2025 SENIOR DESIGN Expo

THE UNIVERSITY OF MEMPHIS
Herff College of Engineering

FROM THE DEAN

Welcome to the Herff College of Engineering 2nd Annual Interdisciplinary Senior Design Expo. I'm proud to present this booklet that exemplifies the hard work and dedication of Herff's budding engineers.

I would like to thank the faculty for their support to these students. I also appreciate the support of our industry partners. Please, take a few moments to read about the innovative ideas and projects that these students produced, and you will be just as hopeful as I am about the future of our city, region, country, and world.

The future is bright. The future is Herff.

Dr. Okenwa Okoli

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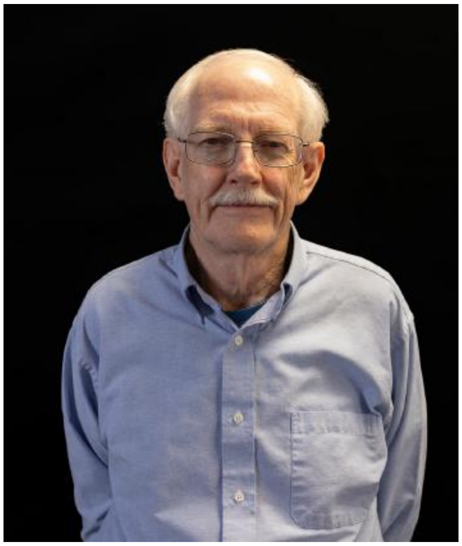
BIOMEDICAL ENGINEERING



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Ankle Architects

Total ankle arthroplasty (TAA) replaces damaged ankle joint components with a prosthetic implant to restore mobility in patients with severe arthritis. Traditional procedures require a large (~125 mm) anterior incision, leading to significant soft tissue damage, and prolonged wound healing. There is a need for a minimally invasive surgical (MIS) approach to shorten the healing time of patients undergoing TAA. However, Stryker's existing Prophecy talar cutting guide does not fit within the smaller (~65 mm) incision required for MIS. To address this, we aim to develop a new cutting guide system that performs accurate bone resections through a smaller incision.

Our device is a patient specific cutting guide that utilizes 3D bone models created using CT scans of the patient. The device combines the current tibial and talar cutting guides into a singular cutting guide. The combined cutting guide is not only smaller to accommodate the smaller incision but also cuts down on material to build it since it is singular device instead of two and is smaller for the minimally invasive approach.

The demand for total ankle arthroplasty (TAA) is growing, with annual procedures increasing by 136.1% from 2009 to 2019, particularly among patients aged 54 and older. This innovation can improve patient outcomes, reduce post-operative complications, and advance ankle replacement techniques. Additionally, it supports Stryker's goal of optimizing orthopedic surgical procedures and expanding the use of MIS in ankle arthroplasty.

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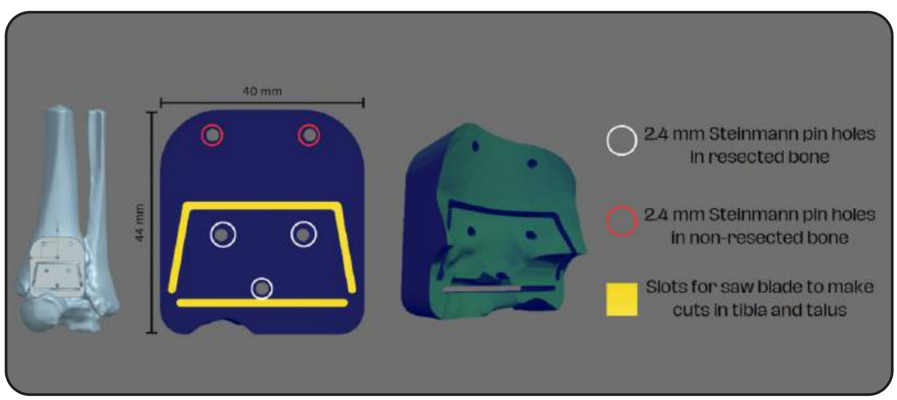

Patient specific cutting guide for total ankle arthroplasty with slots to make bone resections on the tibia and talus and pin holes for 2.4 mm Steinmann pins to fix the guide during surgery. The image on the right shows the posterior of the guide that has been modeled to match the patient's anatomy. The middle image shows the anterior of the guide that surgeons will use to place pins and make bone resections. The left image shows the guide placed on the bone model.

Back In Action

Scoliosis is a spinal deformity characterized by abnormal lateral curvature and coronal rotation of the spine. The American Association of Neurological Surgeons reports that the most prevalent type of scoliosis is adolescent idiopathic scoliosis (AIS), comprising approximately 80% of all pediatric cases in the U.S. Many patients with AIS also have kyphosis and/or lordosis, which are excessive curvatures of the spine in the sagittal plane. If left untreated, AIS can lead to significant complications, including chronic pain, respiratory issues, and impaired physical function. Currently, correction of AIS requires extensive instrumentation and multiple surgeons, increasing surgical complexity and hindering efficiency. Additionally, most correction instruments fail to simultaneously derotate, distract, and compress the spine. Spine surgeons need a way to perform en bloc three-dimensional spinal deformity correction using one hand that minimizes surgical time and the weight of surgical equipment in AIS cases.

Our design features vertical towers that attach to pedicle screws, interconnected with horizontal adjusters, enabling simultaneous derotation, compression, and distraction of the spinal deformity. The towers converge at a single handle, which is attached at a 30° angle to not block the surgeon's line of sight. The handle allows for derotation of the spine and correction of rib protrusions with one hand. All attachments are connected via a rail system to facilitate their ease of attachment and detachment. The towers attach directly to the ModuLeX shanks

Our device aims to improve surgical efficiency of spinal deformity correction for patients with AIS. It addresses the unmet need for one-handed, simultaneous 3D correction of scoliotic deformity, while also introducing a new innovative design for shank-based correction ability. This streamlined surgical process would allow spine surgeons time to treat more patients and expand their care to underserved communities. Additionally, patients post-AIS surgical correction will have increased quality of life due to alleviated pain, improved physical function, and enhanced self-image.

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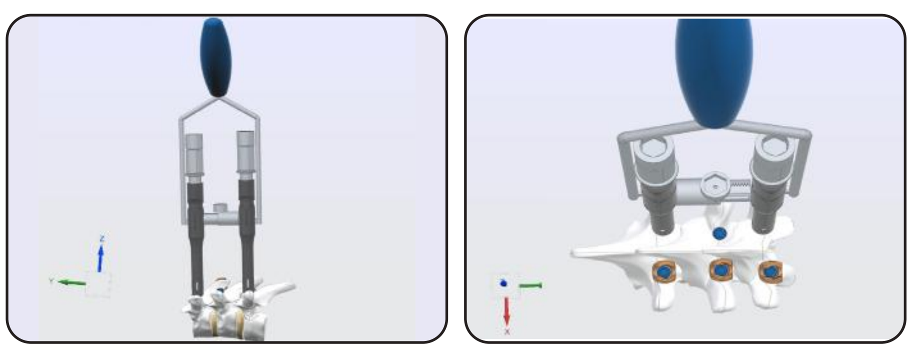

Figure 1. Front view (left) and top view (right) of our fully assembled spinal deformity correction device.

Eye Eye Captain

Globally, the progression of eye diseases and conditions steadily increases. Common treatment methods rely on the use of eye drops, as they allow for quick administration of the medication and are portable. Patients who use eyedrops on a consistent or temporary basis have reported that over 50% have difficulty with administering eye drops properly. [Davies, 2017] Whether due to the eyedrop bottle design and ergonomics, a user's physical disability such as visual impairment or dexterity limitations, there are very few options available in the market to override a patient's difficult experience. The same study reports that approximately 90% struggle with misalignment of the bottle with the eye, instilling the wrong number or volume of drops, and experiencing sanitation/contamination problems that lead to infection. 80% of users fail to properly instill their eyedrop on the first try. This highlights a massive bridge between the poor eyedrop bottle device design and patients not adhering to treatment plans or experiencing the benefit of the medications. The problem lies in the lack of variety of devices that attend to common issues of aligning the bottle with the eye, inconsistent expelling of the drop from the bottle, and decreasing the amount of effort needed to use the device. With additional focuses on specific needs such as sanitation, ease of use, dosage accuracy, portability, and durability, this project aims to propose a viable solution to this current problem. By adding features such as alignment focal points, force-reducing levers, a Volume Reduction Tip (VRT), and antimicrobial materials, this device aims to increase compliance, reduce medication waste, and enhance user independence. Iterative design processes, risk mitigation, verification and validation methods, and anticipated social, environmental, and economic impacts of the device are detailed to reasonable expectations, highlighting this as a potential tangible solution. The product will be verified through testing, including force measurement at the bottle, cyclical testing for durability, volume of the drop, and other verification procedures. It would then be validated through a user observation and survey with input and output experiences noted.

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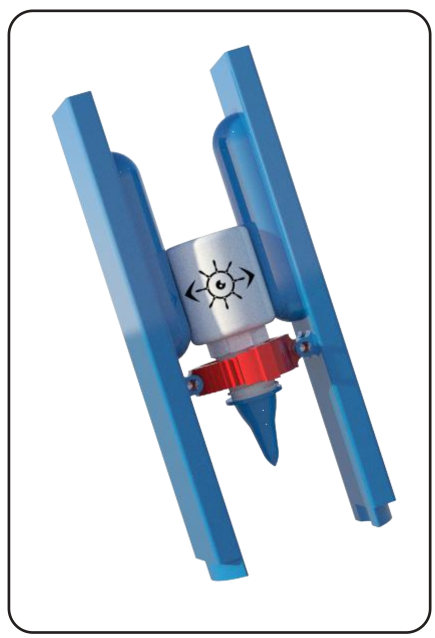

CAD rendering of Captain Droppy Eye Drop Aid Prototype

HeadBangerz

Epilepsy is a neurological disorder characterized by recurring, unprovoked seizures caused by abnormal electrical activity in the brain. It often results in loss of consciousness that inflicts traumatic head injuries (THI's) from collisions between the head and external surfaces or objects. Traumatic head injuries affect more than 2 million individuals in the United States. THI's pertain to concussions, maxillofacial facial bruising and injuries, and skull fractures with 64.4% of toddlers (ages 0-4) with seizure disorders seeking emergency care after falling. Current devices inadequately tailor to epileptic toddlers by retaining heat and weighing excessively. Thus, this increases the frequency of seizure episodes and ineffectively reduces the incidence of THI's. There exists a need for a better way to provide adjustability and protection against skull fractures during collisions of toddlers with seizure disorders.

The epileptic head trauma prevention device is essentially a helmet equipped to reduce the Head Injury Criterion (HIC)-the measure of likelihood of head injury from impact- for THI's by 78.1% compared to no protection and 29.3% compared to competitor products. The shock absorption layering of auxetic metamaterial and memory foam allows for a reduction in the acceleration felt across the coronal, sagittal, and transverse plane of the head. By manipulating the device's natural response to deformation at impact, the device utilizes auxetics 3D printed using polyurethane that contract when compressed at the point of contact due to the material's negative Poisson ratio. This simultaneously decreases the acceleration felt at impact and the prevalence of THI's.

This device aims to foster independence among toddlers with seizure disorders while remaining visually unobtrusive with a bucket hat design. The THI prevention device is meeting a critical need in the market for assistive devices for epilepsy by facilitating effective protection in everyday activities without the onset of additional seizures. Ultimately, this design seeks to make meaningful contributions by addressing unmet needs for the epileptic community through the introduction of a new innovative design for head trauma mitigation.

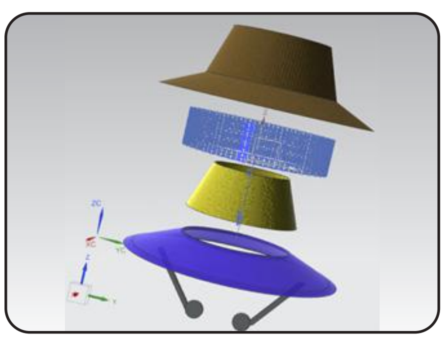

Fig. 1: CAD drawing of Epileptic Head Trauma Prevention Device [from bottom to top: adjustable chin straps, silk lining brim, memory foam, auxetic, outer weather resistant layer].

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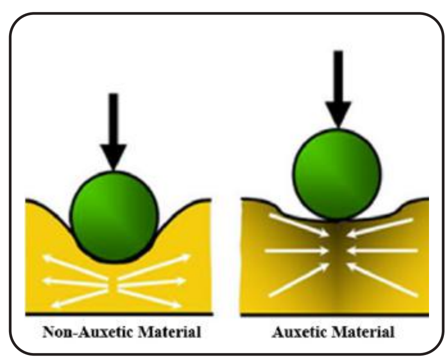

Fig. 2: Comparison between Non-Auxetic (left) & Auxetic (right) Materials under contact.

Magnifuse Graft Delivery

Magnifuse bone graft placement surgeries have been conducted via open procedures by surgeons. In this project, the goal was to create an instrument that could deliver the Magnifuse bone graft from Medtronic, see Figure 1, percutaneously (meaning small incision around 1-3 cm). Minimally invasive procedures have become more of a standard among surgeons as technology has advanced due to better patient outcomes. For posterolateral spinal gutter surgery where the Magnifuse bone graft is placed along the spinous processes, the current surgery involves a larger incision (10-12 inches). The goal of this project was to create a device that can prepare the delivery site and insert the bone graft percutaneously, with its placement be verified with fluoroscopy.

Our final design concept revolves around a main dilator body, seen in Figure 2, which the companion instruments can be inserted into the prepare the surgical site for graft delivery as well as allow for the delivery of Magnifuse. The other components of the delivery system include a bullet nose dilation tip that fills the hole in the end of the main body to allow for tissue separation, a decorticating disposable brush, and a flexible claw to guide and release Magnifuse in the desires location. This device also utilizes the percutaneous incisions made for rod and screw insertion. The main body of the device, dilating tip, and claw component will all consist of medical grade stainless steel for its ease of sterilization and longevity.

This instrument set ultimately allows for minimally invasive applications for the Magnifuse bone graft that originally could only be used in open procedure. The smaller incisions allow for better patient recovery and minimal scarring. The instruments also provide surgeons with one set of instruments that allows them to easily and effectively delivery the graft.

Figure 1. The Magnifus bone graft in various sizes and lengths.

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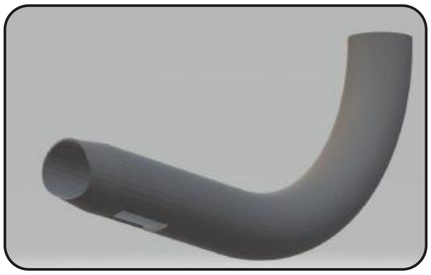

Figure 2. The main body through which the companion instruments are inserted and Magnifuse is delivered.

Sonic Bonecare

A delayed union fracture is defined by the FDA as a fracture that is at least 9 months old and has not shown any signs of healing for 3 consecutive months. A non-union fracture is defined by the FDA as a fracture that has no possibility of healing without intervention, in the opinion of a physician. One method to combat this problem, which affects around 10% of the, on average, 6 million bone fractures that happen yearly in the United States, is Exogen. Exogen is a device created by Bioventus that uses low-intensity pulsed ultrasound (LIPUS) to provide mechanical stimulus to fractured bones to promote bone production for people experiencing this. However, patients with non-union or delayed union fractures struggle with the current methods used to secure the EXOGEN ultrasound transducer and maintain proper alignment. Because of this, a more secure and comfortable alternative that ensures correct positioning and ease of use is needed. Our design is a compression sleeve with a circular port on its central surface. A silicone ring is attached to the inner surface of the sleeve surrounding the port which will aid in containing the ultrasound gel needed for the transducer. The port and lid are detachable and are assembled with the sleeve after the sleeve is put on by the patient. The sleeve is made of scuba-knit fabric, consisting of 90% polyester and 10% spandex, an elastic and durable fabric. While the port and its lid are made with acrylonitrile butadiene styrene (ABS). Our design addresses the shortcomings of Exogen's existing strap by providing a more stable, comfortable, and user- friendly solution. By improving transducer stability to the skin and improving the durability of the device, our compression sleeve increases the effectiveness of LIPUS therapy. With the ability to be used from recycled materials, it can also contribute to sustainability efforts. Additionally, the design reduces the need for manual gel application, minimizing gel mess and making the device unchallenging for patients.

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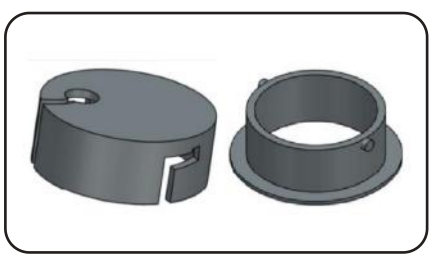

Figure 1: Initial rendering of port. Lid (left) and port (right). The top hole of the lid allows for the transducer wire to pass through. The L-shaped opening on the side allows the lid to slide down onto the port's two prongs and twist into place. The lip at the bottom of the port slides under the sleeve's port hole.

