHT FACILITY

HONORS STUDENT

Abby Maltese

ADVISING

Dr. Keith Holland
Dr. Caroline Lubert
Dr. Roger Thelwell

Launch vehicles create acoustic environments that can be harmful to the vehicle, payload, and surroundings. As it becomes more common to reuse launch vehicles, it is important to be able to accurately model the acoustics of a launch and the pressure wave it creates. For this capstone project the Pad 04 rocket flame trench at NASA's Wallops Island Flight Facility has been modeled and analyzed in COMSOL. Different 3D geometries of the flame trench have been created and tested, each one more complex than the last. After many variations of the flame trench geometry were tested, the Wallops Island Flight Facility flame trench was analyzed for max acoustic loads. Testing this geometry can help inform decisions on rocket noise mitigation techniques put in place to protect the rocket and its payload.

THE DEVELOPMENT OF LASER, IMAGING, DETECTION, AND RANGING (LIDAR) FOR AN ACADEMIC SETTING

HONORS STUDENT

Kris Krueger

ADVISING

Dr. Keith Holland

READERS

Dr. Jonathan Miles
Dr. Jason Forsyth

Laser imaging, detection, and ranging (LiDAR), a technology that utilizes the interaction of lasers with materials to determine position, velocity, and composition, has numerous industrial and research applications. However, the mechanical, optical, and electronic complexity of LiDAR systems results in high acquisition costs, limiting accessibility to students learning about the technology. Doppler LiDAR, a technique that is used to measure the relative velocity of targets is increasingly used in the design of autonomous vehicles and for wind-turbine control systems. This thesis project investigates the underlying physics and design considerations required for the development of Doppler LiDAR systems, with the goal of determining the feasibility and associated costs of constructing a low-cost demonstration system using off-the-shelf components appropriate for undergraduate classroom and laboratory settings.

BUILD


SENIOR

AISC STUDENT STEEL BRIDGE COMPETITION

A digital model of the team's bridge design.

TEAM

William Ahorsu
Michael Allsop
Jack Lochary
Andrew McHale
Jadon Rabon
Katie Smith

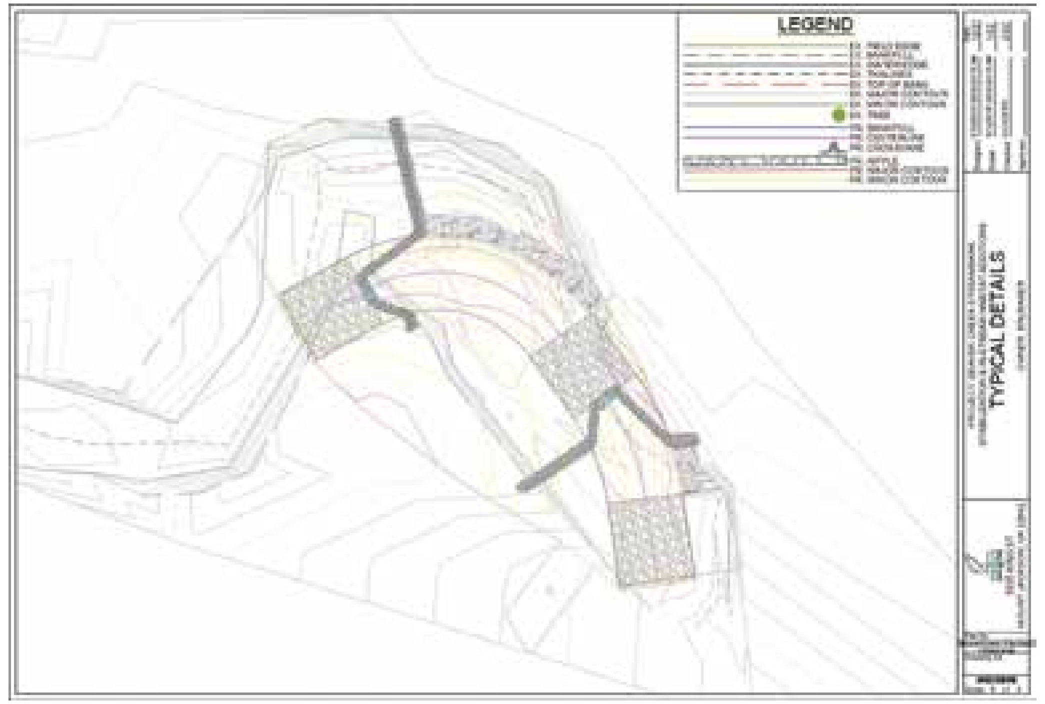
ADVISING

Dr. Daniel Castaneda
Dr. Heather Kirkvold
John Wild

The American Institute of Steel Construction's Student Steel Bridge Competition challenges student teams to design and develop a scale-model steel bridge. Over the past 25 years, approximately two hundred schools compete each year across the country creating a hands-on steel structure that grows interpersonal and professional skills. The teams competing will design and fabricate a bridge that will be rapidly assembled and judged on the day of the competition. Teams will abide strictly by the rulebook and are scored in various categories such as stiffness, construction speed, lightness, and aesthetics. This project explores conception and design through fabrication, erection, and testing. The new 2022 competition rules were released in late August. The team spent time reading over and understanding the rules before beginning the design. Softwares like SAP2000 and SolidWorks were used to help model and test loading conditions that will be applied at the competition. Once the team finalized the design, fabrication began. The team was able to connect with a local company that specializes in high-end metal fabrication and installation. Shickel Corporation has sponsored our team and provided us with the necessary materials to build our structure. The team started out by prototyping then later went on to build the entire bridge structure, made completely out of steel. To become familiar with the assembly, the team practiced assembling the entire bridge from start to finish following competition guidelines and regulations.

Team members practice welding in preparation to help the senior team fabricate their bridge.

BEAVER CREEK RESTORATION



The final Natural Channel Design the team has developed in CAD Civil3D to solve the issues at the case study site. The design will be implemented at Beaver Creek in early April.

TEAM

Hunter Goodman
Jacob Messner
Lacey Monger
Jack Peot
Andrew Sklavounos
Tyrees Swift-Josey

ADVISING

Dr. Bradley Striebig

SPONSOR

Massanutten Chapter 171 of Trout Unlimited (TU)
Dylan Cooper, PE, CED, TU Stream Restoration Specialist
Seth Coffman, TU Chesapeake Bay Project Manager

Beaver Creek is a popular trout cold-water fishery in the Shenandoah Valley of Virginia and is the focus of this capstone. The project site is located at coordinates 38°25'47" N 79°02'28" W, which is near the intersection of Ottobine Road and Briery Branch Road in Rockingham County, Virginia. The existing case study section of the creek is currently split into two channels and is exhibiting signs of uncontrolled sediment aggradation. This section has 152 feet of exposed vertical streambank on both sides of the stream. The site is also exhibiting a loss of in-stream habitat through channel bed degradation. The purpose of this project is to stabilize the eroding streambanks, decrease erosion & sedimentation, and restore the riparian & in-stream habitat of this section of Beaver Creek. Two rock cross vanes and 120 feet of wood toe revetment will be installed to provide bank protection and habitat enhancement. A variety of riparian vegetation native to the Shenandoah Valley and Virginia will be planted to enhance the riparian habitat. The channel pattern, profile, and dimension will be corrected through a Natural Channel Design Process. Massanutten Chapter 171 of Trout Unlimited has completed similar projects upstream of the site in recent years. These recent restoration projects will be used as reference reaches for the case study site. Trout Unlimited will also provide funding for the project through grants that the team has successfully applied for and been rewarded. The project has also engaged the community to raise awareness of the importance of cold-water fisheries in the ecosystem. The final design will allow Beaver Creek to function naturally, so the local trout population and water quality are returned to their proper state.

Team members finishing up a day of collecting stream phenomena data at the case study site at Beaver Creek.

COLLEGIATE WIND COMPETITION 2022

CAD model of full integrated offshore turbine.

TEAM

Joshua Bautch
Alexandra Davis
Garrett Downs
Ban Mansoor
Nicole Peterson
Matthew Porchetta
Colby Schneider
Brian Sweet

ADVISING

Dr. Keith Holland
Dr. Jonathan Miles (ISAT)
Edwin Clamp (Management)

SPONSOR

Department of Energy (DOE)
National Renewal Energy
Laboratory (NREL)

According to the United States Department of Energy's Wind Energy Vision report, wind energy could provide 35% of the nation's electricity by 2035, creating demand for individuals with professionally relevant engineering experiences in the multifaceted wind and renewable energy sector. The primary objective of this project is to develop a small-scale offshore wind turbine for the 2022 Collegiate Wind Competition, sponsored by the U.S. Department of Energy and the National Renewable Energy Laboratory. In accordance with the published competition Rules and Requirements, the functional prototype will be subjected to wind tunnel testing to demonstrate power production, control, and safety capabilities similar to those of industry scale wind turbines. With the competition theme of offshore development, the team has developed and tested various anchoring techniques and geometry to ensure stability and performance at high wind speed. Another focus has been controlling and regulating techniques; with the incorporation of a wind speed sensor the team will be able to pitch the blades and regulate power at wind speeds greater than 11 m/s. Power regulation via pitching disregards the use of the brake except for the emergency stopping conditions to meet the safety regulations provided by the organizers. The team anticipates competing in San Antonio, Texas during the CLEANPOWER Conference in May.