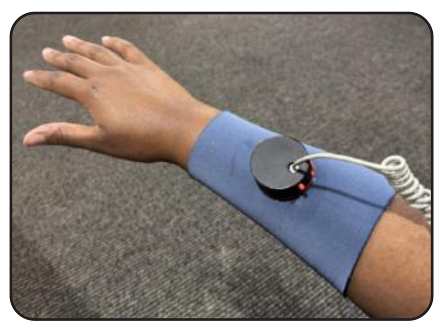

Figure 2: Sleeve, port, and transducer worn together. The sleeve provides better stability and ease of use than EXOGEN's strap, and the detachable port allows for easy cleaning of the fabric & plastic separately.

Super Sub-Q

Subcutaneous implants have become of particular interest due to their slow release of active ingredients and minimally invasive nature, but quick and efficient insertion has been difficult on animals of varying skin thicknesses, like rodents and bovine. Current devices, like the 3-piece trocar kit, work well for humans, yet fall flat when used on animals. Failure to reach the appropriate depth may cause the implant to be too shallow, reducing the drug's effectiveness and increasing the risk of rejection, or too deep, risking migration and may require surgery for later removal. We need a device that allows veterinarians to more safely, accurately, and quickly deliver subcutaneous implants with varying rigidities to animals with varying skin thicknesses.

The trocar is attached to a hollow base, where a horizontal rod sits in the inner lumen of the needle. The base is attached to a slider, which is locked in place until depressed and translated backwards. A cap with a funnel design at the tip is placed over the trocar for easier implant loading. The device works by loading the implant, adjusting the dial connected to the lead screw which moves the trocar mover to the desired height depending on the patient's skin thickness, inserting the trocar into the skin, and depressing then pulling the slider back. When the slider is pulled, the trocar retracts, and the rod within the needle stops the implant from leaving the skin.

The purpose of this project was to create a trocar that can be used on animals with varying skin thicknesses, as well as be useable with implants with varying rigidities. Our design enhances efficiency by improving the process of implanting subcutaneous implants across several skin thicknesses. This improves the ease of use for veterinarians and other users, ultimately supporting more consistent and reliable implant procedures.

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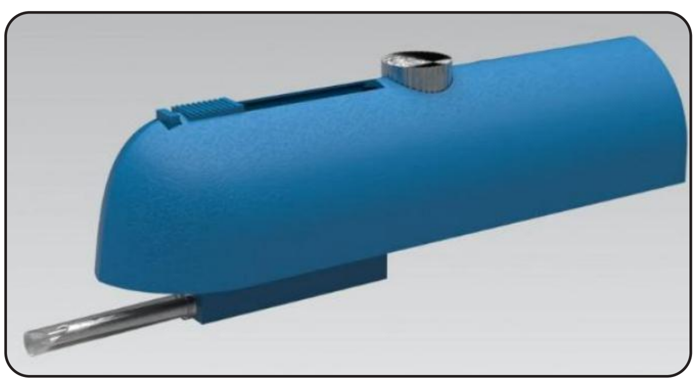
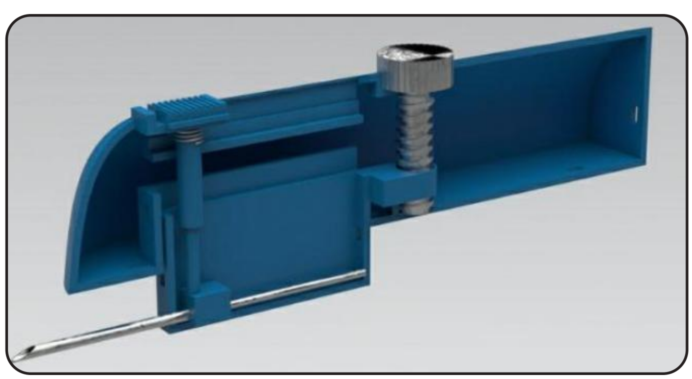
HERA HEALTH SOLUTIONS



Implantation device CAD model.



Cross sectional view of implantation device.

CIVIL, CONSTRUCTION, AND ENVIRONMENTAL ENGINEERING

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Banneker Solutions: Introduction

The Tennessee Department of Environment & Conservation (TDEC) has requested Banneker Solution to develop a solution to a dilapidated bridge located on a frequently trafficked trail in T.O. Fuller's State Park. The design of this recreational bridge in a state park looks to revitalize trail usage and connect a partnership between the state park and surrounding communities.

We encountered a leadership change during the initial phases of the project, which resulted in a budget reduction of $6,000. Additionally, the failure of the existing bridge accelerated the timeline, requiring a swift solution to restore accessibility to the trail and pathway. These challenges, combined with logistical difficulties in transporting materials and equipment to the site, coding constraints for a cantilever bridge, making a durable and safe bridge, and uncertainties regarding the function of preexisting manholes, required strategic problem-solving.

To adapt to the budget cuts, we revised the original design and re-engaged with the new park representatives to ensure alignment of the updated plan. Given the accelerated schedule, we leveraged a bridge design sketch provided by the structural team to expedite the process while maintaining structural integrity. Addressing transportation limitations, we opted for lighter and more cost-effective material that could be carried down to the site more easily. Additionally, to mitigate risks associated with the unknown manholes, we coordinated with the City of Memphis to identify any underlying utilities within the project area. Along with creating a safety plan and emergency contact list to make sure that protocols are in place for emergencies. A stormwater prevention protection plan to address pollution and or debris near the site area during the construction of the new bridge.

Despite these constraints, we successfully adjusted our approach to ensure a structurally sound and functional design that met both financial and logistical requirements. Through collaboration with key stakeholders and proactive problem-solving, we navigated the challenges efficiently, keeping the project on track while maintaining safety and usability standards.

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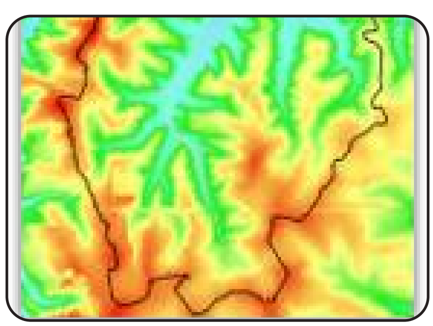
Photograph of existing bridge

Banneker Solutions: Modeling and Testing

The data needed for the design of the nature trail pedestrian bridge required a comprehensive approach integrating geotechnical, hydraulic, and topographic analyses to ensure stability and longevity. A cross-sectional survey was conducted to map the site's terrain and channel geometry, providing critical input for both soil testing and hydraulic modeling. Field and laboratory soil tests were performed to evaluate subsurface conditions and guide foundation design. Hydraulic modeling was used to analyze water flow, predict scour potential, and assess flood impacts. By correlating testing results with modeling outputs, we were able to give the design team the tools needed to address challenges associated with the site.

A history of erosion and concerns about slope stability posed significant risks to the long-term integrity of the bridge and its foundation. The presence of poor-quality, fine-grained soils with low shear strength and high compressibility further complicated foundation design. Additionally, limited LiDAR data constrained the accuracy of initial hydraulic modeling

Flowrates and velocities both through the channel and over top of the channel banks were needed to determine the possible forces applied to the proposed bridge. To estimate these values, a hydrologic model was developed using ArcGIS Pro, HEC-HMS, and HEC-RAS in coordination with historical soil and LiDAR data to determine the possible flowrates through the channel and over its banks during a 10 year-24-hour storm and a 25 year-24-hour storm. The water's velocity at any depth near the proposed bridge location did not exceed ~3.3 and ~4.4 feet per second respectively, and the water level would only exceed the proposed bridge by up to 6 inches in a 25 year-24-hour storm event. To address the challenges posed by poor soil conditions, helical pile foundations were selected to provide deep, stable support. Their screw-like design allowed for efficient installation with minimal soil disturbance, making them well-suited for the fine-grained, low-strength soils present on site. Additionally, a riprap system was incorporated along the embankments to mitigate future erosion risks, help dissipate water energy, reduce scour potential, and enhance slope stability. This combined foundation and erosion control approach ensures the durability and resilience of the pedestrian bridge.



Elevation Contour plot of the watershed

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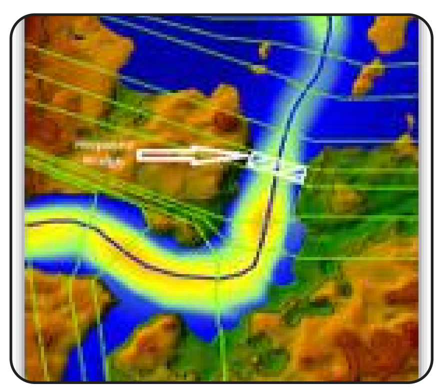

Water velocity map

Banneker Solutions: Design Phase

This project presented several challenges which were influenced by a reduced budget and the impervious soil conditions. Due to the budget reduction, we were challenged to discover alternative bridge designs incorporating materials that satisfied safety criteria, structural integrity, and long-term sustainability. Key obstacles included selecting foundations that were load-compliant and choosing appropriate structures. The team also had to price materials, create a logistics plan to mobilize, source laborers to complete the build, and make a construction plan for the project.

To draw inspiration for the design, the team reviewed the U.S. Forest Service design guidelines for ideas on which type of bridge best fits our site and design conditions. Coincidently, site visits were made to other regional parks, like Shelby Farms and Nesbit Park to access potential designs visually. After modeling the bridge in SketchUp and evaluating load combinations according to the U.S. Forest Service code, a preliminary design was created using the most affordable bridge foundations and struts our budget could ascertain.

For material pricing, we developed a comprehensive pricing sheet that quantified the projected material, allowing us to conduct a cost analysis. The mobilization planning presented delivery and rental options to receive materials for TDEC's consideration. Additionally, we provided cost-efficient all-terrain material transport designs to move materials from laydown areas to the construction site. Coordination with TDEC confirmed that this bridge would be volunteer-based construction, and the team utilized Workflow Manager to finalize a construction plan.

Nevertheless, the constraint, our team's resourcefulness, and strategic problem-solving facilitated the arrival of effective solutions. Consultation with our Senior Design Advisory, engineering professionals, and academic community enhanced our design principles and project execution. This approach allowed us to develop a structurally safe, high-quality bridge that naturally complements its environment through informed engineering judgment.

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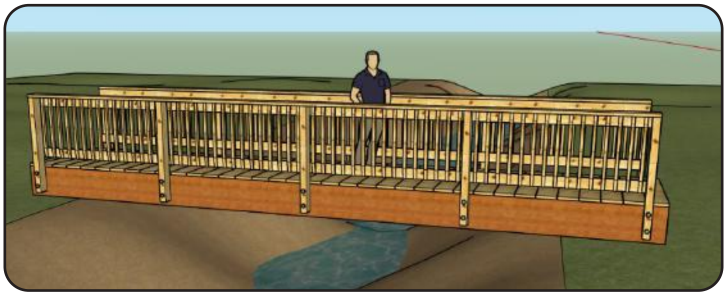

Rendering of proposed bridge

CIVILizers: Geotechnical

The CIVLizers have been asked by the management at T.O. Fuller State Park to submit a proposal for the design of a replacement pedestrian bridge in the heart of the state park. The bridge that is currently in place is deteriorated and unsafe to be used by the general public. As the geotechnical engineering-focused group, our focus has been on the foundational and erosion-related aspects of this project.

There are many challenges associated with this project, from a geotechnical perspective. These challenges include a high groundwater table, very soft soils, and excessive soil erosion. The high groundwater table presents a big challenge for this project because it makes utilizing concrete piers relatively expensive and unfeasible. The presence of soft soils can typically be mitigated on a normal site, however on a site such as a state park where accessibility is limited, the soft soils limit the bearing capacity of any foundation system used for the bridge. The ongoing erosion issue is the most visible issue on this site as there is extreme scouring under the near side of the bridge causing complete exposure and loss of bearing capacity of some support columns. All the site constraints that come with working in a state park make using common foundation methods difficult, but not impossible to execute.

Considering the constraints of a state park, we believe that we have come up with solutions that will provide a safer and longer-lasting bridge. Our first solution is to relocate the bridge to a location avoiding scouring issues from ongoing erosion, as well as providing options to mitigate the erosion with riprap, seeding, or other erosion control methods. The high groundwater table and the issues with soft soils can both be solved with the application of steel piles. These are a great option foundationally as the high groundwater table does not cause issues for these piles if they are rated for corrosion resistance, and they bypass the soft soils to get end bearing for the support columns in the denser soils below.

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Anna Nguyen

Soil Samples

CIVILizers: Hydrology/ Transportation

TO Fuller State Park and the Tennessee Department of Environment and Conservation have identified the need to redesign or relocate an existing footbridge. Located within a large Memphis watershed, the bridge spans a creek prone to seasonal flooding. Our sub-group of The CIVLizers will address hydrologic and transportation challenges and collaborate with the structural and geotechnical sub-groups to provide solutions that are supplementary to the overall final bridge design.

Challenges such as lateral loading must be analyzed to assess its impact on debris accumulation and flow dynamics. Since the bridge is located immediately downstream of a bend in the creek, the stream's sinuosity will influence flow velocity and erosion patterns. The creek contains debris that clogs the bridge opening, increasing hydraulic pressure during floods and raising the risk of structural damage. Bank erosion is exacerbated by high flow velocity and the bend's natural tendency to undercut the outer bank while depositing sediment on the inner bank.

After hydrological challenges are addressed and a new bridge location is decided upon with the other sub-groups, pedestrian transportation measures will be planned accordingly. This includes designing an elevated, accessible pedestrian walkway by preventing flood submersion while ensuring safe passage across the bridge in wet conditions. The proposed design includes calculating the necessary load requirements for pedestrian bridges, using slip-resistant materials to aid in pedestrian comfort across the bridge, and raising the bridge to avoid flood inundation. Hydrology calculations will be performed to determine flood elevations of different storm events at different points both downstream and upstream of the current bridge to aid in determining the most responsible location to place a potential new foot bridge. The computer software HEC-RAS will be used to conduct a flow profile of the site and determine velocity of flow at different sections of the stream to assess lateral loading of bridge foundations and determine appropriate structural members. Erosion of the bank and sediment transport will also be explored and modeled to properly identify which erosion control measures are most effective for this site. Potential impacts on aquatic habitats will be assessed using TDEC's guidelines for stream alteration.

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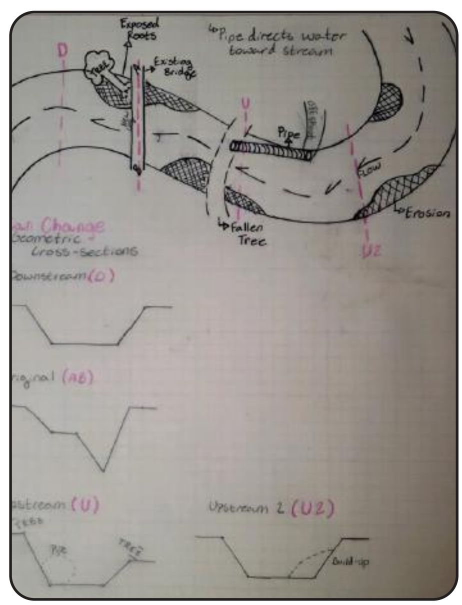

Sketch showing the water stream and areas showing signs of soil erosion

CIVILizers: Structural/ Construction

TO Fuller State Park is actively seeking alternative designs for a new pedestrian bridge that overpasses a water stream. The existing bridge is in poor condition due to issues related to flooding and debris impacts which, overtime, weakened the supporting piers. The existing bridge has been temporarily closed for safety concerns. TO Fuller State Park is looking for effective solutions to address these safety concerns and the various challenges presented by the site's remote location.

The frequent accumulation of debris around the foundation has increased structural strain, resulting in the leaning of the bridge supports. Additionally, the recurring flooding has exacerbated erosion around the supports, further undermining the integrity of the bridge structure. Considering these concerns, a comprehensive design is essential to enhance durability, improve resilience against natural forces, and ensure that the bridge remains a safe and reliable crossing for the future. This new design will examine the structural and construction characteristics of the current bridge, identify key deficiencies, and outline the necessary improvements for a more sustainable design. The remote location of the bridge will require designs to consist only of materials that can be carried by hand. The bridge will also be built using unskilled labor (i.e., volunteers), therefore, the simplicity of construction means and methods are sought.

Due to the flooding and collection of debris at the current location of the damaged bridge, the optimal placement is downstream where the span is shorter. With a shorter span, no intermediate supports will be needed within the water stream and hence less stream forces and impacts from debris will be required for design. The proposed bridge will have moderate bracing with deep foundations to counter hydrological and geotechnical forces. The design will consist of pressure-treated pine dimensional lumber, which is readily available and cost-effective. This softwood has a high strength-to-weight ratio, and the pressure treatment will help the wood resist natural decay in an area of high humidity. The bridge will be designed using dimensional lumber sizes that can be transported by hand to the site.

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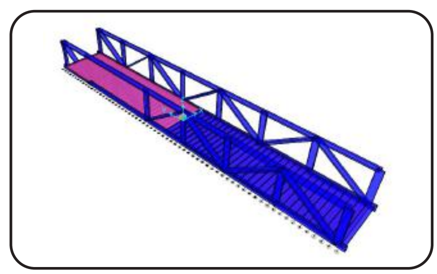
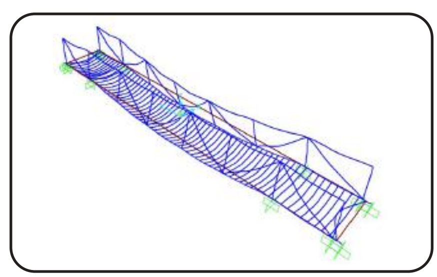


Bridge sap2000 finite element model



Deflected shape of bridge under live load

Congrats Seniors! 2025

ELECTRICAL & COMPUTER ENGINEERING

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Zeus 26

AC/DC

Power distribution networks are essential for delivering energy from power plants, hydroelectric dams, and nuclear sources to local communities and industrial sectors. However, these networks are subject to wear and tear, including issues like rust, transformer leakage, corrosion, wood rot, and more. After recognizing these challenges and engaging in thorough discussions with the local utility company, MLGW, as well as conducting extensive research on the subject, our team has decided to develop a solution to help companies monitor, detect, and maintain the functionality of these networks.

We call our innovation the MLGW Drone-Based Transformer Monitoring System. The objective of this device is to utilize spectral data and thermal imaging techniques to capture images of transformers and highlight potential damage. This monitoring system is intended to be fixed mounted onto a drone, offering feasible methods for inspecting transformers in hard-to-reach or hazardous locations.

The system utilizes mono cameras with bandpass filters, and one thermal camera connected to a Raspberry Pi 5. The Raspberry Pi 5 handles data processing and stores the processed data to an SD card. The captured image files from both thermal and grayscale cameras are then saved to a USB storage device for convenient data extraction. All files saved onto the USB drive will be both time-stamped and dated for both organizational and analytical purposes.

The sensor system features a remote control, allowing the operator to trigger an image capture remotely. The device can identify rust and overheating transformer bodies or connection points. This project aims to enhance the efficiency and safety of transformer and power pole inspections by providing a reliable solution for detecting potential damage in electrical infrastructure without close inspection. This device is intended overall to be a formidable maintenance tool for general upkeep of a city's power distribution system.

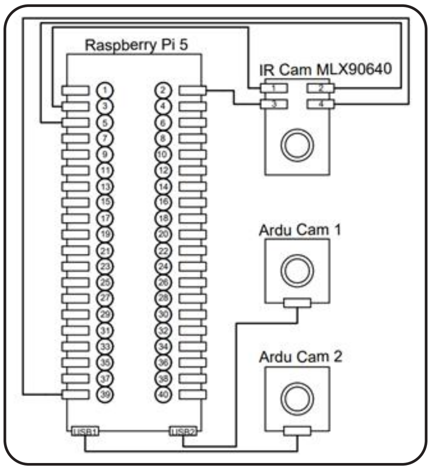

Figure 1. Schematic representation of the sensor system to be mounted on a drone for monitoring operational conditions of electrical transformers such as to identify rust, leakage, corrosion, and pole damage.

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MLGW

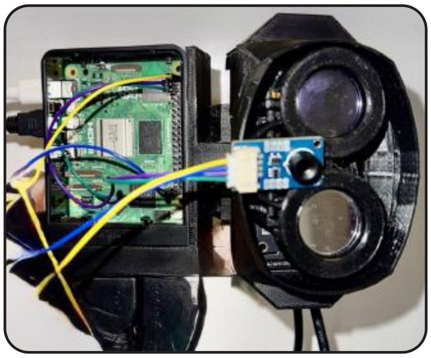
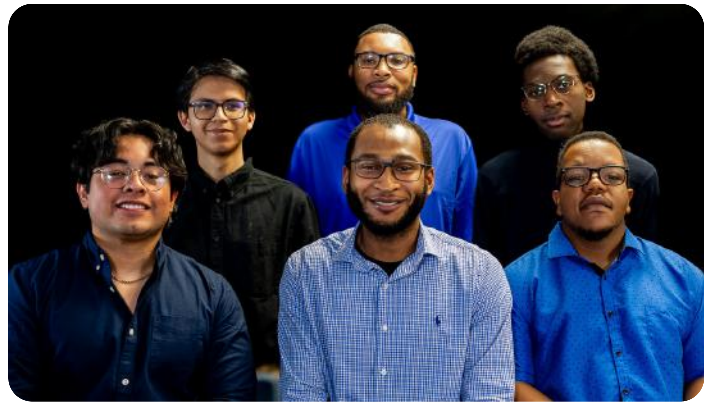


Figure 2. Protype of the sensor mount for drone-based transformer monitoring systems

Blind Innovations



The vision for our group's project is to make innovations in the current process of soil sampling, which is aimed to aid farmers and agricultural workers in their field. Success in this endeavor would lead to more bountiful, more efficient yields for the market. Our vision for this sampler would ideally assist in assessing the quality of soil, and to assist in maintaining soil quality due to additional foresight provided from sampling. We are concerned about the accessibility of current soil samplers. There are currently two paths for farmers to take regarding sampling: a manual soil sampler which is time consuming, and much more expensive samplers that are not fully automatic. To combat this, our goal is to innovate a fully automatic sampler for a robotic agricultural land vehicle and retrieve samples with minimal interaction.

Our current objective, for right now, is to design the mechanism of the soil sampler that will perform the digging during operation. It is one of our design requirements that the system is able to both dig into the soil and retrieve the soil sample while in operation. Ideally, our project will be able to dig its way through rough soil patches, as well as soil that gives way easily. Also, it would possess the ability to isolate and contain the soil that it digs up. This is to maintain the integrity of the sample and prevent opportunities for cross contamination.

Our user-friendly design shall provide a straightforward user interface, that takes very little practice to become familiar with. A simple, universally simple interface will cut down on the overall time spent retrieving samples. The overall vision for our project is all about time efficiency, cost efficiency, and simple effectiveness that gets the job done reliably, every time.

Figure 1: Prototype of the soil sampler

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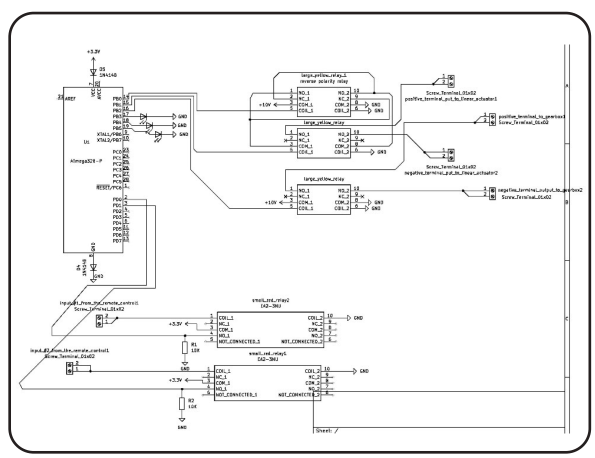

Figure 2: Schematic of the electronic control system in the soil sampler

Line Watchers

Efficient monitoring and maintenance of electrical infrastructure are essential to ensure continuous and reliable service to customers, safeguarding utility workers, and minimizing downtime due to equipment failures. Traditional manual procedures such as visual inspection are used for inspecting and managing utility pole components that are inherently labor-intensive, prone to human error, expensive, and inefficient. This reliance on manual inspections can delay essential maintenance operations, compromise worker safety, and lead to higher operational costs for utility companies such as our project's sponsor, Memphis Light, Gas and Water (MLGW).

As part of Memphis' initiative to update the electrical infrastructure in the Orange Mound area, MLGW sponsored our senior engineering project aimed at leveraging advanced artificial intelligence (AI) technology to streamline and automate the inspection process. The central goal of this initiative is the accurate identification and annotation of critical components on utility poles using aerial drone imagery and machine learning techniques.

This project specifically employs a Faster Region-based Convolutional Neural Network (Faster R-CNN), a powerful deep learning model known for its accuracy and speed in object detection tasks. The Faster R-CNN architecture was selected for its ability to handle complex image recognition tasks efficiently, which is ideal given the project's extensive image dataset. The model is trained and validated on an extensive dataset comprising approximately 30,000 high-resolution images captured by drones. These aerial images provide comprehensive visual data, including a multitude of various angles, lighting conditions, and backgrounds, ensuring the robustness and adaptability of the trained model.

The AI system developed through this project is capable of automatically detecting multiple utility pole components, including insulators, transformers, cross arms, fuses, and other critical assets. Each identified component is annotated clearly and precisely using bounding boxes, enabling straightforward visual interpretation and facilitating rapid analysis. By automating the identification and annotation processes, MLGW can significantly reduce the time required for inspections, dramatically increase data accuracy, and enhance overall operational efficiency.

Moreover, the insights and technologies developed in this project lay the groundwork for future advancements. This AI-driven approach can be further expanded to enable condition-based assessment of identified components, whereby the model could be trained to recognize wear, damage, corrosion, and other signs of potential component failure. Such capabilities would provide MLGW with even greater predictive maintenance power, allowing proactive interventions, further enhancing reliability, reducing maintenance costs, and improving the safety and efficiency of the utility infrastructure maintenance process.

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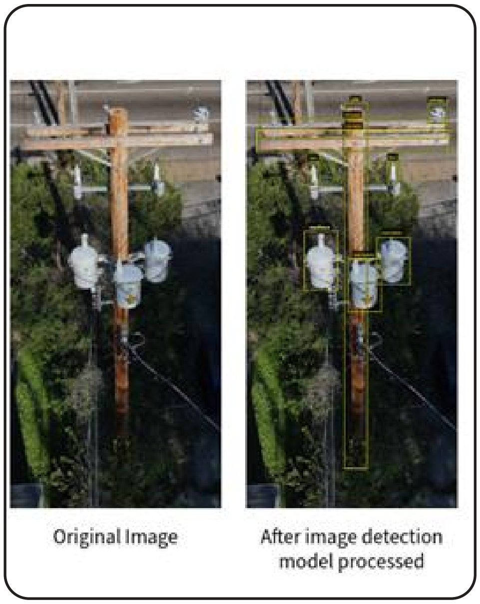
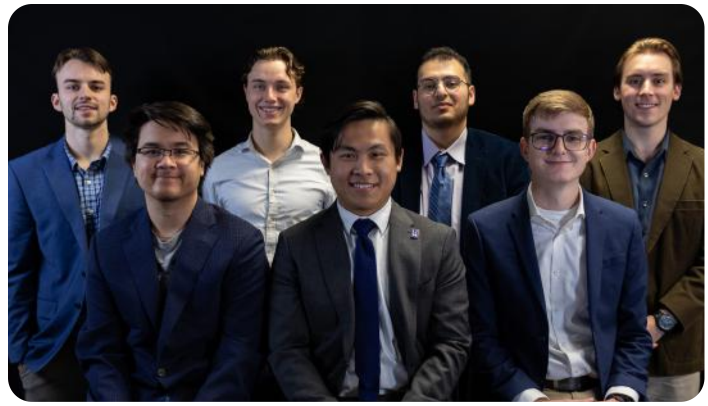


Figure 1. Example demonstrating detection of utility pole components using our deep learning system

Non-Playable Character



This project focuses on developing a versatile autonomous robot designed to locate, collect, and sort specialized materials within a controlled but challenging environment. Unlike many complex space-oriented missions, our primary goal here is to achieve robust functionality and reliability under constraints typical of terrestrial testbeds, competition fields, or future real-world applications. By integrating AprilTag-based navigation, the robot can accurately determine its position and follow prescribed routes, even when encountering partial obstructions or shifting lighting conditions.

Key subsystems include a mobility platform, sensor suite, and custom mechanism for real-time material sorting. The mobility platform relies on differential drive and a low-overhead localization strategy—using AprilTags placed at known field coordinates—to handle pathfinding without a full mapping stack. Meanwhile, the onboard sensors gather both navigation data and details about item positions to trigger the sorting action. Once the robot identifies its target material, it employs a compact actuator system to pick or push the items and deposit them into designated containers.

Throughout development, we conducted a thorough review of existing solutions, identifying the crucial balance between hardware simplicity and software sophistication. Specifically, we chose small, efficient motors and microcontrollers, allocating more processing overhead to high-level autonomy and error handling. This tradeoff allows the system to operate for extended periods while delivering reliable performance. Equally important, we established clear engineering requirements around energy consumption, safety, and maintainability. For instance, the robot includes fail-safes to prevent damage in the event of dropped communications or sensor malfunctions.

Initial tests in a simulated arena show that AprilTag-based localization and state machine logic can enable flexible switching among tasks (navigating, collecting, depositing) with minimal user intervention. By blending real-time image processing, methodical path execution, and streamlined mechanical design, the robot demonstrates a strong foundation for broader autonomous applications—ranging from indoor competitions to specialized industrial tasks. The resulting platform highlights the efficacy of modular design and targeted autonomy in tackling complex material-handling challenges.

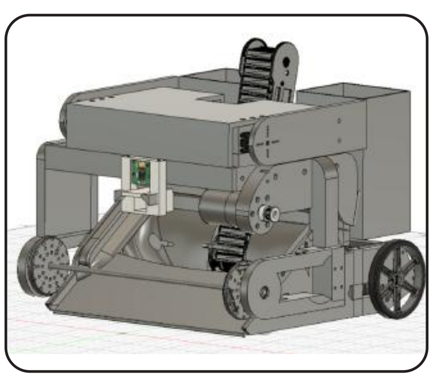


Figure 1. CAD design of the robotic system to locate, collect and sort specialized materials within a challenging and controlled environment

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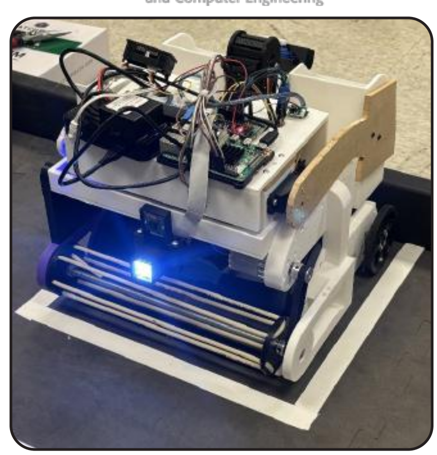

Figure 2. Prototype of the robotic system.

Ohminous Solutions

We have designed and developed an intelligent bi-directional energy controller utilizing a buck-boost converter for renewable energy applications. Our project implements an artificial intelligence (AI)-based controller that optimizes energy flow between renewable sources, battery storage systems, and the electrical grid, effectively managing the fluctuating nature of renewable generation. The global energy landscape is undergoing a profound transformation with renewable energy sources experiencing steady growth.

Wind, solar, and other renewable technologies now constitute a significant portion of the world's energy mix, driven by environmental concerns, declining costs, and supportive policy frameworks. However, the inherent variability and intermittency of these renewable resources present substantial challenges for grid stability and reliable power distribution. Energy storage systems have emerged as a critical solution, yet they require sophisticated control mechanisms to optimize their integration with existing infrastructure. The controller employs an AI algorithm to predict energy production patterns from renewable sources and demand fluctuations in the grid. This predictive capability enables the system to make real-time decisions regarding when to store excess energy in batteries and when to discharge stored energy back to the grid. The buck-boost converter topology provides the necessary voltage flexibility, allowing efficient bi-directional power flow regardless of the voltage differences between the renewable source, battery system, and grid.

Our design encompasses both hardware and software components. The hardware includes the power electronics circuit with the buck-boost converter, a battery energy storage system, and sensing equipment for monitoring voltage, current, and state of charge. The software component features an AI controller with iterative capabilities that continuously improve efficiency through operation. Testing under various simulated conditions demonstrates the system's ability to maintain grid stability while maximizing the utilization of renewable energy. The implications of this project extend beyond academic research, offering a practical solution for integrating increased renewable capacity into existing power grids, ultimately supporting the transition toward sustainable energy infrastructure.

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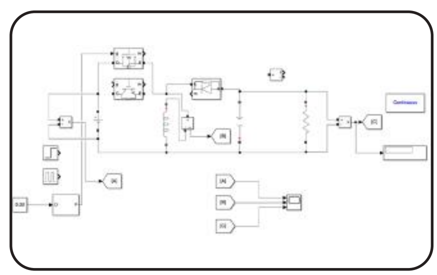

Figure 1. Schematic representation of the electronic control system for intelligent bi-directional energy transfer among renewable energy sources, battery storage systems and the electric grid.

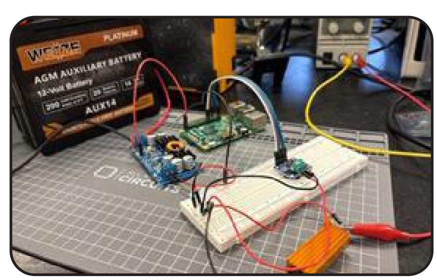

Figure 2. Prototype of the intelligent bi-directional energy transfer system.