Team members assessing their individual subsystems: electronics, generator, and anchoring.

CONNECTED RELATIONSHIPS WITH IOT SENIOR CAPSTONE TEAM

TEAM

Katelyn Anderson
Cassie Bedard
Garrett Hutson
Evelyn Munsterman

ADVISING

Dr. Shraddha Joshi

Keurig Coffee maker (left) and IoT device (right) containing Raspberry Pi connections.

Due to obstacles including lack of time or long distance, more people are routinely using the virtual environment to stay connected to friends and family. Our project's goal is to aid the older generation to utilize this environment to stay connected with their grandchildren. We are doing this by prototyping a coffee maker attachment, Coffee Time Connections, that enables users to send voice messages to each other and play them back while brewing coffee using the internet of things (IoT). We chose a coffee maker to implement our goal because making coffee is integrated into everyday life for all generations. The team designed Coffee Time Connections using universal platforms due to their low cost and extensive documentation. Buttons are connected to pins on a python programmed Raspberry Pi. The code downloads, plays, records, and uploads voice messages stored on Google Drive. We added two buttons (record and send) to the coffee maker which are placed in a 3-D printed box that stores all the added hardware. The record button allows the user to record a message, and the send button uploads the message to Google Drive for the paired coffee maker to access. The download and play functions are connected to the already existing brew buttons on the coffee maker. After a message is uploaded and sent, the corresponding coffee maker will download the message from Google Drive and play it aloud for the individual who pressed the brew button. This easy-to-use structure limits confusion and enhances connection between individuals.

Cassie Bedard (left) testing the microphone functionality with the Raspberry Pi while Garrett Hutson (right) works on being able to connect to the device wirelessly.

EMBEDDED SYSTEMS FOR PRECISION AGRICULTURE

TEAM

Sofiya Gorban
Stephen Mitchell
Dylan Varghese
Tyler Webster

ADVISING

Dr. Jason Forsyth
Dr. Justin Henriques

SPONSOR

Blenheim Vineyards

Team member examining a potential location for a later testing site on a local vineyard.

Precision agriculture is a farming management technique that consists of taking into account temporal and spatial variations for a more sustainable approach to agriculture. The variations are taken into account when treating fields with pesticide, watering, and other maintenance measures in order to maximize crop yields and labor efficiency. Due to the inherent cost of precision agriculture systems, it is difficult for small-scale farms to adopt cutting-edge technologies. The Embedded Systems for Precision Agriculture Capstone aims to bridge the connection between precision agriculture and smaller agricultural sectors.

Due to the nature of the microclimates in the Shenandoah Valley, cultivating grapes is a challenge for vineyards due to a high risk of frost. Frost events occur in isolated portions of the fields that are susceptible to freezing and can account for the loss of over half the expected crop yield. For the past two years, this Capstone team has worked on creating a sensor network that measures temperature at multiple points on a vineyard to track variations and predict isolated frost events. This information is presented to vineyard managers via a web application so that preventative measures can be taken to counter frost damage in a timely and resource considerate manner. The team has partnered with multiple vineyards in the Shenandoah Valley to test the system and evaluate different frost prediction algorithms.

The team deploying a prototype for a system test on the JMU grounds.

INTERACTIVE BIOPHYSICS MACHINES

TEAM

Lauren Dargan
Jenna Lindsey
Ryan Motta
William Sullivan

ADVISING

Dr. Callie Miller
Dr. Nathan Wright (Chemistry)

Technical display of all three beta prototypes developed by the team showing lesson one's backside (left), lesson two (middle), and lesson three's digital display (right).

The Interactive Biophysics Machines capstone project kick-started in 2021 based on the U.S. Department of Education statement: "we must also make sure that no matter where children live, they have access to quality learning environments." The faculty advisors envisioned a serial capstone project teaching engineers biology, challenging them to communicate biology concepts to children through interactive displays, and presenting their displays at the Rockingham County Fair annually- a population and venue lacking any representation from JMU. Our team, Engineering Iron Man, has focused on how signals in the nervous system translate to muscle movement while also telling the story of how engineers might make a real Iron Man suit.

After extensive stakeholder research, our target demographic is 4th-6th grade students with lessons and displays viewed through the lens of "how might we engineer Iron Man?" We found that "Rockingham County Public Schools appear to have an abundance of STEM-based resources made available for students of all grade levels. However, the students do not have an interest in utilizing them and do not take advantage of the opportunities provided, especially with 4th to 6th grade students. Therefore, the goal of this project is to spark and empower the 4th-6th grade students' interest in STEM."

To bring this story to life our team has constructed three different interactive machines that together teach a larger lesson about how the human nervous system works:

- Lesson 1 focuses on a general understanding of what our nervous system is and does. Here students use our life size Iron Man display to send ping pong balls (brain signals) through a tubing network (nerves) via a robotic dispensing system (the brain).
- Lesson 2 demonstrates how ions move across cell membranes to create the electrical signals using a large Plinko board.
- Lesson 3 shows the electrical signals in our muscles using EMG signals and how the body's signals can be read by equipment and translated into movement by causing a robotic arm to mirror the movements of the human demonstrator.

All three lessons together tell of the amazing mechanisms in our body's to send signals and change electrical signals into mechanical muscle movements. Furthermore, with our intentional designing, we can share the "engineering" aspects of making the displays work and how one of the students might be able to engineer a real Iron Man suit one day.

Engineering Iron Man Senior Team displaying their alpha prototypes of lessons one, two, and three at the 2021 Rockingham County Fair.

JMU ROCKETRY TEAM

The team's full-scale rocket.

TEAM

Coleson Baughan
Brandon Carroll
Cameron Funk
Ben Hoare
Kris Krueger
Abby Maltese
Gray Roisch
Kelly Sadel
Trace Scordo

ADVISING

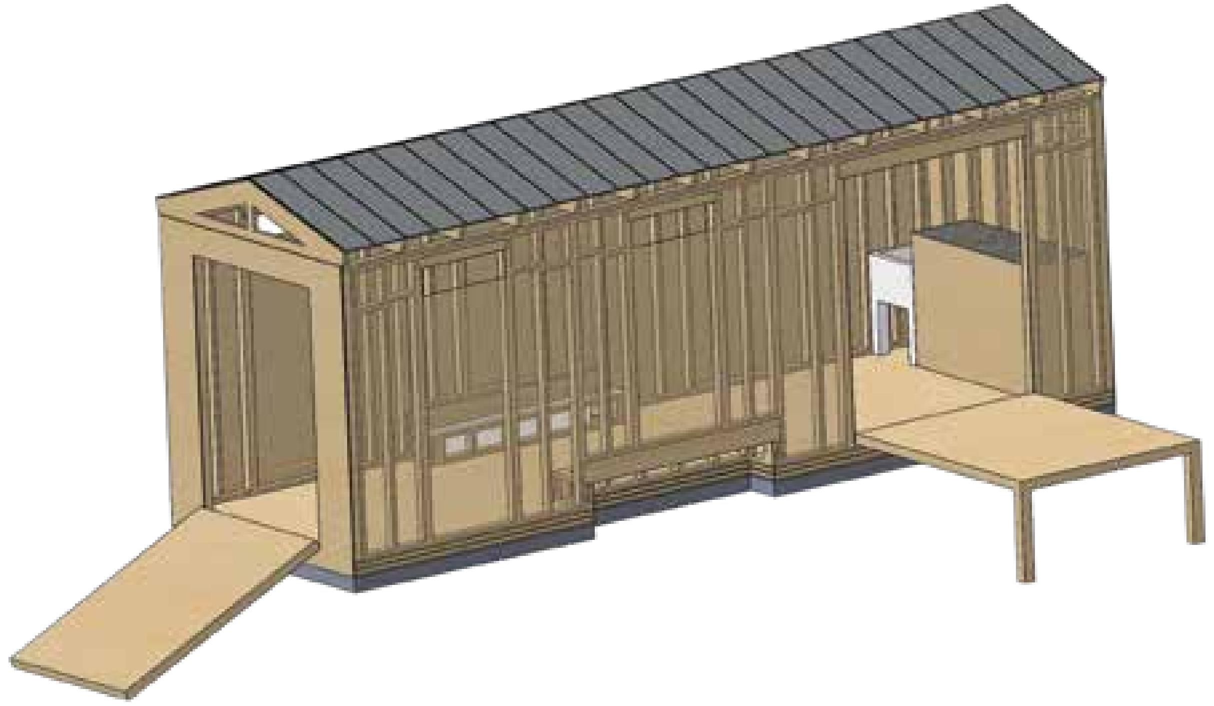
Dr. Keith Holland
Dr. Samuel Morton III

Each year, NASA hosts a Student Launch Initiative (SLI) competition, which offers students the opportunity to engage in a research-based, experiential project to develop and launch a high-powered rocket vehicle (HPR) and payload system. Additionally, the student team will present detailed design, technical, and safety reports for review, presentation, and approval by NASA officials, maintain an online presence, and host STEM engagement events to reach a minimum of 250 individuals within their community. Students must design, fabricate, test, launch, recover and obtain data from a scientific payload at the competition launch site in adherence with competition requirements. The payload objective changes each year with the objective for this year being that the payload must be able to autonomously locate the rocket upon landing on a gridded image of the launch site without the use of GPS. This is the first year that JMU has been represented in this fast-paced competition which has required simulations, modeling, subscale modeling, establishing relationships with local rocketry experts, fabrication work, fulfilling requirements, and project management.