Zeus

Electric vehicles (EVs) are becoming a widely adopted sustainable transportation solution, yet conventional charging methods rely on physical cable connections that can be inconvenient, prone to wear, and require dedicated infrastructure. Wireless charging technology offers a promising alternative by using electromagnetic induction to transfer energy from an underground coil to a moving vehicle, eliminating the need for physical connectors while maintaining efficiency and safety. This project introduces the Dynamic Underground EV Charger, a wireless charging system designed to improve the efficiency and practicality of EV charging. Unlike traditional systems, this charger incorporates real-time misalignment detection using a magnetic field sensor to optimize energy transfer. One of the primary challenges in wireless EV charging is ensuring precise alignment between the vehicle and the charging coil, as misalignment can lead to energy loss and reduced charging efficiency. Our system addresses this issue by continuously monitoring the receiver coil's position relative to the transceiver coil and adjusting power delivery accordingly. To enhance performance, ferrite shielding is integrated to minimize electromagnetic interference and improve coupling efficiency, while a control system dynamically manages power flow based on alignment data. The use of a metal oxide semiconductor field effect transistor (MOSFET) switching mechanism ensures that the coil is only activated when the vehicle is properly positioned, preventing unnecessary energy consumption. (edited)

A small-scale prototype, tested with an RC car, serves as a proof of concept, demonstrating the feasibility of underground wireless charging with misalignment correction. The insights gained from this prototype can be scaled for real-world EV applications, offering a convenient, durable, and user-friendly solution for future urban charging infrastructure. By addressing key limitations in current wireless charging methods, this project aims to enhance the adoption of EVs by making charging more seamless, efficient, and accessible.

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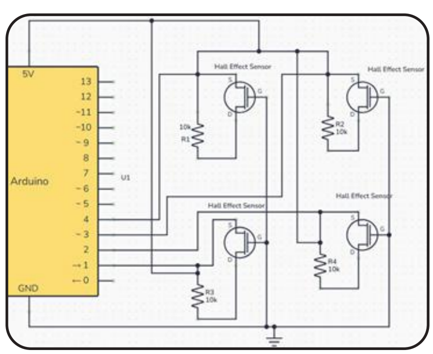


Figure 1. Schematic representation of the electronic system designed and developed for improving the efficiency and practicality of EV charging using a dynamic underground EV charger.

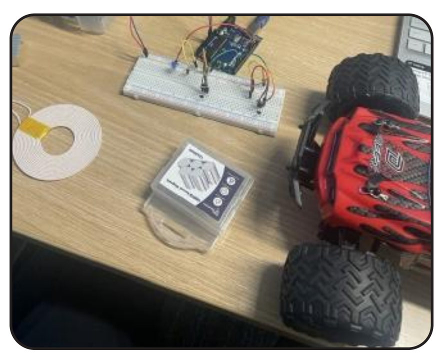
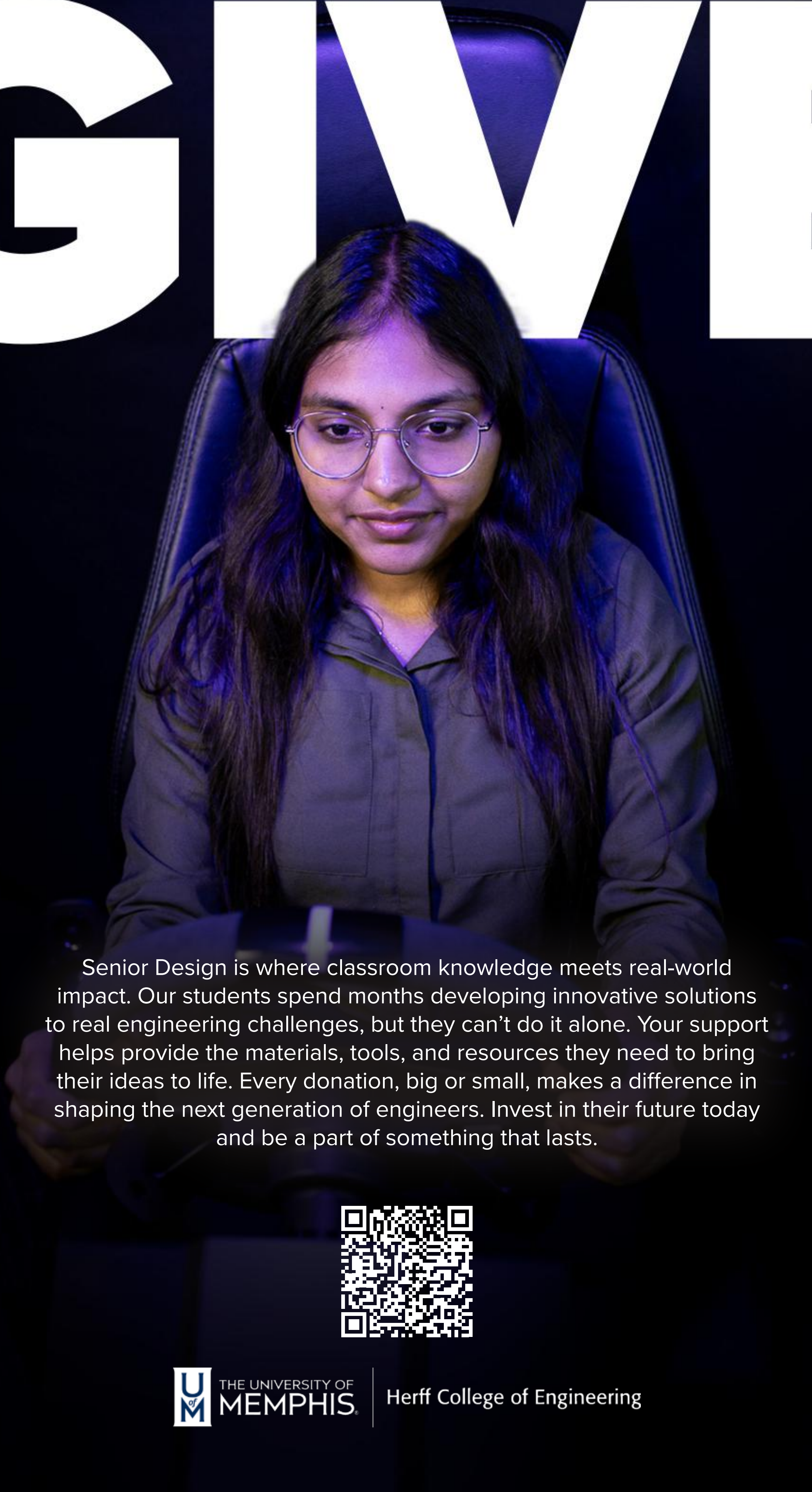


Figure 2. Prototype of the dynamic underground EV charging system.

GIVE



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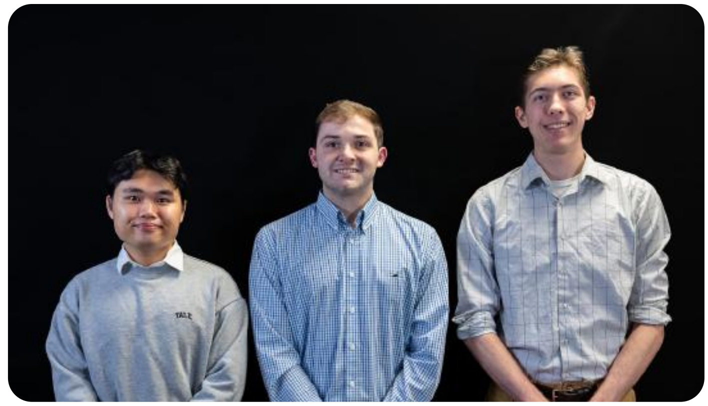
All Terrain Robot for Undergraduate Lab Development



An introductory course is required of all engineering technology majors in order to familiarize them with the many fields of study within the major. Designing and building a tracked robot that can navigate a range of terrains is a key component of this course. Programming, microprocessors, electronics, and mechanical systems design are only a few of the disciplines that are integrated in this project.

Students start the process by thoroughly outlining designs, determining the project scope, developing a schedule, and learning how to work on a budget. This structured method ensures that the project moves forward without problems and that all team members agree.

During the design and sourcing phase, students will see how the necessary parts were chosen, such as hardware, electronics, and structural materials. A programmed Arduino, which serves as the computer, provides the motor control necessary for the robot to function properly. Furthermore, 3D-printed chassis parts are incorporated into the design to ensure a sturdy yet lightweight structure.

Since the Arduino manages the motors and communicates via a wireless remote, programming becomes a vital aspect of the project. In addition to improving coding capabilities, it also offers insights into system functionality and integration.

Detailed calculations of gear ratios and RPMs are necessary for the drive system design in order to maximize the robot's performance over a variety of terrains. The chassis is made to support the electronics and drive system at the same time, providing correct connection and compatibility.

Students set all of the components onto the chassis and connect the electronics with the drive system components during the assembly phase. To make sure that everything works as it should, attention to detail is important.

Lastly, to determine the robot's performance and find areas for development, it is tested in certain working conditions. Students get practical experience and a greater comprehension of the complexity of engineering technology through this project, which successfully illustrates the combination of several fields of engineering technology. The collaborative effort in designing the drive system and chassis results in a functional prototype, preparing students for future challenges in their engineering careers.

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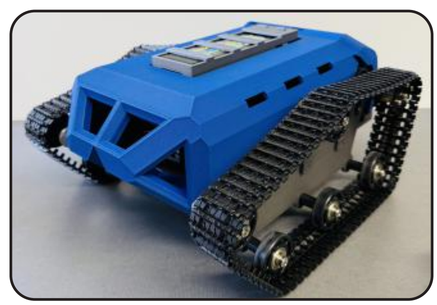

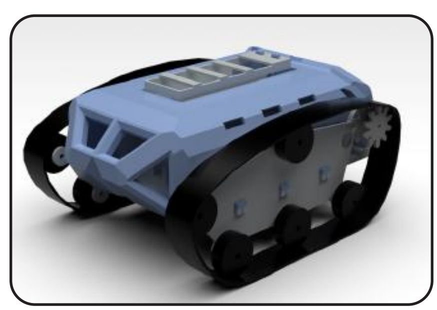

Atma.io Software Development of an Avery Dennison Interface

This software project involves the development of a graphical user interface (GUI) designed to manage the status of cartons, or packages, within a fulfilment system using Avery Dennison's atma.io APIs. The GUI allows users to efficiently update and reset the status of all cartons back to their initial state. Without the GUI, users would have to manually reset each carton by scanning it one at a time. By providing an intuitive interface, the solution simplifies carton status management, enhancing operational efficiency and ensuring seamless integration with a supply chain process. This tool will help streamline workflows, reduce manual interventions, and improve overall system control for users interacting with the atma.io platform.

Team Members:
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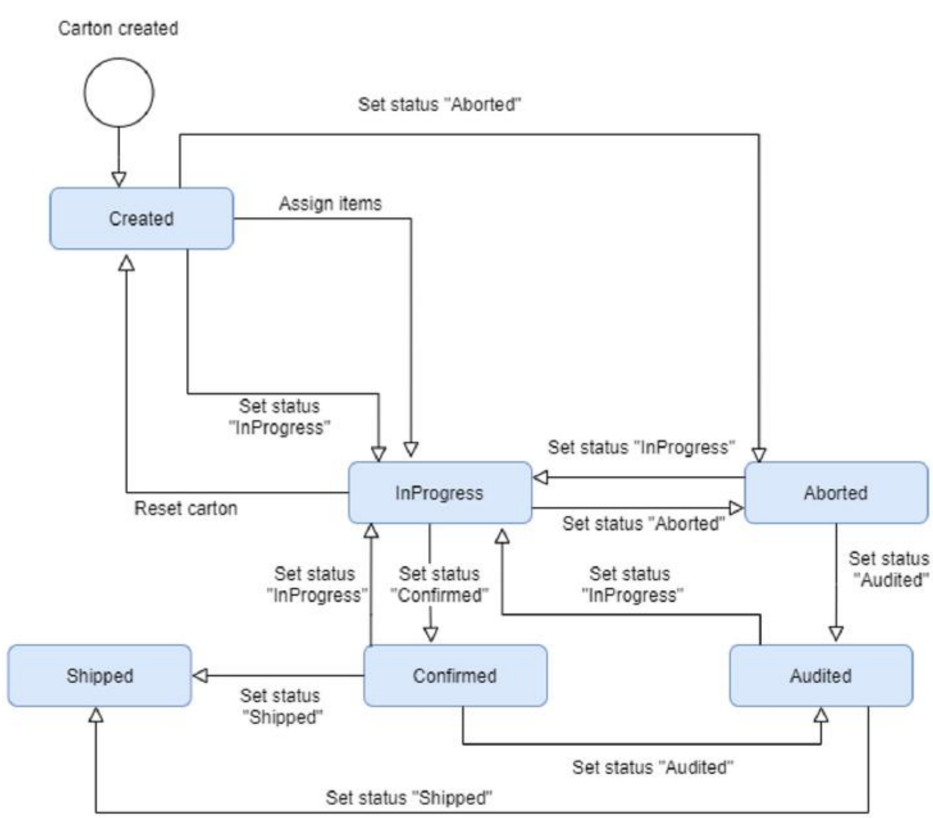
Sponsor:
Avery Denison

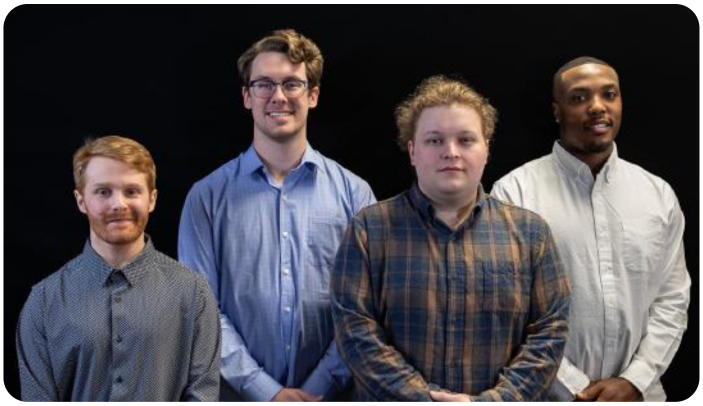
SCAN ME

atma.io infographic



atma.io infographic

Benchtop Shear Design and Build



For this senior design project, the team is designing and developing a benchtop shear with an integrated fence that delivers precise, consistent, and efficient cutting performance for a variety of sheet materials. The project aims to enhance the functionality of traditional shears by incorporating a sturdy, fixed fence system, ensuring accurate and repeatable cuts and increasing workflow efficiency. The design prioritizes safety, ease of use, and durability, making it ideal for metalworking, plastic fabrication, and crafts for both professionals and hobbyists. This manually operated shear will feature a robust lever system to minimize user effort while maintaining cutting performance. The design process will involve developing models of each component and creating an assembly using CAD software, selecting material to ensure durability and strength, manufacturing the product using machining, welding, heat treating, electrochemical processes, and fastening techniques, and lastly creating a user manual for safe and reliable use. The compact design of the benchtop shear also allows for portability and use in limited workspace environments.

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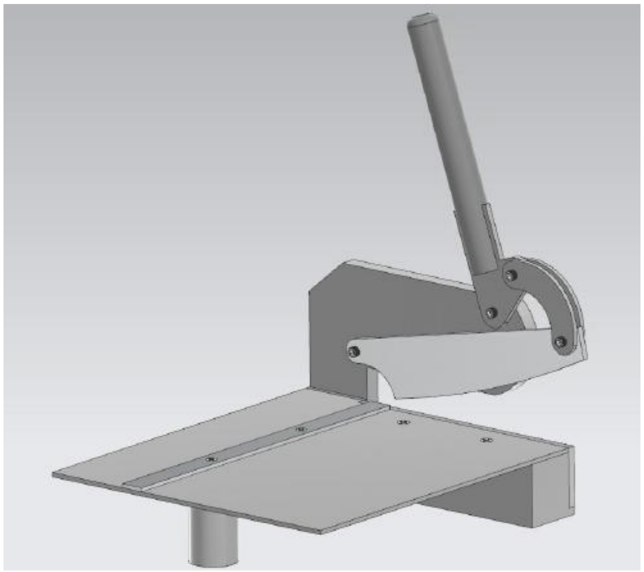

Freshman Lab Activity Redesign

The Engineering Technology department offers TECH 1411 as an introductory course designed to provide freshmen with an overview of the program. To better represent the department's diverse fields of study, the lab has been redesigned to create a more interactive and practical learning experience. As part of this improvement, a new RC car project has been introduced, incorporating concepts from mechanical systems design, microprocessor systems, production realization, and Lean principles. This project aims to make learning more engaging and collaborative while connecting it to real-world applications. The RC car project is divided into four lab sessions, each focusing on a core skill relevant to Engineering Technology. The first session introduces Computer-Aided Design (CAD), where students learn basic 3D modeling techniques. The second session covers circuit design and assembly, providing hands-on experience with electronic components. The third session explores computer programming, enabling students to write basic code to control the RC car's functions. The final session focuses on quality control and the RC car's assembly, where students integrate all the components into a working model. Throughout the course, students will collaborate in groups of four to five, promoting teamwork and problem-solving. As the lab sessions progress, students apply their newly acquired skills to construct and optimize their RC cars. Toward the end of the course, the groups participate in a competition, testing their cars against one another in a series of challenges. By the conclusion of the course, students gain a deeper understanding of the various fields within Engineering Technology while developing practical skills. The RC car project not only reinforces technical concepts but also encourages creativity, collaboration, and critical thinking—essential abilities for future academic and professional success, as well as for helping students select their field of study in their sophomore or junior year.