The final design is a 119-inch long, 44.7-pound, fiberglass rocket comprised of three sections that will utilize a dual deployment recovery system and launch to approximately 4900 ft AGL (above ground level). The payload will be utilizing an IMU sensor, Arduino Pro, Kalman filter and radio system to interpret and communicate the location of the landed rocket. The team will be traveling to Huntsville, Alabama to launch with other NASA SLI teams in April 2022 for the final competition launch at which the team will launch the finalized and fully functional vehicle and payload.

The JMU Rocketry team posing with their rocket.

MAGIC BREW BUS



CAD Model of what the trailer will look like.

TEAM

Raphael Bianchi
Nick Ciccone
Erik McIntosh
Matt Paredes
Zach Weller

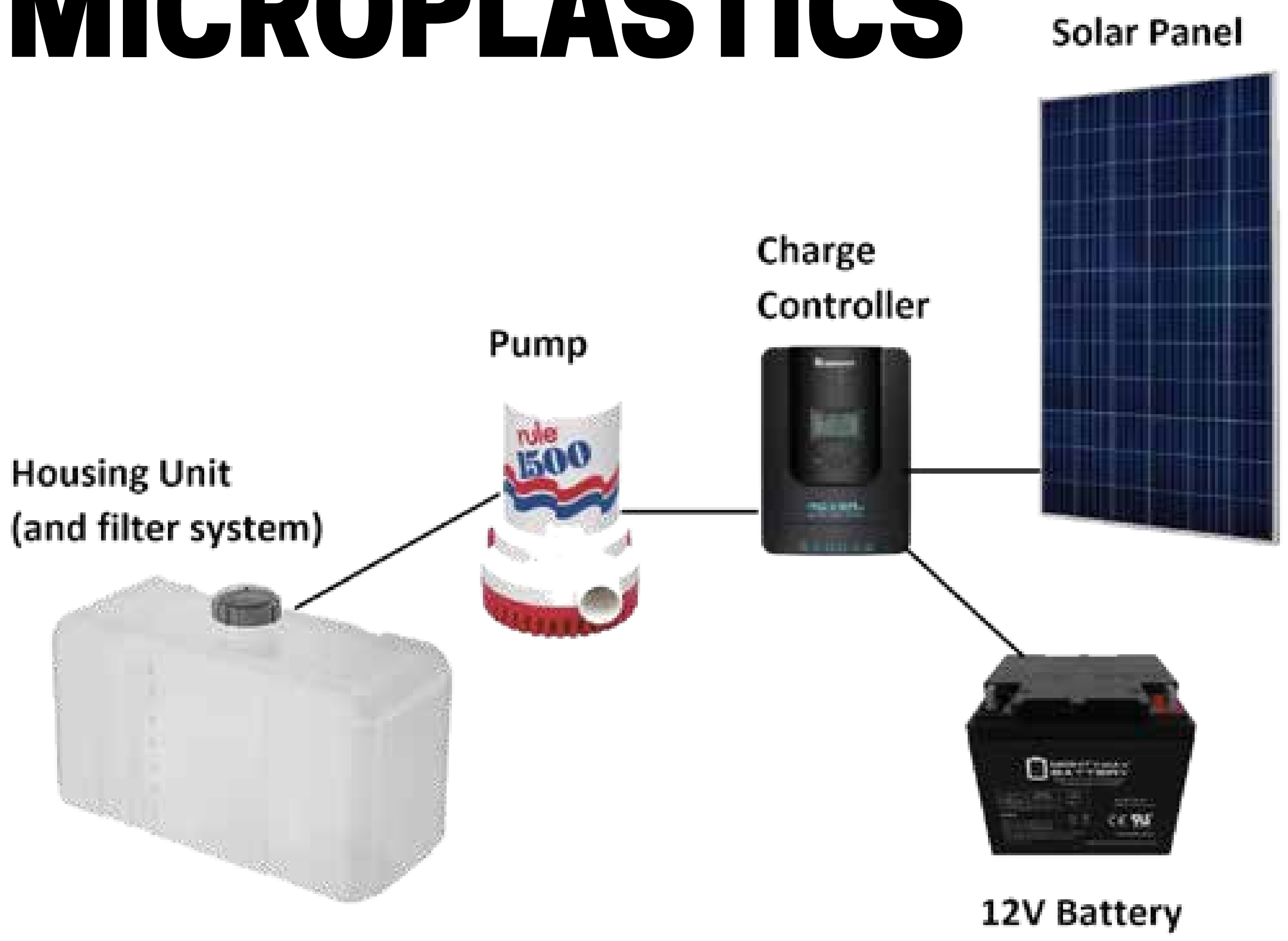
ADVISING

Dr. Steven Harper
Dr. Samuel Morton III

In the United States, half of the high school graduates who have interest in Science, Technology, Engineering, and Mathematics (STEM) are not proficient in skill sets necessary for these fields due to a lack of educational engagement. The Brew Bus project explores this deficiency and has been tasked with increasing interest in younger generations for STEM education in Rockingham County. The team has worked on designing, planning, and constructing a mobile trailer that will allow STEM educators to communicate technologies and subject matter to an outdoor audience. The end-product will be a modular space that accommodates for multiple methods of learning in a variety of topics. So far in our project development, the team created a project management plan, CAD Models, a fluid drag analysis, a weight analysis, roof analysis, installed plumbing system, installed floor, and installed the whole trailer structure. The previous team has also completed construction of the trailer's frame and purchased some of the required materials. Since this project is still in the building phase, there has not been an observable impact on the surrounding community. The trailer is expected to be used as a tool to engage the Rockingham community in learning about STEM technologies, which will hopefully lead to a more active community in STEM learning.

Magic Brew Bus testing and inspecting the roof prototype on top of the trailer.

MAN-O-WAR ON MICROPLASTICS



The setup and connections between components of the design.

TEAM

Jeremy Lunn
Zachary Mountjoy
Wesley Quill
Kelly Riggan
A. J. Smith
Gage Waltner

ADVISING

Dr. Jacquelyn Nagel

An estimated 14 billion pounds of trash, mostly plastic, makes its way into the oceans every year. Consequently, the average person consumes around five grams of microplastics every week. Inspired by the United Nations Sustainable Development Goals, this project aims to prevent increasing amounts of litter from entering the oceans by targeting major watersheds. Team OCEAN6 utilized biomimicry, or inspiration from nature, to address the world's litter crisis.

Inspiration for the design came from the filter feeding function of whales and the process by which the Portuguese man o' war traps prey from different depths and pulls it up into its mouth.

The team's solution consists of a solar panel that connects a battery to power a pump and tube system that extracts water and microplastics from the waterway. Inside the system are two filters layered on top of each other designed to filter out microplastics down to five microns. A buoyancy system and an anchor will allow the design to remain at the most effective location and height in the watershed. OCEAN6's goal is to improve the conditions of the world's waterways and oceans for humans and wildlife everywhere.

Team OCEAN6 tests the interface between the housing and electrical subsystems of the design.

SHELL ECO-MARATHON JMU SUPERMILEAGE TEAM

TEAM

Adam Gremminger
Camden Hollowell
Kyle Lewis
Nicholas Pumpelly
Jake Schmank
Charlotte Solak
Jack Stephenson
Nick Tsoleas

ADVISING

Dr. Robert Nagel
Dr. Rob Prins

SPONSOR

Royal Dutch Shell

Preliminary design of the energy and propulsion systems on the vehicle, includes the 30cc Ryobi four stroke engine, gear reduction system, Ecotron engine control unit, wire harness and fuel pressure system.

In 2019, the USEPA reported that Transportation is the largest source of carbon emissions in the United States. Carbon emissions are largely responsible for climate change worldwide. Every year, Shell Eco-Marathon brings students from across the world to help make steps toward reducing fossil fuels by designing energy efficient vehicles to compete against one another. This legacy project has evolved over the last few years allowing James Madison engineering students to explore automotive design and cross-collaborate with previous Shell Eco-Marathon Teams. The team inherited a full vehicle chassis with an engine that did not integrate with the Eco-Cal software, gearing system that was not adequate for our competition goals, and a need for a vehicle testing device. The team is split into three sub-teams of four students with the first team focusing on fabricating an engine dynamometer, the second team concentrating on engine/propulsion optimization, and the third team focusing on designing/fabricating a gearing system. The team has spent spring 2021 working towards finalizing the design of the engine dynamometer and learning how the Eco-Cal software operates. By the end of fall 2021, the team achieved getting the engine running with our fuel injection system and completed the physical construction of the dynamometer. Spring 2022 was spent finishing the loading system of the dynamometer, testing our vehicle design, and preparing for the competition in April. To reach these goals, the team utilized SolidWorks CAD, SolidWorks Simulation and the ECU's Ecotron software as well as machining, 3d printing and design skills. The team has created a vehicle that has been accepted into the competition and will be in Indianapolis for competition in April.

The team makes final touches on the vehicle before submitting phase two of the competition's application.

SYNTHETIC BIOLOGICAL MACHINES

TEAM

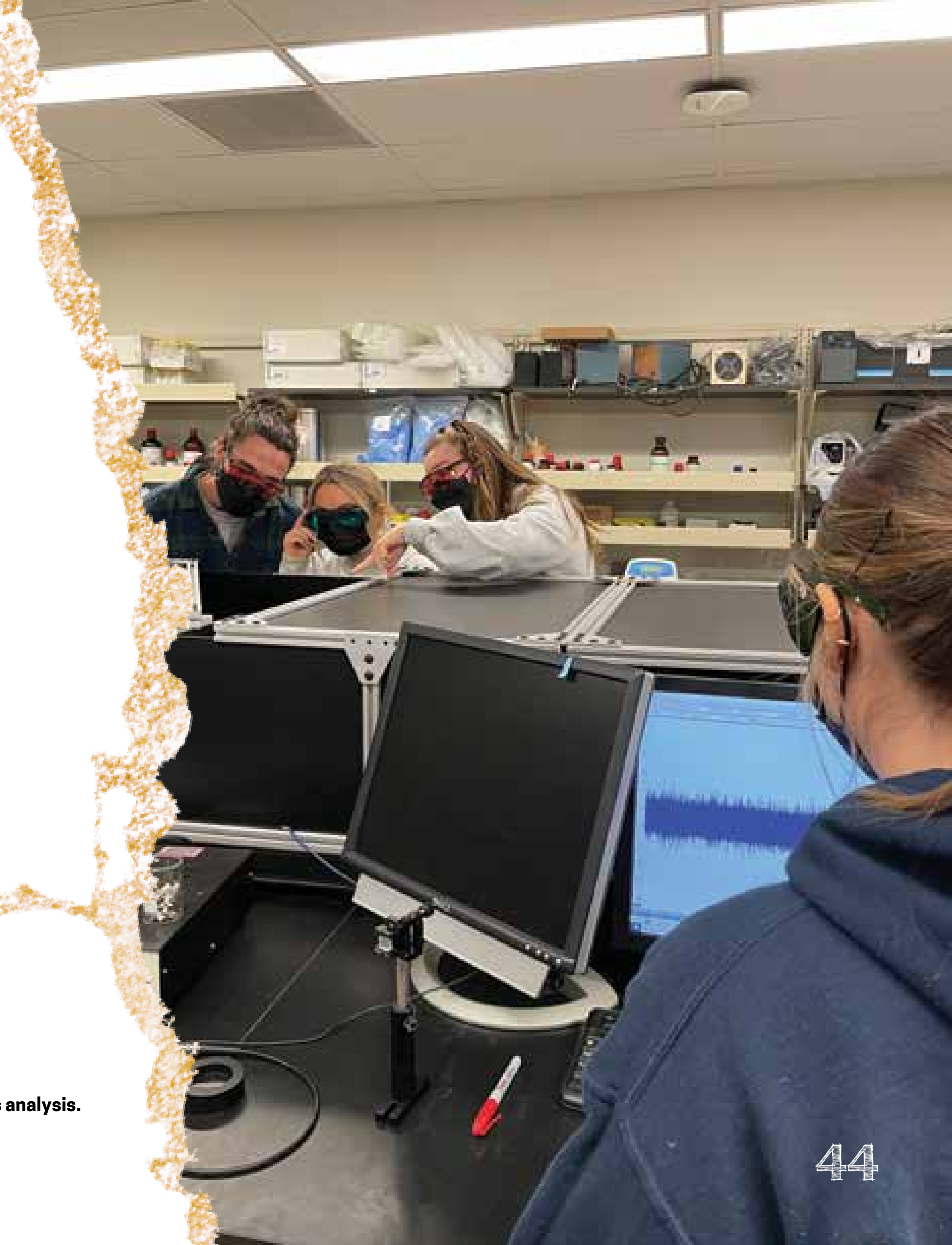
Melanie Blatt
Corinne Brady
Lydia Chupp
Tommaso Piccorossi
Amy Veihdeffer
Johnna Verry

ADVISING

Dr. Kyle Gipson
Dr. Stephanie Stockwell
(Biotechnology)

Synthetic biology is a newly emerging field of biology in which an organism is engineered to carry out a function that it was not originally designed to do. Synthetic biology has a multitude of applications such as those in life sciences, environmental, and agricultural industries. This project uses the production of nanobodies as a foundation to make current processes used in synthetic biology more accessible within education and undergraduate research by decreasing the expensive start-up costs. The goal of creating these processes is for them to be replicated and improved upon. The project consists of three components. The lab subdivision focuses on building the cell factory through biomanufacturing. The automation subdivision consists of creating a building process for a protein purification system. The final team's goal is to discover ways to align the process within the scope of existing markets. Our hope is to bring more exposure and lower economic barriers that prevent the widespread usage of synthetic biology.

Micropipetting in the biotechnology lab.



Working on optics analysis.

REDESIGN

JUNIOR

BIO-INSPIRED CLIMATE ADAPTABLE SOLAR ENERGY SYSTEM

TEAM

Joe McGinn
Zachary Wynn
Ben Love
Ryan Ulmer

ADVISING

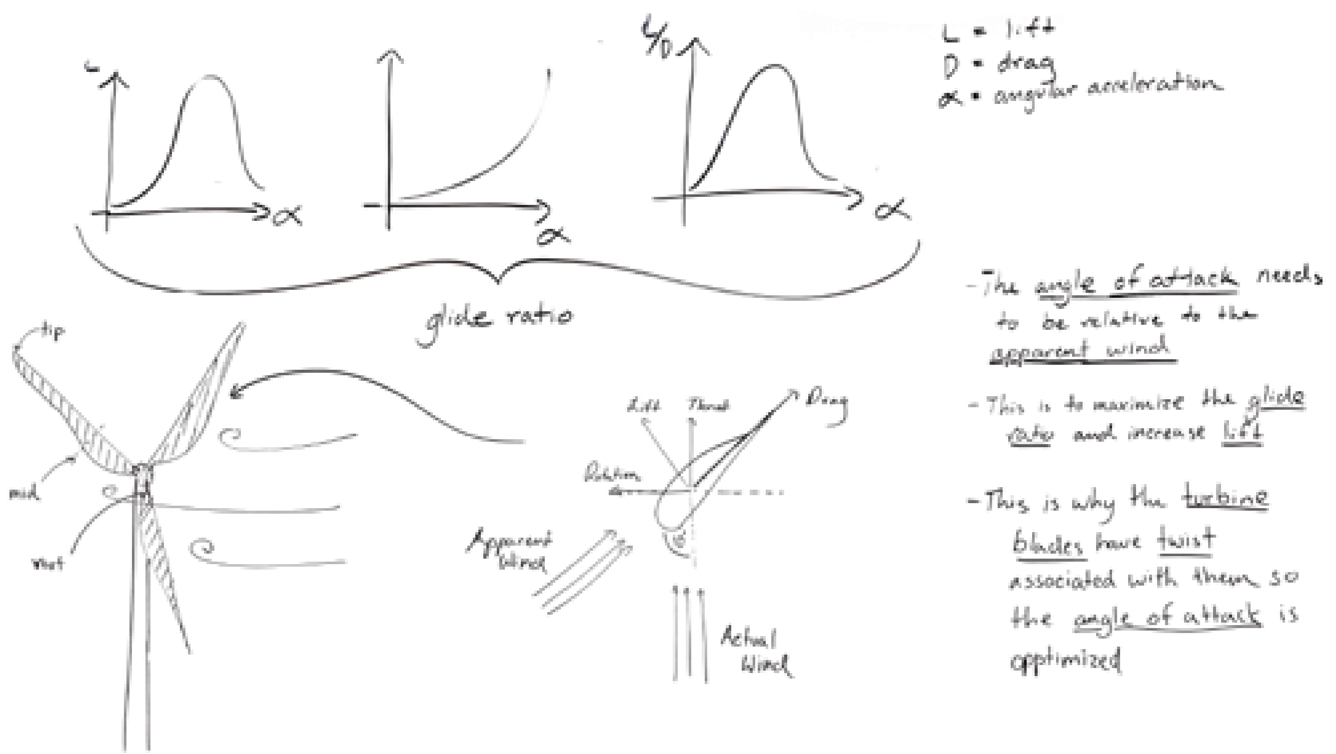
Dr. Jacquelyn Nagel

Our team aims to design and develop a climate adaptable solar energy system. The objective of our project is to increase the level of energy production of solar panels by regulating the system's internal thermal energy. Solar cell efficiency drops as the system's internal thermal energy increases. To improve efficiency, our team draws inspiration from lichen. Lichen is a symbiotic partnership between two separate organisms, alga and fungus. We plan to use this relationship to influence our design choices and increase solar energy production.