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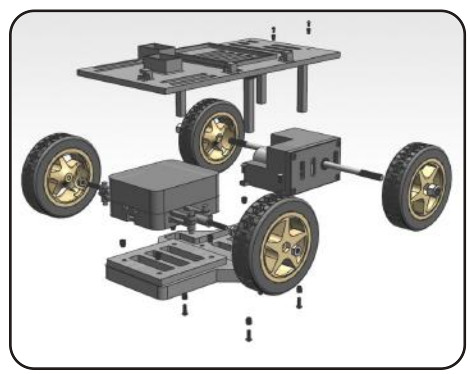
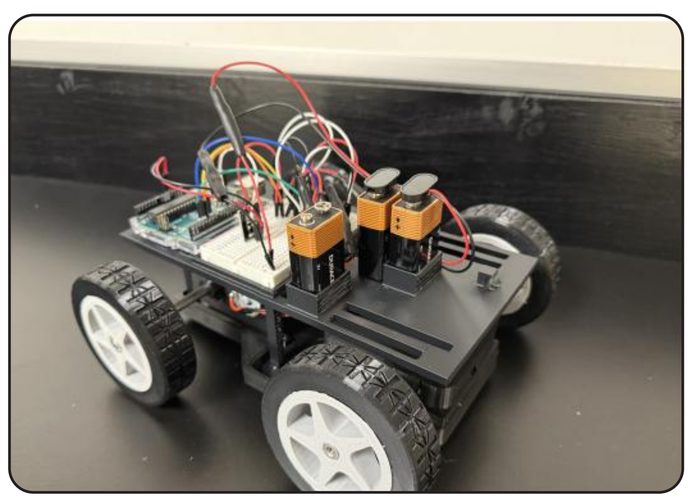
Rose Saeed
Marco A. Zamorano
Hendrick D. Cuestas
Kaleb Z. Hess





Fulfillment Center Receiving Process Improvement

Team Member:
Charles Bache Kudi

This project focused on optimizing the Receiving process to significantly improve efficiency and standardization. The initial process required 56 minutes to receive a pallet containing 32 boxes, each with six units. Through targeted process improvements and workflow redesign, the time was reduced to just 15 minutes per pallet which is a 73% reduction in processing time.

Key initiatives included streamlining labeling operations by reducing the number of label printers from two to one per workstation, and minimizing equipment needs while maintaining productivity. Additionally, the process was simplified by standardizing label usage to one label size across the entire operation, eliminating the complexity of managing multiple label types.

These enhancements led to faster throughput, reduced operational costs, improved workstation organization, and greater consistency in the Receiving process.

Figure 1. Printers with two different label sizes needed for worksation.

Figure 2. Workstation after project implementation.

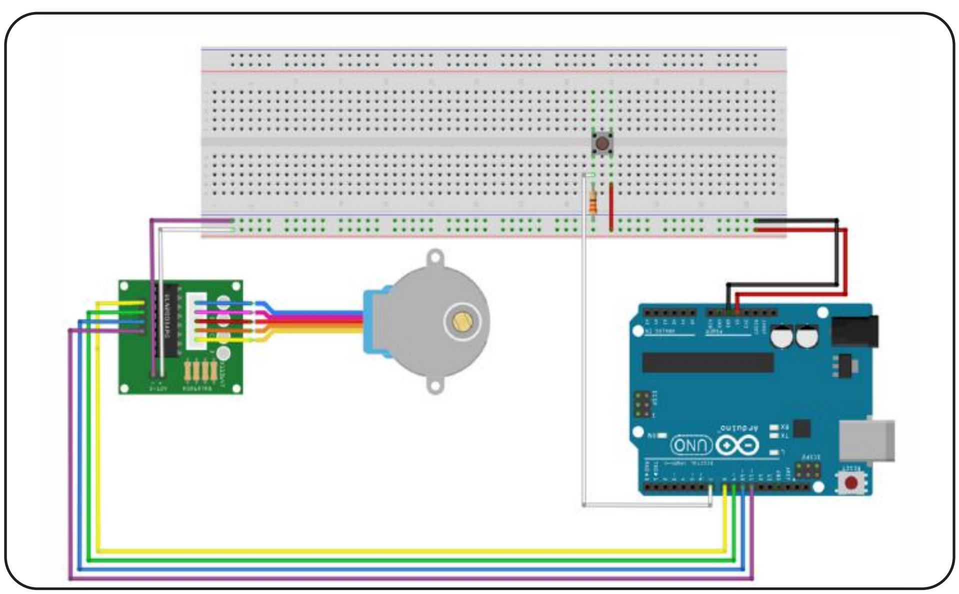
LIDAR Scan Conversion through Motion Control

This project involves using the SICK LMS111-10100 2D LIDAR in conjunction with servo motion control to scan in multiple orientations, generating 3D point clouds that are published for further use or analysis. The goal is to integrate open source drivers that would facilitate a working environment of multiple scan types and positions.

Team Member:
Srage R Johnson

Sponsor:
SICK

Bulkscan Sensor



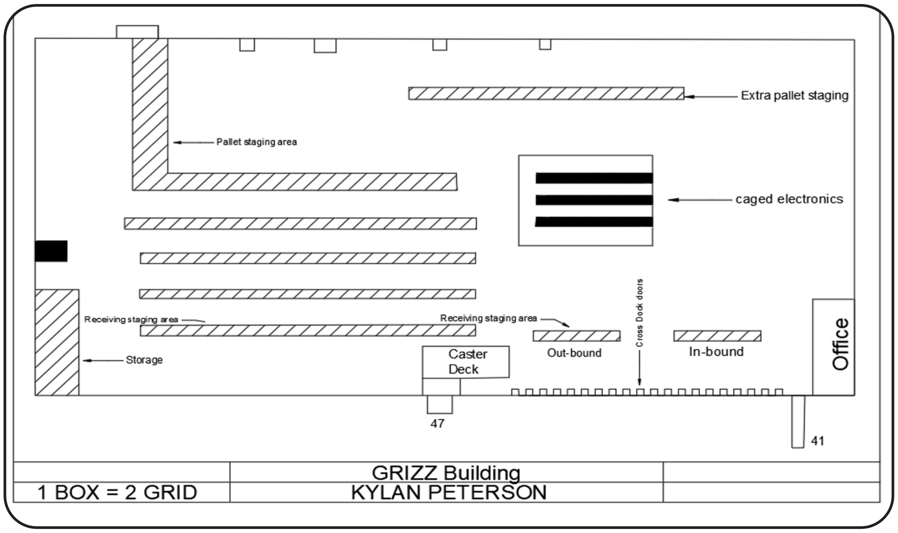
Turntable Wiring Diagram

Logistics Process Optimization

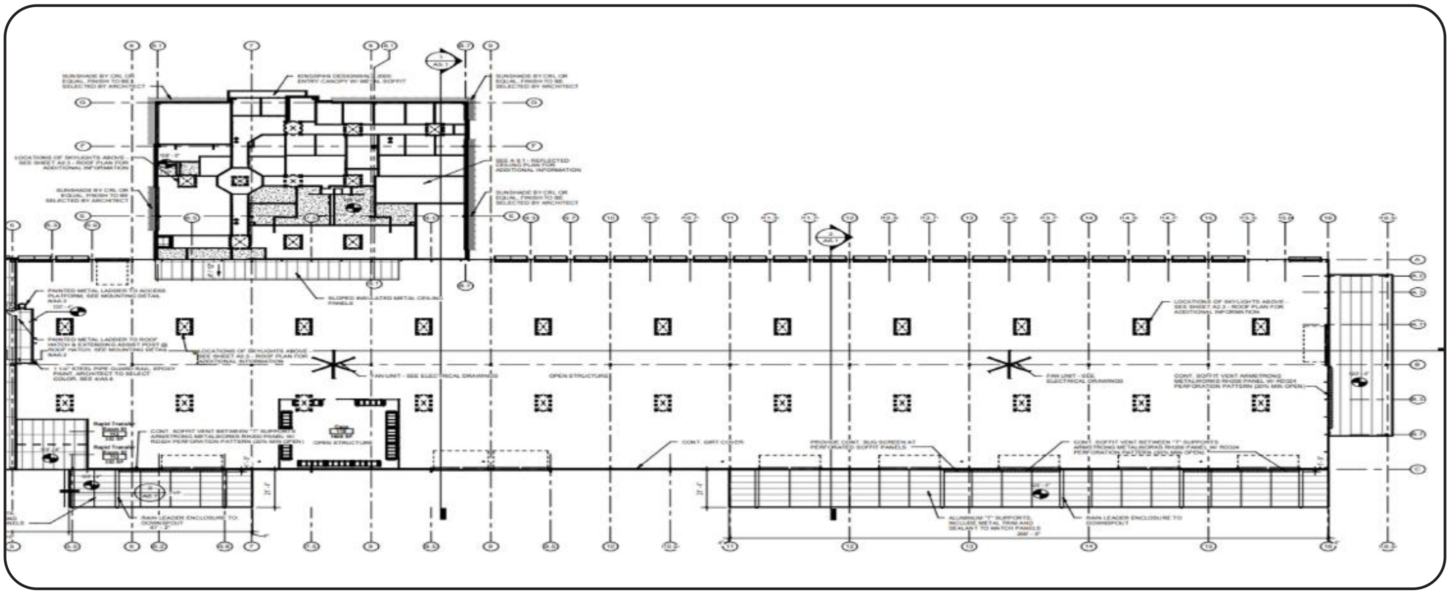
The project, "Logistics Process Optimization," is a lean operations based project that is focused on creating a proposal to save cost and implement a current cross dock facility into a new facility along with its production processes. If there are any errors in the process due to the new building layout of the workspace, the process will be optimized. This proposal will be presented to Operations Management (OP's) for approval for implementation.

Team Member:
Kylan A Peterson

Mentor:
Rajesh Balasubramanian



GRIZZ Facility Layout



OLVRT Facility Layout

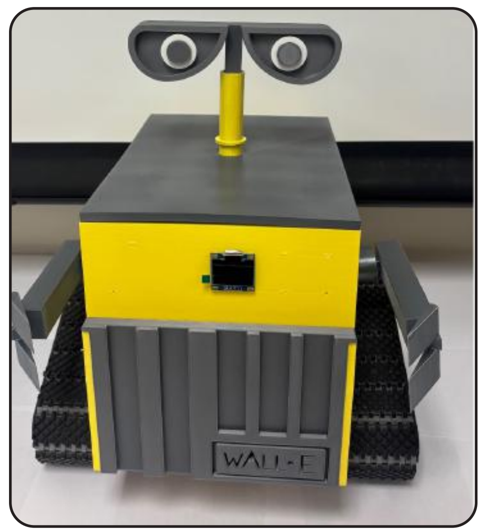
Mobile Robot Platform Development

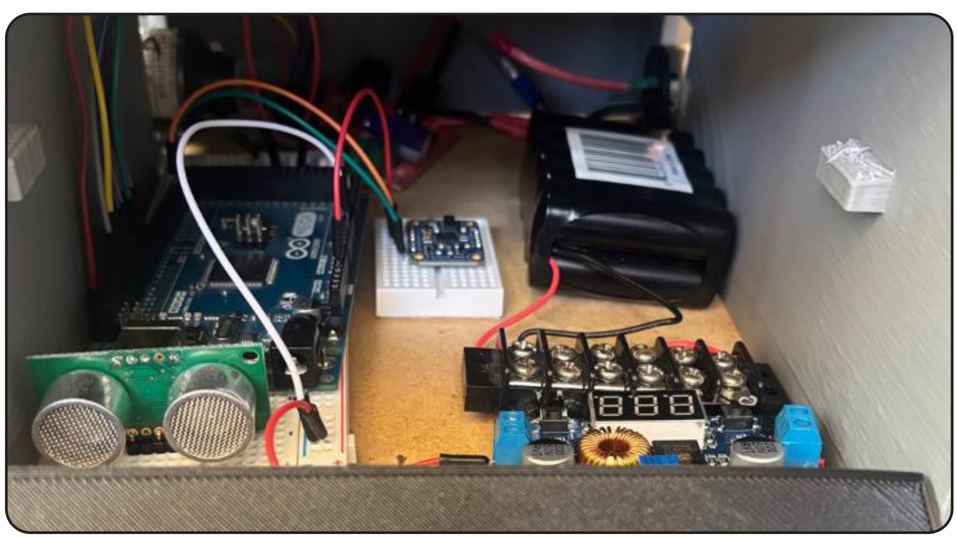
The Mobile Robot Platform Development is a senior design project focused on building a self-navigating robotic system that resembles WALL-E and integrates sensor-based navigation, motor control, and real-time decision-making. This robot is designed for autonomous movement, detecting and avoiding obstacles, and executing precise turns based on sensor feedback.

The robot's structure is based on the Lynxmotion Tri-Track Mobile Base, providing a stable tracked platform for movement. The exterior will be 3D-printed using PLA (Polylactic Acid) offering a lightweight yet durable shell that protects internal electronics. The internal structure of the shell will include built-in shelves that will enable quick upgrades and modifications without requiring major structural changes and ensure a clean and modular layout. This design will also support future advancements, making it easier to integrate additional components due to the accessible shelves. The design encloses all electronic components and serves as a mounting structure for key sensors, including HC-SR04 ultrasonic sensors for obstacle detection and a BNO055 IMU sensor for orientation-based turns. The chassis will also feature mounting points for additional components such as a camera module, speaker, and power system, ensuring both functionality and adaptability.

The system will be programmed to operate independently, controlled through software-driven movement, processing sensor data to make real-time decisions. The ultrasonic sensors will continuously scan for obstacles, triggering movement adjustments as needed, while the BNO055 IMU ensures precise 90-degree turns for navigation which will allow the robot to operate independently without external control. The robot will be also designed to handle various environments, and a well-planned power distribution system will be incorporated to support all electronics while ensuring long operational runtime.

Team Members:
Troy Shelby Ernest
Jamia L Westbrook
Joseph Lee Harris





Multi-Function Synthesizer Module

Synthesizers are among some of the most capable instruments to have been developed within the past century, being used by several historically important artists in several ways. Their development mirrors that of recording technology in general; alongside revolutionary equipment such as reel-to-reel tape decks and innovations within microphone and headphone capabilities, the synthesizer's primary elements and components were developed and perfected. At the core of a synthesizer are several circuits acting in series, such as an oscillator that generates sound, going into a filter that shapes the sound quality, going into an amplifier that controls the volume activation over time. Many keyboard synthesizers are designed with a fixed signal path that cannot be changed. Modular synthesis instead divides each step into "modules" that can be connected in any order the user desires.

The Multi-Function Synth Module was designed according to the "Eurorack" standard, allowing for all signals generated by the device to be compatible with other modules in the same format. This format has grown to be the most popular standard for boutique modular synthesis within the last decade. This format also provides rigid dimensions for the physical space that the module can occupy within a case that confines to the same standards, allowing for systems to be built from several modules that act as those elements within a typical signal path. Our device is a proof-of-concept for the utilization of a microcontroller unit being capable of acting as any part of the signal path. The device is capable of running one of several algorithms at any given time, and in this case, primarily as an oscillator or a delay. These two modes were chosen to show the ability for the device to both synthesize its own signals, as well as affect incoming signals. This demonstrates it is capable of being a solution for most synthesizing needs.

Team Members:
Torrey Washington
Andrew Sean Kallaher
Jacob Alexander Turner

Mentor:
Professor Dan Kohn

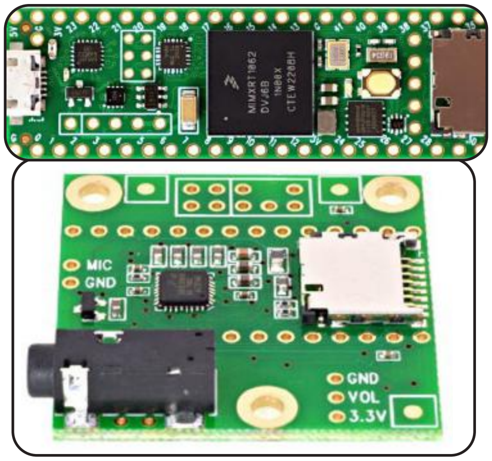


Figure 1. The module utilizes a Teensy 4.1 microcontroller with an audio shield breakout. This allows for 44.1 kHz audio processing using the I2S communication protocol between the Teensy board and the SGTL5000 chip on the shield.

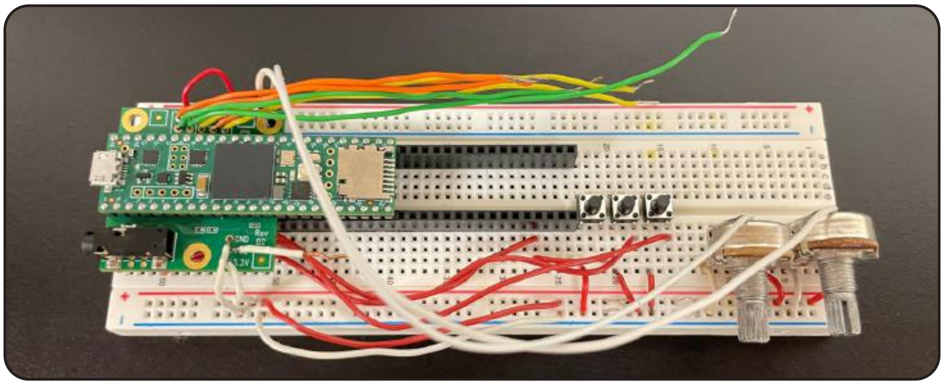


Figure 2. The current testing iteration of the module. Current controls include 2 potentiometers and 3 buttons, all of which can be recognized by the Teensy 4.1 and programmed to control any parameter deemed necessary.

Public to Private IP Address Scheme Implementation

Company A is currently in the process of consolidating their network across their different locations. They recently acquired a new company. Upon inspection, they have identified what they believe is an undesirable situation with the network. This new location is routing public IP addresses internally. Additionally, the intermediary devices, specifically the network switches, need to be updated with new hardware. They want to mitigate security risk and comply with the ongoing integration initiative. To accomplish this, they want to move the network from a public IP address scheme to a private IP address scheme. Additionally, they want to plan a budget for upgrading the equipment soon.

This project will primarily focus on implementing a new IP address scheme for the newly acquired network. The biggest goal for the new network is to improve scalability. The new scheme will include an increase in the number of available IP addresses. This means that it will support the expansion of more devices in the future. The next goal is to improve network traffic management. This will improve network performance by increasing traffic prioritization. Simulation software will be used to show the integration plan and its functionality.

The last goal of this project is to create a budget for new equipment. This company already has an agreement with a vendor. All new equipment must be specific to that vendor as part of the integration initiative. The new equipment must also meet scalability requirements ensuring that the network is future proof.

Team Member:
Bradley Alexander Gilliland

Mentor:
Professor Daniel Kohn

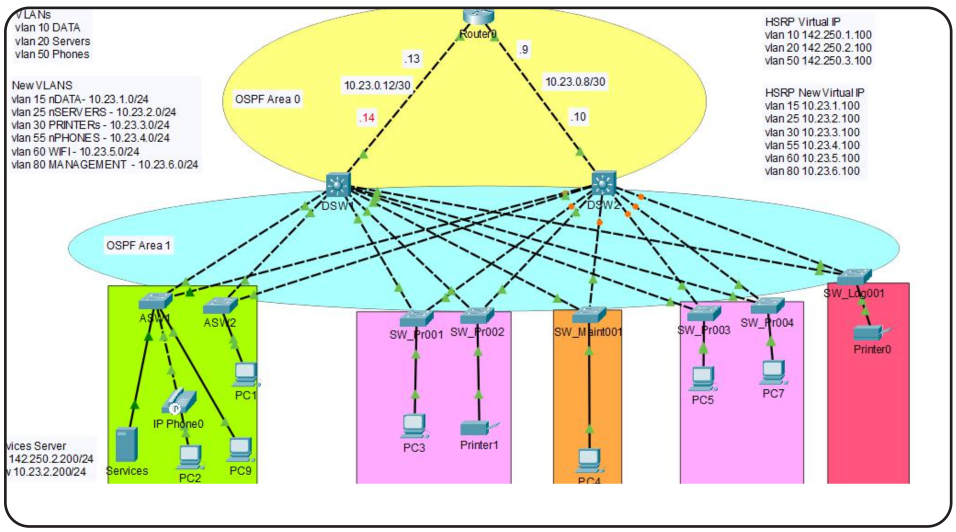


Figure 1. Shows Collapsed Core network topology

```
Gateway of last resort is 0.0.0.0 to network 0.0.0.0

     10.0.0.0/8 is variably subnetted, 5 subnets, 3 masks
C       10.23.0.8/30 is directly connected, GigabitEthernet0/2
L       10.23.0.9/32 is directly connected, GigabitEthernet0/2
O IA    10.23.1.0/24 [110/2] via 142.250.0.10, 00:01:06, GigabitEthernet0/1
O IA    10.23.2.0/24 [110/2] via 142.250.0.10, 00:01:06, GigabitEthernet0/1
O IA    10.23.4.0/24 [110/2] via 142.250.0.10, 00:01:06, GigabitEthernet0/1
     142.250.0.0/16 is variably subnetted, 7 subnets, 3 masks
C       142.250.0.4/30 is directly connected, GigabitEthernet0/0
L       142.250.0.6/32 is directly connected, GigabitEthernet0/0
C       142.250.0.8/30 is directly connected, GigabitEthernet0/1
L       142.250.0.9/32 is directly connected, GigabitEthernet0/1
O IA    142.250.1.0/24 [110/2] via 142.250.0.10, 00:01:06, GigabitEthernet0/1
O IA    142.250.2.0/24 [110/2] via 142.250.0.10, 00:01:06, GigabitEthernet0/1
O IA    142.250.3.0/24 [110/2] via 142.250.0.10, 00:01:06, GigabitEthernet0/1
S*   0.0.0.0/0 [1/0] via 142.250.0.5
               is directly connected, GigabitEthernet0/0
```

Figure 2. Image of routing table after configuring OSPF

RFID CueTrac

Since August 2024, our senior design team has collaborated with Meucci Cues to embed RFID (Radio Frequency Identification) tags in pool cues for tracking and brand authentication. Guided by Dr. Berisso, the project applies expertise in product realization, software development, and automation, with completion expected in April 2025.

Objectives / Deliverables:

- Embed RFID tags for tracking and authenticating pool cues.
- Develop software to track and verify cue ownership.
- Provide manufacturing instructions for RFID integration.

Deliverables:

- Working software prototype for RFID tracking and authentication.
- Detailed process guidelines for embedding RFID tags.
- RFID selection report with sourcing and cost analysis.
- RFID Tag Testing / Selection
- SmarTrac Wet (Adhesive) Inlay Tag: Chosen for its durability and 45-inch scan range when embedded.

Range Test Results:

- SmarTrac: 1” to 64” (reduced to 45” when embedded).
- 7018 Avery Dennison: 1” to 50” (reduced to 23” when embedded).
- Tire tag: 1” to 17” (unreadable when embedded).

Hardware Testing:

- Zebra FX9600 RFID Scanner: Provides a 20 inch scan range and 1,300+ tag reads.
- Challenges: Inconsistent battery duration and manual scanning.

Software Testing

- Database System: Stores and tracks RFID data for cue identification.
- User Interface: Enables efficient cue authentication and ownership verification.

Hardware:

- PVC Pipe, Avery Dennison SmarTrac RFID Tag, Rubber Bumper
- Zebra FX9600 RFID Scanner
- Software
- Custom database and tracking software
- User-friendly authentication system.
- Customer Tracking Interface

Features:

- Verify cue authenticity and ownership.
- Enhance inventory management and lifecycle tracking.
- Design Focus: Simple, scalable, and future-ready.

Team Member:
James Issac Shaw
Michael C. Moody
Iley D. Hinton

Mentor:
Dr. Kevin Berisso

Sponsor:
Meucci Cues

Figure 1. Ultra-High Frequency (UHF) RFID inlay tag

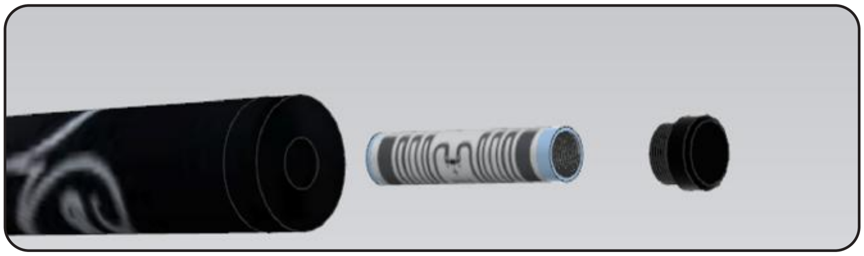


Figure 2. Illustration of RFID inlay tag being placed in PVC pipe.

BIOMED
CIVIL
EECE
ENG TECH
MECHANICAL

RFID Enabled Attendance Tracker

IThe purpose of the RFID-Enabled Attendance Tracker project is to make the professor and student life simpler. This project is to increase the ease and accuracy of student attendance along with decreasing the class time professors need to take attendance.

The goal is to use Radio Frequency Identification (RFID) tags/cards to track student's classroom attendance.

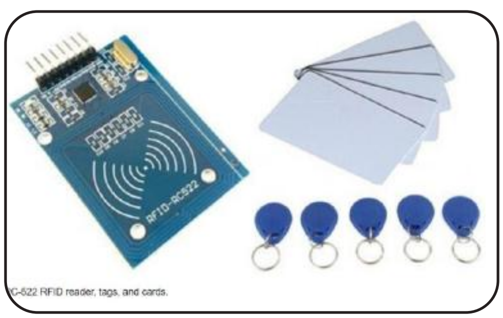
A circuit that captures RFID scans and stores them in a database. A GUI (Graphical User Interface) that retrieves the data from the database.

Use a Radio Frequency Identification (RFID) RC522 which is a wireless system comprised of two components: tags and readers. The reader is a device that has one or more antennas that emit radio waves and receive signals back from the RFID tag. An Arduino Uno, a programmable open-source microcontroller board, will be integrated/connected to the RFID Reader. The student uses the RFID tag/card to scan the RFID reader that is connected to the Arduino Uno. The Arduino will be uploaded with program code to read the RFID tag scans and write to an output device. The Arduino outputs the user (RFID tag/card number), date, and time which is stored into a database. A Raspberry PI, a minicomputer, will be connected to a local network and used to run a server that stores the database containing the student data. This data can be retrieved and displayed through a software program. A custom GUI (Graphical User Interface) allows the professor to query the student attendance data. Eclipse IDE (Integrated Development Environment) is used to develop a Java Application to display output.

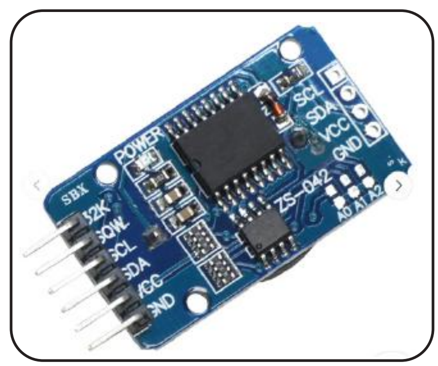
The RFID-Enabled Attendance Tracker project increases accuracy while decreasing the time and effort needed to record student attendance. It allows a simple scan for the student to enter the data and a simple query for the professor to retrieve the data.

Team Member:
Keith Anthony White

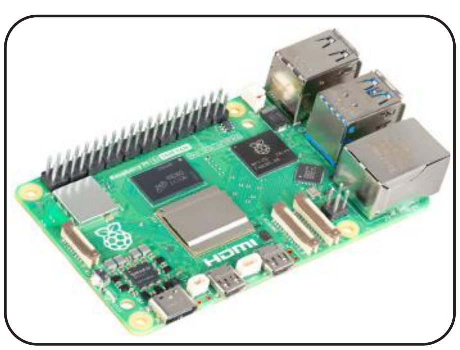
Mentor:
Professor Daniel Kohn



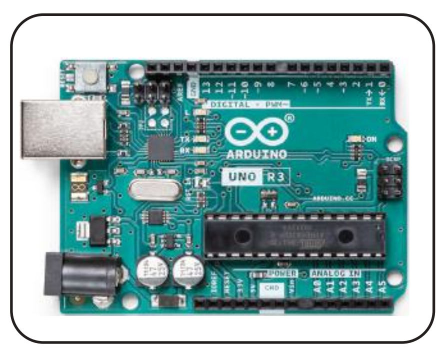
RFID Tag, Card and Reader



Real Time Clock



Raspberry PI



Arduino Uno

Smart Home Energy Meter Product Development

The project focuses on designing a smart energy meter for residential use that measures energy consumption and displays it in clear graphs using InfluxDB. The aim is to come up with a solution that is both more affordable and safer than many existing products

A key feature is the use of split core transformers. Unlike in traditional systems that require hardwiring and pose installation hazards, these transformers can be simply wrapped around wires. This significantly improves safety and simplifies installation, making it suitable for hobbyist-level users who may not necessarily possess the professional electrical expertise to work with potentially deadly electric systems.

Another noteworthy aspect is the development of a custom PCB using an energy metering IC, the Microchip Technology ATM90E32AS. This specialized PCB is designed around this IC as the brain of the meter, ensuring precise and reliable measurements of energy consumption. The IC not only enhances accuracy but also keeps the product compact, efficient, and low-cost.

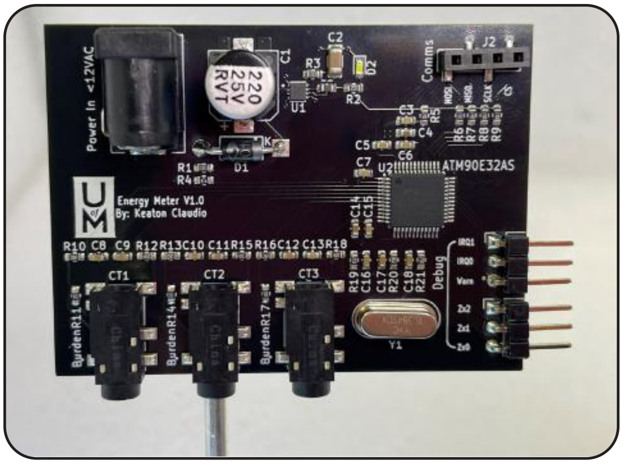
The product is specifically designed for U.S single split phase residential power systems; a use-case often overlooked by more complex industrial solutions. By focusing on this gap in the market, the project provides consumers with clear energy usage data, which is essential for making informed decisions about consumption and costs.

A major motivation behind this project is the real-world issue of data unavailability. Whilst every home comes installed with a meter by your energy company, energy usage data isn't always accessible to you, depending on where you live, leaving many unable to verify if they are being billed correctly by their energy company. This gap in transparency can lead to overcharging or inefficient energy use. By providing accurate, real-time data through graphical displays, the meter allows users to monitor trends, spot inefficiencies, and question any discrepancies in billing.

The process is straightforward and pragmatic. Rather than indulging in the usual hype around "smart" technology, the project sticks to delivering tangible benefits: enhanced safety, ease of installation, and accurate energy usage data. This product is designed to appeal to both tech enthusiasts and everyday consumers whilst being an interesting yet practical smart home solution.

Team Member:
Keaton B. Claudio

GitHub Repository Information



Custom PCB

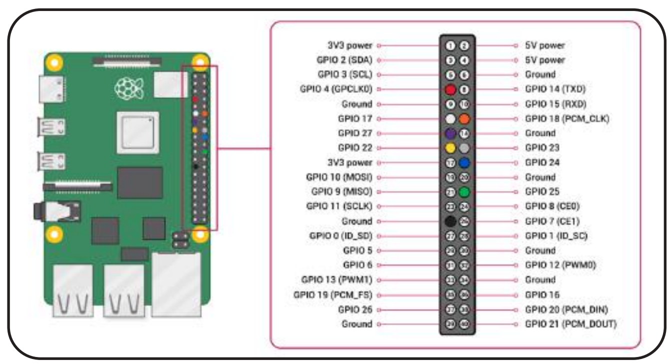
Web Controlled Robot Arm

The main goal of this project is to create a website to control/ operate the LabVolt Armdriod 1000. I chose this project because it falls under both of my fields of study: Microprocessors, and Automation and Control Systems. I worked with a Yaskawa robot arm for a while doing a separate project involving dominoes, and I have taken many classes programming Arduino paired with many ICs to do different things, so naturally I would gravitate to this project. The project has many parts that work together to achieve this goal: The coding languages and the hardware are the biggest parts of the program because they tie everything together. The coding languages used for this project are HTML, CSS, Javascript, and Python. The plan for the programming aspect is to use HTML and CSS to create and design the website on the front end. We use JavaScript to allow the tabs to be linked to the different HTML files so we can separate the code for each of the tabs because I know that the Programming HTML file will have the most code and to keep it neat. On the backend of the website, Python will be used to control the robot and ask for user input on the website, which will connect to the Raspberry Pi to control the robot arm. CSS will be used to make the website itself presentable cosmetically. On the hardware side is mostly just the robot arm itself and the Raspberry Pi. The Raspberry Pi holds all of the information and allows everything to communicate with each other using a webserver called Flask. Flask ties the program that runs the robot arm and the actual website to transfer data between each other. The User will go into the website and go to the programming page. The user will type in the number of steps that the motor will take, positive is forward, and negative is backward. Flask will extract the user input and run the robot code with that information and the robot arm will move.