The team testing different types of pump's abilities to pump antifreeze.

The team discussing how to use the PLC controller to record temperature.

COLLEGIATE WIND COMPETITION 2023



Sketches created by the team.

TEAM

Austin Zicafoose
Nicholas Gartner
Brandon Landes
Alexander Ziemke
Yazeed Salameh
Josh Savage
Mari Wari
Joseph Scully
Jack Williams

ADVISING

Dr. Keith Holland

The Collegiate Wind Competition is a nationwide competition held by the U.S. Department of Energy open to undergraduate students. The competition contains three different categories. Our team's main focus is the turbine prototype contest where our goal is to create a small scale wind turbine that adheres to a set of requirements drafted by the Department of Energy. The prototype is then judged on its ability to produce power as well as further dynamic parameters set each year. Our team also works with other departments to create a site plan, which includes a financial analysis and environmental impacts section. This allows the Engineering department to work with the business department and compete in the project development section of the contest. Lastly, our team competes in the connection creation contest which tasks the teams to raise wind energy awareness in our community and promote our team's accomplishments. In May of 2023, our Collegiate Wind Competition team will travel to New Orleans to compete and present to a panel of judges. An overall winner is chosen which takes into consideration all 3 aspects of the competition as well as a turbine prototype winner. Within the Engineering department, our team consists of nine members and one academic advisor. We are honored to represent JMU in this contest and we will strive to make the Engineering department proud, while learning valuable lessons along the way.

The 2023 JMU Collegiate Wind Competition team works in the classroom to understand key wind energy concepts.

DUKES OF STEEL

Pieces of steel used in the team's project.

TEAM

Maggie Bouch
James Stopa
Patrick Kaczmarek
Raylen Jones
Timothy Hunter
Gabe Hindle
Ryan Groel

ADVISING

Dr. Daniel Castaneda
Dr. Heather Kirkvold

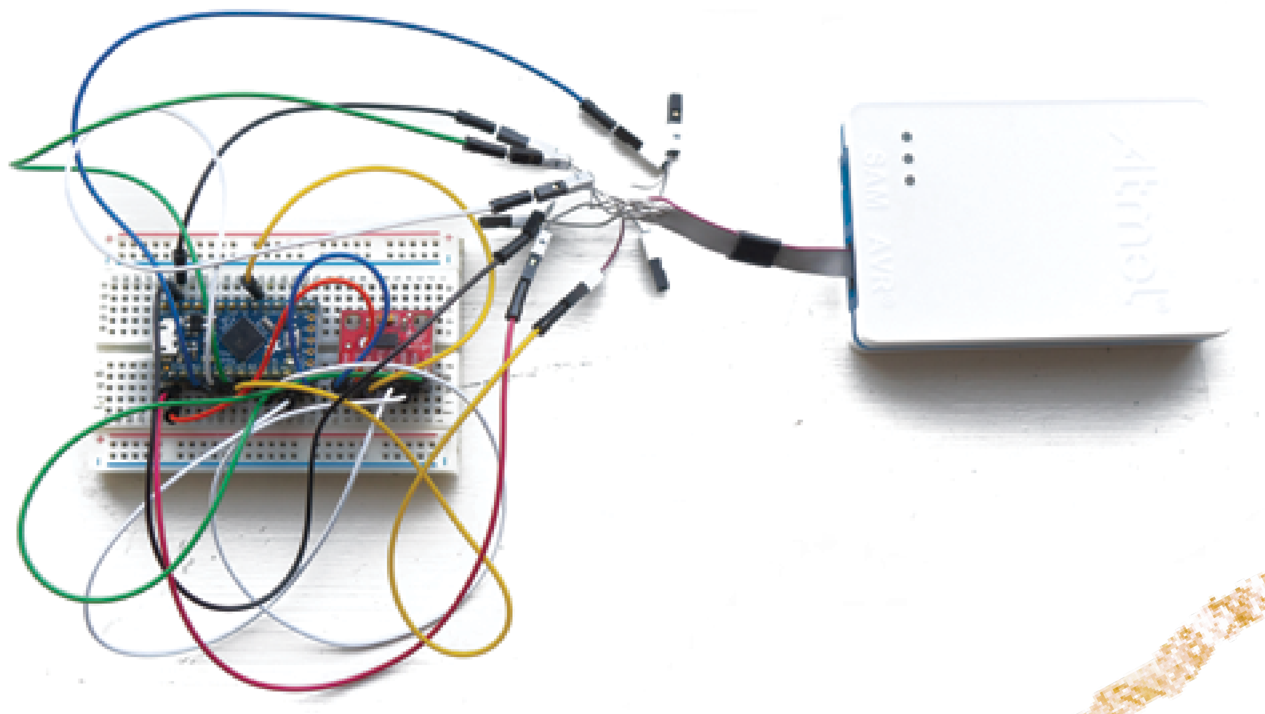
SPONSOR

Shickel Corporation

The Student Steel Bridge Competition (SSBC) is hosted annually by the American Institute of Steel Construction (AISC) and American Society of Civil Engineers (ASCE). The competition challenges students studying structural engineering topics to come together in teams to design and fabricate a scale model steel bridge. The prefabricated bridge segments are brought to the competition where teams from all over the Commonwealth assemble and load test their steel bridges in front of a panel of judges. Student teams are provided with a detailed list of constraints, and the overall experience offers students the chance to explore bridge designs and construction techniques typically practiced in structural engineering fields. The Junior Team is apprenticing the Senior Team's bridge building efforts. Generally, the Junior Team is learning about structural engineering software like AutoCAD, Solidworks, and SAP2000 for the design and structural analysis of the bridge they will be building next year. For this year, the Junior Team is focused on designing and fabricating transportation boxes to carry the steel members from JMU to the competition location, as well as benchmarking and prototyping designs for next year's competition and learning fabrication skills such as welding.

A team member demonstrates the proper form during the team's welding training.

EMBEDDED SYSTEMS



Potential sensors to be used for prototype.

TEAM

Olivia Bucciarelli
Dylan Gnagey
Thomas Wasylenko
Justin Blevins
Ritavash Chowdhury
Michael Chung

ADVISING

Dr. Jason Forsyth

The goal of the Embedded Systems Capstone team is to design a wireless and/or embedded system. An embedded system is a computer network that has various sensor systems integrated together with storage, processing, and energy requirements. The team was divided into two to explore different areas of interest to sense, collect, transmit, and analyze data.

One of the areas being addressed is monitoring hydration levels in individuals with dementia to alert in the case of dehydration, promoting the highest possible cognitive performance. Even mild dehydration can impair cognitive functionality and has been shown to be a major contributing factor to the cognitive decline in those with dementia. As humans age, they have a challenging time sensing that they are dehydrated. People with dementia have an even more challenging time because of their lessened cognitive functionality. The goal for this project is to create a proof-of-concept prototype with major components and within wearable housing that can monitor hydration levels continuously and alert in the case of dehydration to inform the users. Hydration levels will be measured using bio-impedance analysis. When dehydration occurs, the blood becomes more concentrated, and a bio-impedance test measures the concentration of the blood to determine hydration levels.

The second area of interest is the improvement of bench press posture for lifters. It was reported in research by the British Journal of Sports Medicine that around 50% of all reported pectoralis major tendon injuries occur during a bench press exercise. Without proper form there is an even greater chance of injury as this rupture occurs during the maximum eccentric contractions of the exercise, when the barbell is coming back down towards you. The team aims to design a prototype that will help lifters practice proper form by providing them feedback based on data collected from their posture, which will help reduce the risk of injury.

The dehydration team researches bioelectrical impedance analysis (BIA) while the posture team reviews and shares articles found on bench pressing.

FOOD TRUCK FOR THE MIND

TEAM

Trevor Ferares
Christopher Canonica
Mason Horton
Riley Allison

ADVISING

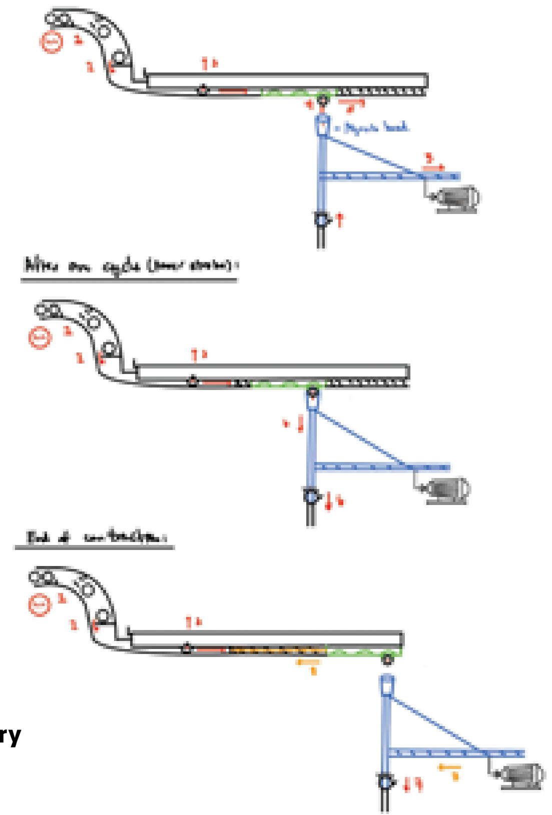
Dr. Steven Harper

In the United States, half of the high school graduates who have interest in Science, Technology, Engineering, and Mathematics (STEM) are not proficient in the skill sets necessary for these fields due to a lack of educational engagement. The STEM educational trailer will focus on spreading STEM awareness through the use of educational displays. The interior of the trailer will be modular and allow for different educational modules to be placed within. The first module will focus on the brewing process, educating participants on the involved chemical processes, basic electrical theory, physics, and architecture. The senior team has successfully put up the walls of the trailer and is on schedule to finish construction on the roof by the end of the spring 2022 semester. Our team will be responsible for the electrical schematics of the trailer and all interior design including flooring, displays, and lighting. The current focus of our team is to design a steel platform, welded to the frame of the trailer, to store the generator while traveling to different sites. Having just begun this project, there is much to be completed, but the team is eager to begin working towards a completed trailer.

Team members Riley Allison (front), Trevor Ferares (right), Christopher Canonica (left), and Mason Horton (back) take a break from building.

Trevor Ferares measures the trailer walls.

INTERACTIVE BIOPHYSICS MACHINES



A sketch of a concept for an interactive machine to show the Sliding Filament Theory of muscle contraction.

TEAM

Jacob Brothers
Alex Sedley
Collette Higgins
Mason Ong

ADVISING

Dr. Callie Miller

The Interactive Biophysics Machine junior team is continuing to focus on the intersection of biophysical concepts and interactive STEM education methods. Our team hopes to connect with students in 4th-6th grade in Harrisonburg, Virginia and the surrounding Rockingham County to generate interest in STEM topics and fields. Building off of ideas in hands-on learning, our team intends to design and build an interactive display to show and explain the process of muscle contraction, i.e. the Sliding Filament Theory. Our prototype will be displayed at the Rockingham County Fair in August 2022, along with the senior team's current work. Together, the 3 displays and lessons created by the senior team, and our display will describe how the nerve signals from the brain travel through the body, through cells, to create mechanical movements in the muscles, culminating in a demonstration of live electrical signals in muscle cells causing a robotic arm to move. Our team anticipates future use of the interactive machines in workshops at local schools and organizations to further the outreach efforts and expand the population of students reached. This capstone will have implications when addressing an identified lack of interest in STEM topics for the targeted age range by encouraging the interaction and visualization of traditionally lecture-based biological concepts.

Our team presenting updates to each other.

NASA SLI JUNIORS

TEAM

Hemant Patel
Finn Otto
Grace Klein
Tyler Emory
Matthew Caulfield
Hanim Ibrahim
Aakash Girdhar
Patrick Foreman

ADVISING

Dr. Keith Holland

The NASA Student Launch Initiative Competition, hosted by NASA in Huntsville, Alabama, is a student led and student organized capstone project. The capstone involves designing, simulating, building, and launching a high-power rocket capable of reaching 5,000 feet with a desired payload. The aim of this project is to learn and apply Aerodynamic principles and concepts to physical design and simulations, providing verification and justification alongside results. Marking the second year for JMU being a part of competition, the team hopes to continue to build the foundation to inspire future students to pursue rocketry and advance the understanding of aerospace engineering at JMU. As of now, the team is working towards finalizing their proposal and learning rocketry skills and principles through small-scale models and simulations. This will help the team as they prepare for the 2022-2023 competition and launching their full scale high-power rocket!

Members of Junior NASA launch team mounting model rockets to prepare for flight.

Finn Otto and Matt Caulfield inserting a starter into the motor that ignites the motor for launch.

OFF-ROAD TRAILER

Members studied floor plans prior to creating their own.