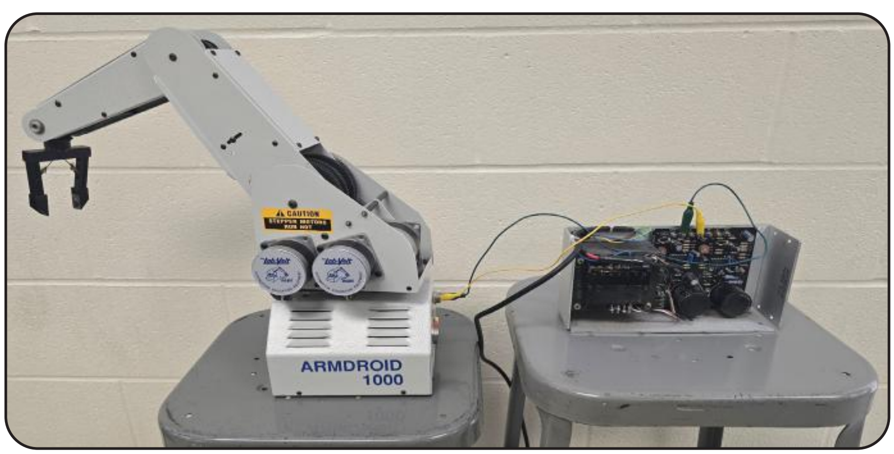
Team Member:
Antonio Rashun Tinnon

Mentor:
Professor Daniel Kohn

Raspberry Pi



Raspberry Pi (BPIO Pin layout)



LabVolt Armdroid

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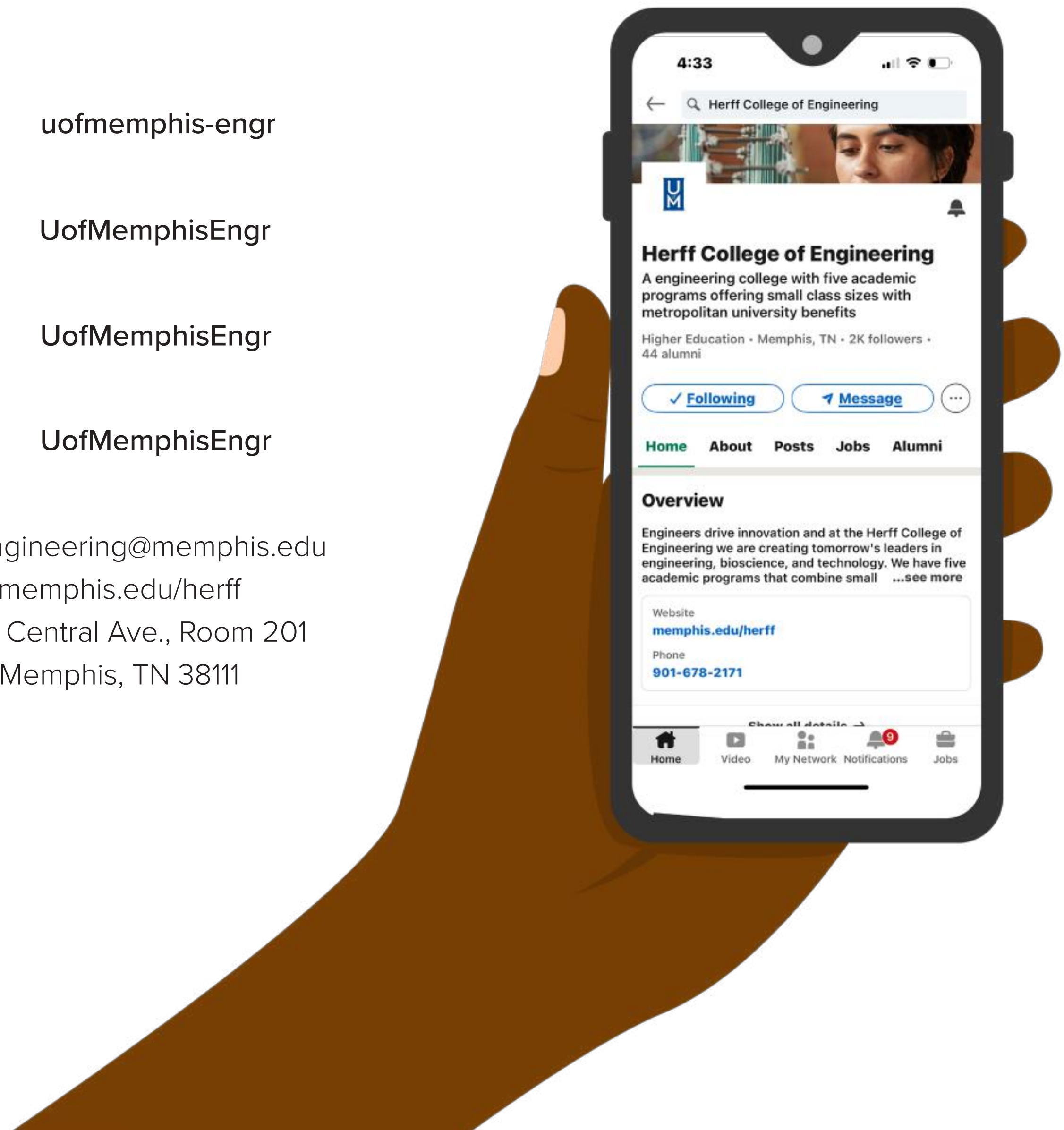

MECHANICAL **ENGINEERING**

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Almost Hireable 45
Blue Bolt Innovation 46
Dough People 47
Gear Heads 48
Gravity Falls 49
Mech Men 50
Shake N' Bake 51
Squeaky Clean Crew 52
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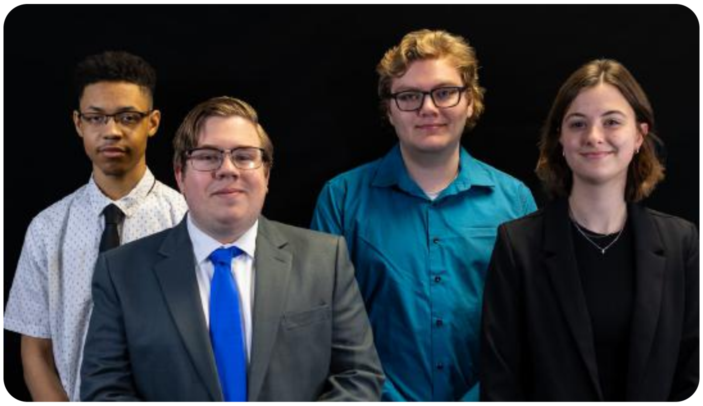
We're Not In Kansas Anymore 58

Almost Hireable



Idiopathic scoliosis and other spinal deformities are common congenital defects, affecting approximately 3% of the world population. Spinal deformity correction is traditionally a complex, multi-step process that requires a team of surgeons to reposition and stabilize the spine. This process often involves multiple instruments entering and exiting the surgical field, making it time-consuming and cumbersome.

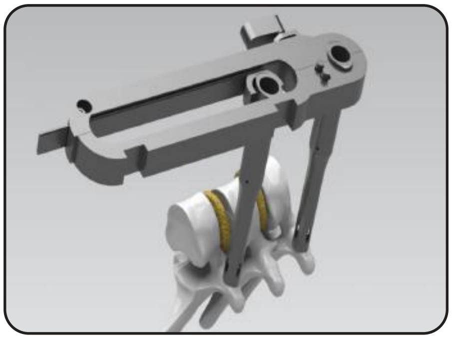
The proposed design aims to streamline the spinal correction procedure by enabling manipulation of all three anatomical planes of the spine (coronal, transverse, and sagittal), ensuring proper derotation and alignment with a single instrument. After connecting to the existing Medtronic ModuLeX shanks and screw extenders, the new prototype attaches to two vertebral bodies: one representing the diseased body in need of correction and the other serving as a healthy reference body, acting as a datum. Once the two vertebral bodies are securely connected, the surgeon can manipulate the spine in the sagittal plane and lock the vertebrae. Afterwards, they can apply force to the prototype along the other two planes of movement, either coronal or transverse, to facilitate correction. Afterward, permanent rods and screws are placed to ensure the correction is held in place.

The proposed design will allow the surgeon to perform the entire correction process with just two hands, reducing the need for additional surgical assistance. Additionally, the instrument has en bloc capabilities, enabling it to connect to multiple levels of the spine. This feature allows the surgeon to correct several sections of the spine simultaneously, thus reducing the overall duration of the operation. The instrument will be fabricated from 465 stainless steel to ensure biocompatibility and durability. By reducing the complexity of spinal deformity correction and enabling more precise, time-efficient, and intuitive procedures, this design aims to improve surgical outcomes. It enhances the surgeon's ability to correct spinal deformities with greater speed, precision, and ease.

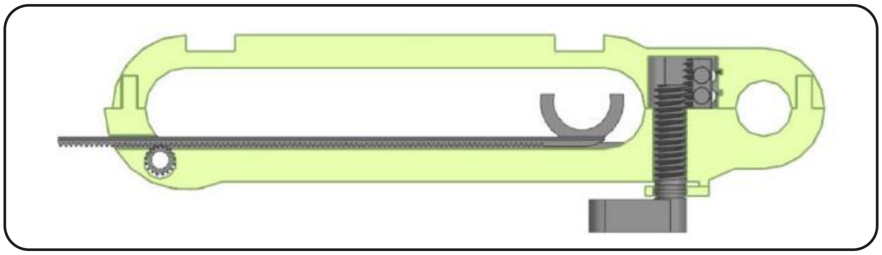
Team Members:
Brandon Walton
Jalen Juzeszyn
Zachary Volner
Sydney Mitchell

Faculty Mentor:
Dr. Amir Hadadzadeh

Client:
Medtronic



CAD Drawing of the Design



Cross-Sectional View

Blue Bolt Innovations

This project focuses on developing a stable walking robot with interchangeable leg components, designed as a teaching demonstration tool for undergraduate mechanical engineering courses. The primary objectives are to illustrate how walking robot functions can be implemented using mechanisms commonly covered in undergraduate curricula and to explore how different limb geometries affect the robot's postural stability. The project utilizes a walking robot kit, consisting of a battery, switch, and motor. The robot uses primarily four-bar and slider-crank mechanisms to facilitate walking. The project aims to modify the robot to allow for quick, tool-free interchangeability of leg components, facilitating easy replacement and assembly. This feature aims to enable students to experiment with various leg designs and analyze their impact on walking stability.

The walking robot will be tested on an even surface to ensure stable motion. Additionally, the robot's stability will be assessed by subjecting it to a sudden pendulum impact during its walking cycle. Stability metrics will be determined by measuring the maximum impact energy the robot can withstand without compromising its posture.

Key deliverables include the modified walking robot, at least four sets of interchangeable leg components, and a scaled pendulum impact device, adapted from both existing equipment and fusion deposition modeled (FDM) parts. The project will also produce detailed design drawings and an assembly manual, ensuring replicability and ease of use. A simple dynamic analysis will be conducted, incorporating energy and momentum calculations to evaluate the robot's performance under lateral impact and inform the design of leg components.

By integrating theoretical concepts with practical application, this project aims to enhance students understanding of mechanical design principles, stability analysis, and mechanism implementation in walking robots. The final deliverables will serve as a valuable educational resource, demonstrating the relationship between mechanical design choices and stability in a hands-on learning environment.

Team Members:
Kailee Ashe
Andrew French
Alex Go
Matthew Frederic

Faculty Mentor:
Dr. Yue Guan

Client:
ME Department

THE UNIVERSITY OF MEMPHIS
Department of Mechanical Engineering

Dough People

One out of every seven people in the world suffers from osteoarthritis, a degenerative disease that affects the joints. One of the most effective methods for treating end-stage osteoarthritis is cemented total joint replacement (CTJR). In the United States, the cost of CTJR surgery is between $16,000 and $60,000, putting it out of reach for patient care in low-income countries.

One way to reduce the cost of a cemented CTJR replacement surgery is to use a low-cost but effective bone cement mixer and dispenser. We designed and fabricated a novel combined bone cement mixer and dispenser (tradename: MEMMIXDIS). It is an almost completely reusable system that allows for mixing and dispensing bone cement under a vacuum.

The components of MEMMIXDIS are a sealed polymeric box, a polymeric jar, a mixing paddle, a mixing lid for the jar, and a syringe. The box's removable lid allows the user to easily place the polymeric jar inside the box. Once a vacuum is created in the sealed box, two gloved entry ports allow the user to access the bone cement ingredients (packet(s) of powder and vial(s) of liquid) that would have been placed in the box without disturbing its interior vacuum. Thus, the bone cement ingredients can be mixed while remaining under a vacuum.

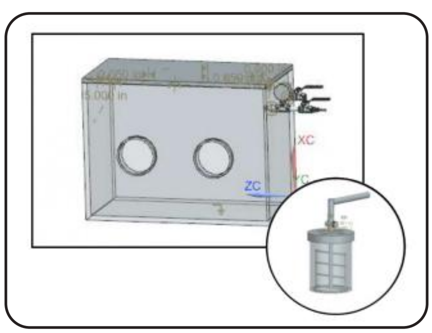
Once the cement is mixed, the syringe will be used to transport the cement dough to the surgery site. MEMMIXDIS has three features that make it very attractive for use in low-income countries. First, its production cost is about $300, which is less than half that for single-use-only vacuum bone cement mixers and dispensers used in CTJR procedures in the United States. Second, being almost fully reusable, its environmental footprint will be very low. Third, since the system allows the cement to be mixed and dispensed under vacuum, it is expected that the cured cement will have very low porosity, thereby reducing the potential for aseptic loosening of the implant in service, which translates to better patient outcome.

Team Members:
Jacinta Fritz
Craig Bowlin
Fancisco Cano
Trey Mallory

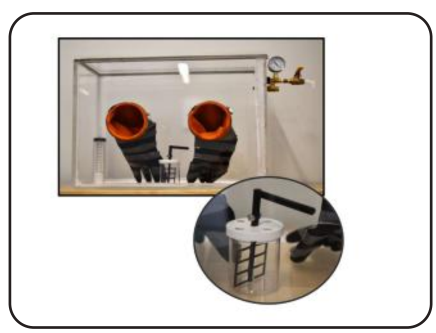
Faculty Mentor:
Dr. Gladius Lewis

Client:
ME Department

THE UNIVERSITY OF MEMPHIS
Department of Mechanical Engineering



CAD Design of Sealable Box and Mixing Bowl



Fully Integrated Combined Vacuum Mixer and Dispenser

Gearheads

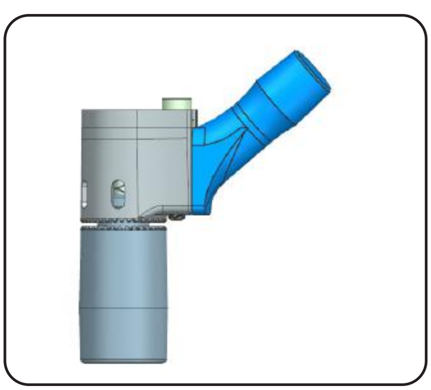
Arthroplasty revision surgery requires precise control over implant positioning to ensure proper joint function and longevity. Smith & Nephew requested the development of a modular trial body adapter to improve height and version adjustments during femoral component trialing. The design needed to allow for height adjustments from +0 to +30mm in 10mm increments and provide version control of at least ±45 degrees. To meet these requirements, the proposed design incorporates two interchangeable trial bodies rather than a single unit. The first trial body allows for height adjustments between +0 and +10mm, while the second covers +20 to +30mm. This modular approach ensures that surgeons can achieve the necessary vertical offsets without excessive instrumentation.

The design surpasses the required version control by allowing for a continuous

360-degree rotation, ensuring greater flexibility in aligning the femoral component. The trial body system features a lead screw locking mechanism that secures height adjustments while maintaining ease of assembly and disassembly. The interface between the trial body and stem preserves stability during trialing while enabling smooth transitions between adjustments.

Furthermore, to improve the ease of sterilization, the design integrates open-slot features that facilitate thorough cleaning and debris removal.

A critical factor in the design process was ensuring the trial body could withstand the forces experienced during surgery without excessive deflection or failure, particularly at its fully extended position. One primary concern was the bending moment exerted on the extended arm of the trial body, which led to the decision to separate the height adjustments into two bodies rather than one. Key hand calculations were performed to evaluate the structural integrity of the design under expected surgical loads, with supplementary finite element analysis providing further validation. Material selection focused on maintaining durability and resistance to mechanical stress while ensuring compatibility with existing surgical instruments. The final design successfully meets all specified requirements, providing an adaptable, user-friendly solution for arthroplasty revision surgery.



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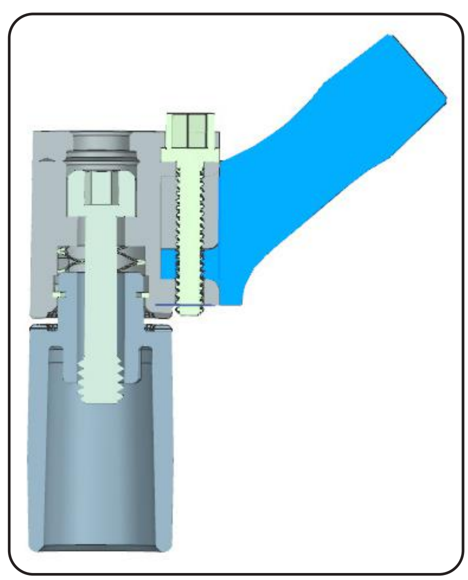
Client:
Smith&Nephew



Gravity Falls

This senior design project focuses on redesigning an existing Security Sliding Door Kit, produced by NGP (National Guard Products), a product that covers windows on doors. The current kit provides privacy by blocking visibility; however, it lacks a ballistic rating. The kit, constructed from steel, includes a 12-gauge sliding door panel that does not meet any bullet-resistance standards with a 10-gauge steel frame with two tracks, one in the top and one in the bottom to secure the sliding door.