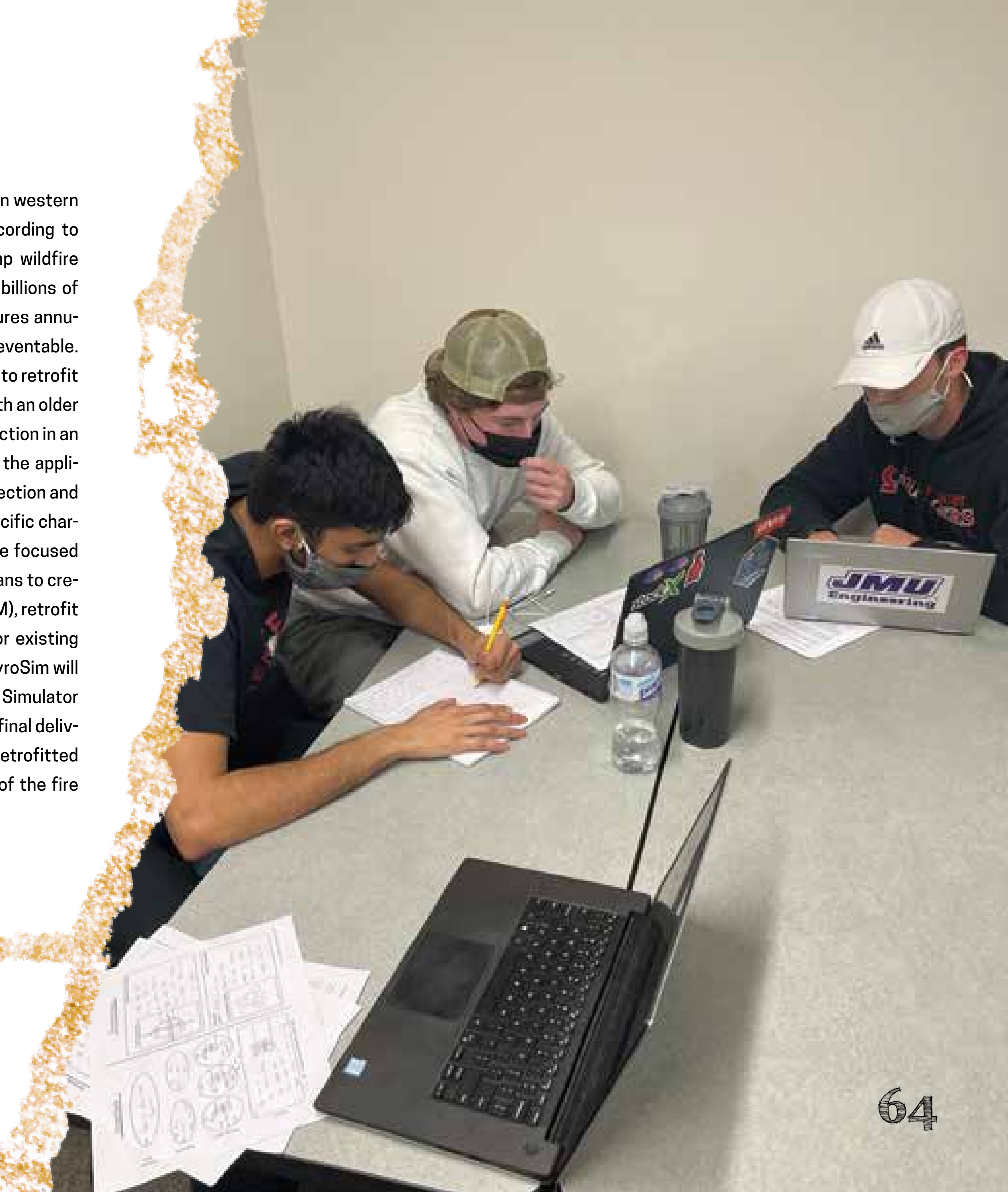
TEAM

Hayden Hunter
Nicholas Colavita
Manav Mehta

ADVISING

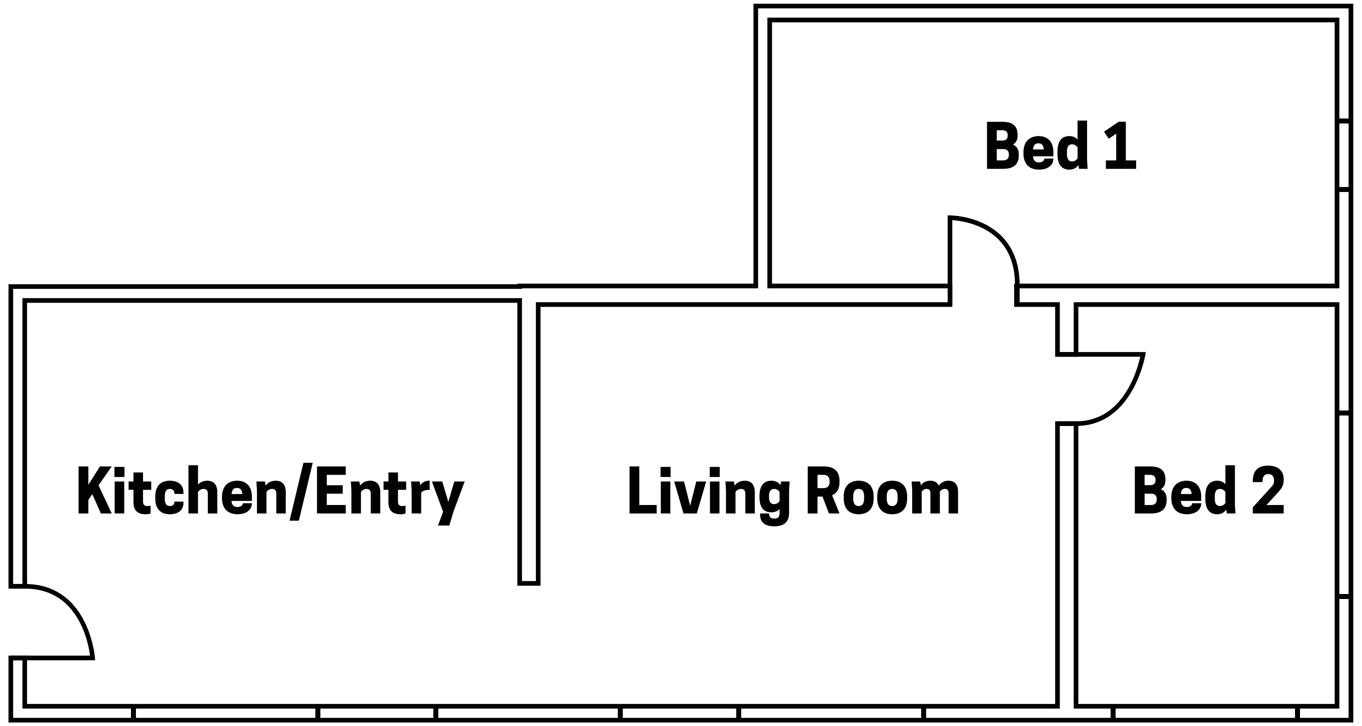
Dr. Heather Kirkvold

Wildfires destroy thousands of buildings each year in western United States including California and Oregon. According to Headwater Economics, in 2018 the California Camp wildfire alone destroyed over 18,000 buildings and caused billions of dollars worth of damage. Fires destroy more structures annually than any other natural disaster, and fires are preventable. This project includes performance-based fire design to retrofit a commercial or residential building that was built with an older fire building code to increase the building's fire protection in an event of wildfire. Performance-based fire design is the application of science and engineering to design fire protection and life safety systems in buildings, considering the specific characteristics of the building. Initially our project will be focused on creating floor plans, and then using those floor plans to create a model. Using Building Information Modeling (BIM), retrofit designs will be developed to reduce fire damage for existing homes in fire-prone areas. To evaluate the design, PyroSim will be utilized to port the CAD model into Fire Dynamic Simulator to test the design before and after the retrofits. Our final deliverable will be a Building Information Model of the retrofitted building, along with building blueprints and a video of the fire simulator in action.



Members planning their trailer.

PRINCIPLES OF EARTHSHIPS



Blueprint of a Potential Earthship.

TEAM

Caitlin Chamberlain
Juliana Cruz
Rachel Cole
Zachery Scheuer
Owen Plimpton

ADVISING

Dr. Justin Henriques

By definition, an Earthship is a passive home built upon six principles necessary for a harmonious life on earth: Food, Energy, Clean Water, Shelter, Garbage Management, and Sewage Management. These homes are made out of upcycled materials, can harvest energy and water from its environment, grow food, and manage waste all on its own. With the rise in emission and pollution all over the world solutions such as earthship are becoming more attractive. These eco-friendly and sustainable pods are designed and constructed to be self-sufficient and made with green materials.

Our capstone is focusing on creating a small-scale model that encompasses four of the six characteristics of Earthships; water and energy harvesting, repurposed materials, and passive heating and cooling. This model will be designed based upon specific environmental requirements provided by a stakeholder and their location. By April 2023, our team will be presenting this model in hopes of sparking awareness for more sustainable living practices.

The Earthship Capstone Team is analyzing a material to be used in the final prototype.

SHELL ECO-MARATHON JUNIORS

The vehicle with the wind shield assembled.

TEAM

Mitchell Roudybush
Robert Coleman
Luke Markus
Ryan Peacock
Jack Gavin
Kevin Denmark

ADVISING

Dr. Robert Nagel
Dr. Rob Prins

SPONSOR

Royal Dutch Shell

The Shell Eco-Marathon is a global competition challenging university teams from around the world to see who can create the vehicle with the highest fuel efficiency. While there are different propulsion and vehicle classes, the JMU supermileage teams have a vehicle that has been passed down over the years designed for the prototype vehicle, internal combustion engine class. The 2023 Shell Eco-Marathon competition team is continuing to optimize this legacy vehicle. This semester's focus included research into first understanding the different systems onboard the vehicle, how they each individually function, and how they all work together. With a baseline of information on the vehicle built, the team moved towards seeking how the vehicle can be further improved allowing for a higher fuel economy. Much of the semester was spent identifying what factors contribute to fuel efficiency, and then modeling said factors so that vehicle performance could be analyzed at different conditions. Using this model and collaboration with the current senior team, we selected specific factors to focus our efforts on, such as rolling resistance, aerodynamic drag, and engine data acquisition. With models and information surrounding these factors, the team will be able to pinpoint where exactly the vehicle should be optimized for the time and resources that we have.

The team completes a test fitting with our soon-to-be driver, Jack.

SIBLING R. I. O. T.

TEAM

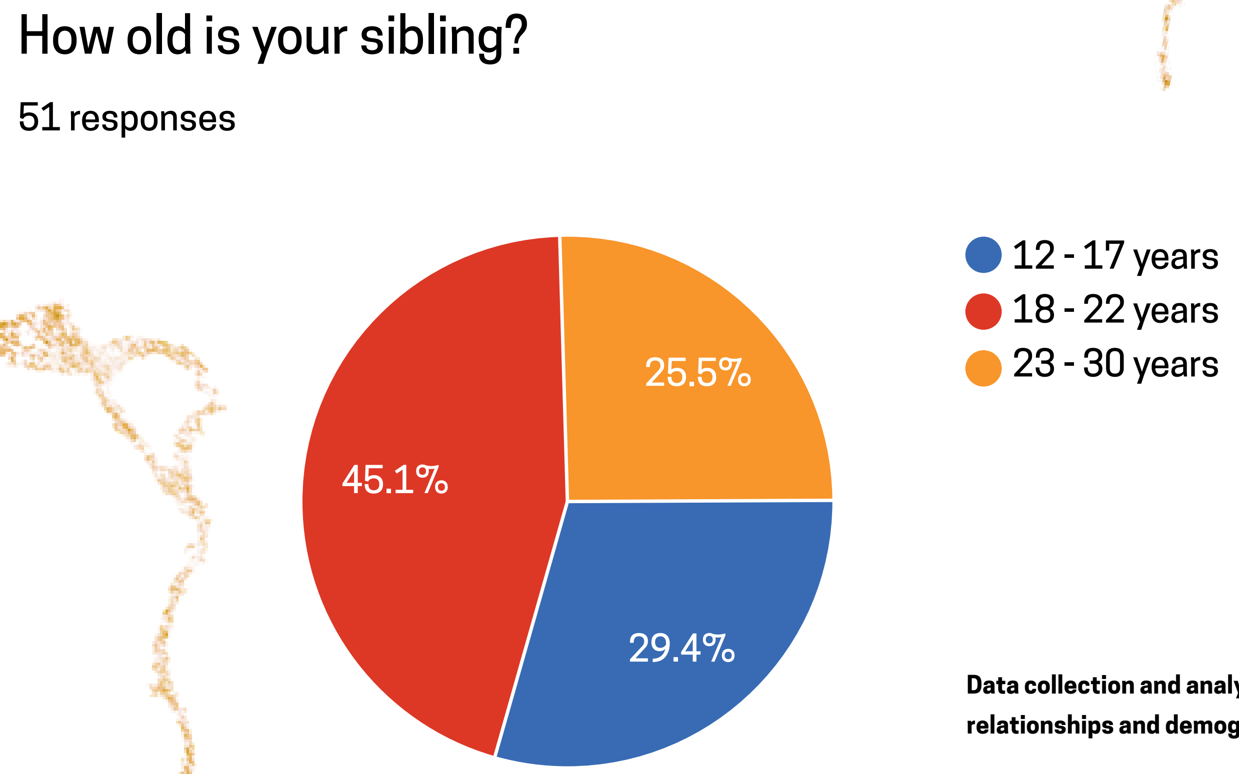
Jack Navarrete
Sherinne Zhang
Ondoua Chris Stevens
Tia Stamp-Querry
Matt Marini

ADVISING

Dr. Shraddha Joshi

The focus of our two-year capstone experience is to help siblings maintain and enhance connections when they are physically separated. More specifically, we are concentrating on the connection between college students with their siblings who are between their early teen years to adult years. We plan to design a product using the Internet of Things (IoT) technology to alleviate the pains of not being able to connect with siblings face-to-face.

IoT describes the network of physical objects that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. There are obstacles in today's world that prevent people from being able to see each other and experience moments of true connection that are only possible when they are face-to-face. This could be long distance, busy schedules, and even recently the COVID-19 pandemic. The team's goal is to use IoT technology to design a tangible device to allow for a more meaningful connection than video calls and texts provide. We plan to transition to establishing design requirements and starting the concept generation phase in our Spring 2022 semester. The final two semesters will consist of fabricating and testing our design to meet our stakeholder's needs.



Data collection and analysis of sibling relationships and demographics.

The team's personal sibling relationships led to this IoT Connection Inspiration.

STREAM RESTORATION

TEAM

Caleb Carney
Hailey Sauvageu-Shlaffer
Ayana Oancea
Cameron Traywick

ADVISING

Dr. Bradley Striebig

There are more than 3,500 miles of cold-water streams that contain wild trout populations in Virginia. Wild trout are an indicator of healthy watersheds and contribute to our quality of life. Trout also require exceptional water quality that is well oxygenated. Preferred stream habitat includes sand and gravel bottoms with very little silt. Pool habitat with woody debris and other forms of cover are also important habitat components. Our stream, Boone Run, is a tributary of the Chesapeake Bay Watershed located in the First Mountain State Forest in Elkton, Virginia. Boone Run is one of the few streams left in Virginia with native brook trout; however, man-made alterations to the stream have halted the natural migration of the brook trout. In the reach of Boone Run that we will be looking into, a culvert and wet ford have become clogged and damaged, mainly resulting in excess flooding and prevention of passage. Specifically, it has disrupted the natural flow of the stream through creating pools and causing the channel to become braided, or broken off into multiple channels. These harm the local ecosystem as the banks became steeper which causes excess erosion of materials such as phosphorus and nitrogen that contribute to eutrophication and depletion of oxygen. Additionally, the steep banks and shallow areas reduce the availability of habitats for aquatic life. To approach these issues, the team will be using the ten phases of Natural Channel Design and the guidance of the local Massanutten Chapter 171 of Trout Unlimited and Department of Forestry.

Culvert pipes used for aquatic organism passage that will need to be replaced along with adding a bridge across the top of the culvert.

Team members at Beaver Creek learning about the natural process of streams and riparian ecosystems with the Senior Beaver Creek Restoration team and Trout Unlimited.

DELIGHT

SOPHOMORE

CONSERVATION EFFORTS FOR LEATHERBACK SEA TURTLES

ADVISING

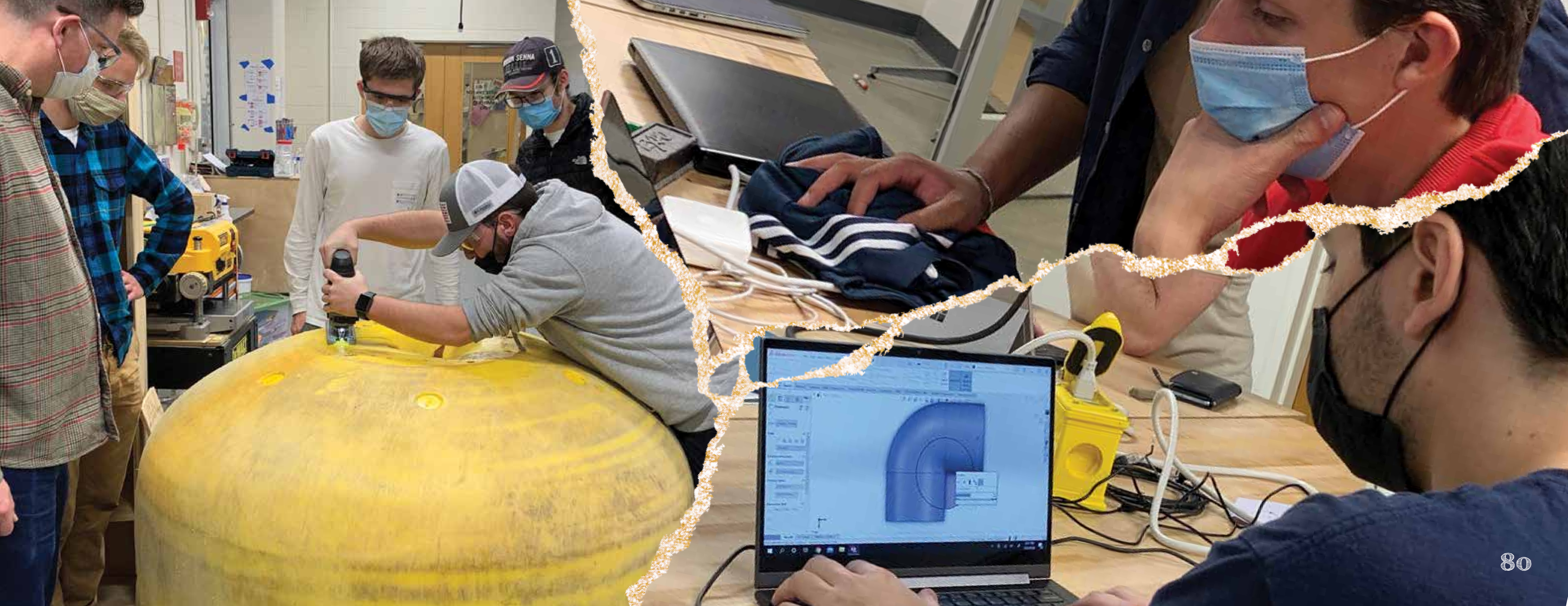
Dr. Robert Nagel
Dr. Jason Forsyth

How might we positively impact conservation efforts for leatherback sea turtles?

Ask any of our Madison Engineering sophomores, and they might say: the answer lies in being able to deploy sensing equipment off-shore for remote monitoring, data collection, and transmission—a goal our students have been working steadily toward since August 2020 with Northrop Grumman Corporation and Madison Engineering alumni, Joshua Kay and Farrell Bojarski.

Sophomores over this past academic year have focused on designing our second-generation system of extensible buoy platforms. Our sophomores' buoys have capabilities for energy harvesting and storage, data collection and storage, networking and transmission. The final deliverables will be usable by organizations in Melbourne, Florida to understand leatherback sea turtle migrations. The overarching goal is to explore off-the-shelf components to create low-cost options accessible and applicable to a wide range of conservation and monitoring applications.

Guided by Dr. Forsyth and Dr. Nagel, students have worked together to create and test three buoy systems, one per class section, that network and communicate with shore. Within each section, students have worked as sub-teams with each focused on 1) energy harvesting and storage; 2) networking and transmission; 3) data collection and storage; and 4) buoyancy, stability, and environmental conditions. To manage this project, students are organized to have engineering leads for each section, each sub-team, and each major engineering task. Through this design experience, students have learned engineering design processes, tools, and management while working remotely and engaging with Northrop Grumman engineers from across the nation to create final designs applicable to real world conservation needs for real world clients.



KINTSUGI

Kintsugi (“golden joinery”), also known as kintsukuroi (“golden repair”), is the Japanese art of repairing broken pottery by mending the areas of breakage with lacquer dusted or mixed with powdered gold, silver, or platinum; the method is similar to the maki-e technique. As a philosophy, it treats breakage and repair as part of the history of an object, rather than something to disguise.

- From Wikipedia

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