Our objective is to improve this product by adding a ballistic rating, reducing production costs, and maintaining compliance with Underwriters Laboratories' UL 10C, the fire test standard for positive pressure fire door assemblies. The redesigned solution introduces a rigid Kevlar® composite panel attached to the door on a set of parallel tracks instead of the original steel frame. Changing from a frame to parallel tracks reduces the amount of welding and grinding required, processes that took a lot of manufacturing time, which lowers labor costs.

The Kevlar® panel is included to meet or exceed Underwriters Laboratories' Level 3 of the UL 752 standard, which is rated as offering protection against medium-powered handguns. The design is retrofit-friendly to ensure easy installation into existing infrastructure with minimal extra effort. In addition to its enhanced protective capabilities, the kit's simplicity ensures mechanical reliability as it requires little to no maintenance. Furthermore, the design is simple enough to be implemented with any size of window and door configuration, making it versatile for any facilities where security and safety is a priority.

Our redesigned Security Sliding Door Kit is well suited for environments such as schools, offices, hospitals, and government buildings where fast response and protection may be needed. Through this project, we aim to strengthen the security of these spaces, ensuring they are better equipped to handle potential threats, even though we hope they will never need to face such events.

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CAD model of prototype redesign

Mech Men

Our team's project was to develop and complete the design, manufacturing, and testing of an alternative solution for the 2024-2025 Design, Build, Fly (DBF) competition, "The X-1 Supersonic Flight Program". The team has worked to meet competition requirements, including carrying multiple "fuel tanks," completing several laps at high speed, and releasing a lightweight glider (the X-1 test vehicle) capable of precise, independent, autonomous landing at designated coordinates.

This year's competition emphasizes high-performance flight, with missions that balance all-up weight, structural integrity, and lap speed. Specifically, Mission 2 (M2) requires robust aircraft design to withstand high g-loads at elevated speeds, guiding our development toward optimized wing loading and streamlined aerodynamics. Mission 3 (M3) further tests the aircraft's control systems, maneuverability, and the released X-1 glider's accuracy and navigation speed to its landing zone.

Initially, our team's approach utilized traditional construction methods using balsa wood and composite materials. However, in an effort to innovate and explore new ideas a strategic pivot toward additive manufacturing (3D printing) was made. This pivot significantly enhanced design capabilities by enabling rapid prototyping and complex geometries previously unattainable through conventional methods. Utilizing materials such as PLA, foaming LW-PLA, and TPU, the mothership is fully 3D printed in modular sections for simplified assembly, rapid replacement, and efficient maintenance.

The resultant aircraft prioritizes agility, structural integrity, and modularity, modeled off a Piper J-3 Cub aircraft incorporating a Clark Y airfoil with a 3-degree angle of attack and a 63" wingspan with 660 square inches of wing area. Trade studies support carrying two fuel tanks, effectively balancing weight, aerodynamics, and structural considerations. The glider (X-1) will utilize a delta wing configuration made from lightweight foam, selected for aerodynamic efficiency and manufacturing ease.

Iterative prototyping and rigorous testing facilitated by additive manufacturing addressed significant technical challenges, ultimately yielding a competition ready aircraft with an overall flight weight of 3.6kg, including the two tanks and glider attached as payload, a stall speed of 22 mph, and a level flight speed of 60 mph.

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AIAA

Shake N' Bake

Team Shake N' Bake is the senior design group tasked with designing and fabricating the rear suspension system for the SAE Tiger Baja car. In short, the SAE Baja team needed a system that would allow for advanced handling along the rough terrain of a Baja course. In this course, there would be sharp turns, large climbs, and long jumps to be made by the speeding car. Because of this, Team Shake N' Bake needed to design a system that could withstand the shock that is experienced by the car repeatedly leaving the ground. After developing some preliminary design concepts, the group settled on an independent rear suspension with two A-shaped control arms of differing lengths. This allows the wheel of the car to have a built-in camber which increases the car's ability to take turns at high speeds. Another feature that increases the vehicle's handling is its toe adjuster. This is an additional rod mounted from the chassis to the wheel's spindle that controls the angle between the tire tread and the plane parallel to the direction of the car. As this value varies, the handling characteristics of the vehicle change. For example, a minor inward adjustment of the wheel's toe can cause a dramatic increase in the vehicle's stability along straight paths at high speeds. This toe control rod is also entirely adjustable, meaning that the Tiger Baja racing team can adjust the toe of the wheel during a brief pit stop. Thus, the ever-changing conditions of a racetrack can be accounted for on-site. A final characteristic of the vehicle suspension is the drawn-steel tubing that composes the A-arms. The hollow tubing allows the suspension to withstand the impact of landing on a single tire from a height of 3 feet without making the suspension overly bulky. This gives the car a strong base without drastically increasing its overall weight.

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THE UNIVERSITY OF MEMPHIS
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Squeaky Clean Crew

Downtime is the leading cause of production inefficiency in manufacturing. Various factors contribute to downtime, including mechanical failures, insufficient parts, and untrained staff. By identifying a specific area for improvement, targeted adjustments can be made to enhance productivity.

To address this, Vanguard Soap has enlisted the Squeaky-Clean Crew to improve efficiency on their liquid-fill soap line by approximately sixty percent.

The team aims to achieve this by implementing a “bad bottle” rejector with an accompanying spacing wheel, eliminating the need to stop the line due to spilled bottles, thus significantly improving uptime and production efficiency.

After passing through the torquing machine, bottles may tip over or have improperly seated caps. If these bottles reach the labeling machine, they could spill, damage additional bottles, and cause production delays. Residual spillage may also result in incorrect labeling. If such bottles are packaged, they risk leaking during shipping.

To prevent these issues, our system utilizes a laser measurement sensor programmed to detect improperly capped or tipped bottles.

When triggered, a multi-arm diverter mechanism pushes defective bottles off the production line onto a rotating circular table. These bottles will then be collected and corrected by a production line worker or removed and disposed.

By reducing production delays and minimizing waste, the “bad bottle” rejector will enhance production efficiency and overall profitability for Vanguard Soap .

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Synergy Solutions

Cell cultivation is a fundamental process in biological research, critical for studying cellular behavior, characterizing viruses and diseases, identifying drugs and vaccines, and testing the effectiveness of various therapeutics. The conditions within the cultivation environment significantly influence the growth, function, and production of cells, closely simulating in vitro conditions. This process is vital for advancing drug and vaccine development, as well as for producing biological compounds and therapeutic proteins, ultimately contributing to the treatment and prevention of medical conditions. In recent years, technologies such as the organ-on-a-chip (OOC) model, which builds on lab-on-a-chip (LOC) principles, have been developed to simulate the cellular activities and mechanics of living organs. These chips provide a dynamic, adaptable environment for growing diverse cell types, offering a promising alternative to traditional cultivation systems.

This project designed a microfluidic pumping system for these cell-culture chips. The purpose of the system is to sustain a cell culture for seven days within the environmental conditions of the incubator (35˚C and ~80% humidity). The cells that concern this project are MDA-MB-231 breast cancer cells, which are derived from a late-stage breast cancer tumor. The fluid medium used in this application is DMEM (Dulbecco's Modified Eagle Medium) with 10% fetal bovine serum. There are two primary necessary criteria for the system: (1) it must create a flow rate range of 0.1-1.0 mL/min, and (2) it must be biocompatible, minimizing contamination. The flow rate is governed by the amount of shear stress that the flow exerts on the cells, which must be less than 0.1 Pa, corresponding to 0.1 – 1.0 mL/min. If the system does not meet these criteria, the cells are at high risk of damage or death from excessive shear stress and/or contamination. The system designed is a closed-loop system that utilizes a peristaltic pump with a heavy-duty motor, a controller arm, and a battery to continuously move the fluid through 1/16" tygon tubing, filters, and the cell-culture chip. This design provides a solution for sustaining a long-term cell culture that is compact, portable, and simple to use.

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THE UNIVERSITY OF MEMPHIS
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Synthetik

The 2024-25 ASHRAE Applied Engineering Challenge is to design and build an innovative carbon capture and utilization module that integrates with existing HVAC&R systems. This challenge centers on the capture of locally produced carbon dioxide for repurposing as a valuable resource while enhancing the sustainability and decarbonization of HVAC&R operations. To address the Challenge, the team has designed and fabricated a carbon capture system with a Modine PDP 175 natural gas heater using soda lime canisters to reduce carbon dioxide emissions. The Modine PDP 175 heater is a high-efficiency unit heater designed to heat commercial and industrial settings. While the heater is effective for space heating, the natural gas combustion produces carbon dioxide, contributing to the greenhouse gas emissions. The objective is to design and evaluate the efficiency of a post-combustion carbon capture system that utilizes soda lime pellets to chemically absorb the carbon dioxide from the heater's exhaust system.

Soda lime is a mixture of calcium hydroxide, sodium hydroxide, and water. It reacts with the carbon dioxide from the exhaust to form calcium carbonate, along with other byproducts, effectively removing the carbon dioxide form the exhaust. Calcium carbonate is used in agriculture to increase calcium levels in soil. The system is designed to be retrofitted to the heater's exhaust, so this solution will be able to be retrofitted to any similar system. The exhaust gas will go through a heat exchanger, which will reduce the temperature and will increase the carbon capture efficiency. The system will then direct a portion of the exhaust into the soda lime canisters, while the rest of the exhaust will proceed out of the existing flue. The reaction efficiency, absorption capacity, and the lifespan of the canisters are the performance metrics under evaluation.

Results from this study could inform future efforts to implement carbon capture solutions in small to medium scale heating systems, reducing the carbon footprint of the user. While soda lime offers a practical and low maintenance method for carbon dioxide absorption, this research will help future efforts in modifying the design and improving the efficiency and reducing the overall cost. This project serves as a foundational step towards integrating carbon capture technology into existing heating infrastructure, contributing to a greener future.

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Client:
Etairos
ASHRAE Memphis Chapter

ASHRAE University of Memphis Student Branch

The Fab Five

Accurate quantification of the forces exerted during spinal surgery is essential for improving procedural safety and efficacy, particularly in maneuvers such as rod reduction and pedicle screw insertion. Currently, surgeons depend on subjective tactile feedback, which can vary widely, leading to inconsistencies in technique. To address this challenge, we propose a smart instrument adapter that captures real-time data on both axial and torsional forces. By integrating seamlessly with existing Medtronic instrumentation, this device aims to enable objective, data-driven insights in cadaveric studies, laying the groundwork for safer spinal surgery practices.

The adapter's principal advantage lies in its potential to mitigate the heightened risk associated with procedures in the cervical spine, where anatomical features are smaller, more mobile, and adjacent to critical anatomy. Real-time force monitoring would allow surgeons to instantly adjust their technique, reducing the chance of overexertion and inadvertent harm to the patient. In a cadaver lab setting, the adapter will collect force data during procedural steps like rod reduction and pedicle screw insertion, helping define safe force thresholds and guiding the refinement of surgical methods. Display of real-time data on the forces and torque exerted during screw insertion would allow the surgeon to adjust pressure instantaneously, reducing the risk of damage that could compromise the integrity of the procedure. By using this adapter in a controlled cadaver lab environment, engineers and surgeons can better understand the range of forces typically required for safe and effective procedures.

Key design considerations for our smart instrument adapter include durability and minimal disruption to surgical workflow. This project advances the integration of objective metrics into spinal surgery, providing a valuable tool for both engineers seeking to refine implants and instruments, and surgeons striving for safer, more predictable outcomes. Ultimately, our wireless, smart instrument adapter represents a significant step forward in surgical innovation, promoting precision and enhancing confidence across a range of spinal procedures.

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The Loose Screws

The Kresling class of structural origami introduces a versatile basis for origami robotic applications. With its multiple stability states, multi-directional bending capabilities, and modularity, the Kresling origami is a strong candidate for soft-robotics applications. In this project, we investigate a range of fabrication methods, material candidates, and modes of magnetic actuation for the fabrication of a multi-directional modular robotic arm comprised of Kresling origami modules.

Our research explores novel fabrication techniques for Kresling origami, expanding the potential for highly reconfigurable soft robotics systems. A defining feature of Kresling origami is its coupled movement; when a Kresling origami rotates, it also translates vertically. Combining the origami's rotational and translational coupled movement with its capability to bend in multiple directions enables six degrees of freedom.

Varying the geometric parameters of the Kresling geometry changes the properties of the origami, such as the number of stable states and strain energy of the system. Modifying the parameters of the geometry to obtain stable properties will build upon the six degrees of freedom of each Kresling origami module to maximize mobility.

Throughout various iterations, 3D-printed and laser-cut Kresling origami of varying geometric parameters were fabricated to achieve Kresling origami with the capability to exploit all six degrees of freedom. 3D-printed Kresling origami panels, fabricated from TPU, feature varying thicknesses to allow for controlled bending. Laser-cut mylar sheets use perforated edges to achieve the same effect. The panels are parallelogrammatic Kresling panels which are then fastened onto 3D-printed PLA baseplates.

Material selection, perforation density, panel thickness, and geometric parameters directly impact stability. Magnetic actuation enables precise and unrestricted control of the Kresling origami modules. Embedding a neodymium disc magnet in the baseplate of each Kresling origami module allows a magnetic field to manipulate the geometry in multiple directions.

A custom-fabricated Helmholtz coil generates a magnetic field that induces a force on the Kresling origami modules via the embedded neodymium magnets. The result is a soft-body robotic arm with a high degree of mobility, functionality, and controllability. Magnetic actuation in Kresling origami unlocks new possibilities for advanced, reconfigurable soft robotics systems.

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The Mechanical Tigers

Our senior design project aims to develop a gravity-powered fan as a sustainable cooling solution for individuals without access to traditional air conditioning. The fan operates using a descending weight that transfers rotational energy through a compound gear system, driving a 12-inch fan blade. By leveraging gravitational potential energy, the design provides reliable airflow to cool a single person for an extended period.

We utilized Siemens NX to modeling and motion analysis to verify and optimize the gear ratios. Our small-scale prototype uses three 3D-printed gears arranged in a 4:1 gear ration with roughly 3-pounds serving as the power source. All components in the prototype aimed to be interference fit. Initially, a solid metal weight was considered, but we opted for a 25-gallon tank that can be filled with rocks, sand, or other dense materials. This design modification allows for easy weight adjustments and the ability to incrementally load the tank in manageable batches.

During prototyping, we encountered challenges, including slippage on the shaft. We mitigated this issue by adding vice grips implanted into our pulley. The scale model provided valuable insights, validating our theoretical calculations and highlighting areas for further refinement.

Since gears follow a linear relationship, we anticipate that scaling up the mechanism will follow a similar pattern. Our small-scale prototype achieves a mechanical advantage of 64, while our full-scale design is projected to exceed a mechanical advantage of 1000 Additionally, we plan to incorporate a stand capable of withstanding the required weight to drive the system. The scale model provided valuable insights, validating our theoretical calculations and highlighting areas for further refinement.

For the full-scale design, we plan to machine all components and implement press-fit bearings using a hydraulic press for improved durability and efficiency. While we initially considered further testing and prototyping, time constraints have limited our scope to the completion of the small-scale prototype. Our focus remains on demonstrating the feasibility of the mechanism and validating our theoretical calculations.

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THE UNIVERSITY OF MEMPHIS
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We're Not In Kansas Anymore

The goal of this project is to design a functional wave generating tank that can be used in testing prototype offshore wind turbine floating structures and begin its construction. The student senior design team will design, analyze, begin to construct, and develop a prototype for a small-scale water wave tank, approximately 8 ft x 4 ft x 4 ft, to emulate ocean waves.

The structure will be designed with the intent of using sturdy acrylic panels and load-bearing frames, ensuring it can hold water and withstand both hydrostatic and hydrodynamic forces generated by the waves. A custom wave-generating actuator will be designed to produce waves of varying amplitudes and speeds. Additionally, the tank will be engineered to support the dynamic load of a person walking inside when the water is drained. Adjustable height footings or wheels will be incorporated to ensure stability on uneven or inclined floors, and a drain valve will be installed for easy water discharge.

The design will include a wave damping structure at one end and the wave generating actuators at the opposite end. All electrical components, including the motor generating the waves, will be adequately protected from water splashes to eliminate electric shock hazards. A structure separate from the acrylic tank will be implemented to make room for the transportation of the tank and the "carry along" capability of the motor and variable frequency drive.

The structure will be made of wood and have a length of 12 feet and a width of 10 feet. Heavy duty adjustable casters will be installed to the support structure for mobility. The custom wave-generating actuator will consist of a two-bar mechanism that connects to the motor. The paddle itself will connect to the floor of the tank via marine grade bearings. The bearings will be supported by acrylic sheets that reinforce the tank to withstand shear stress and loading. Lastly, a drain will be installed to the end face of the tank to allow for efficient draining of the tank.

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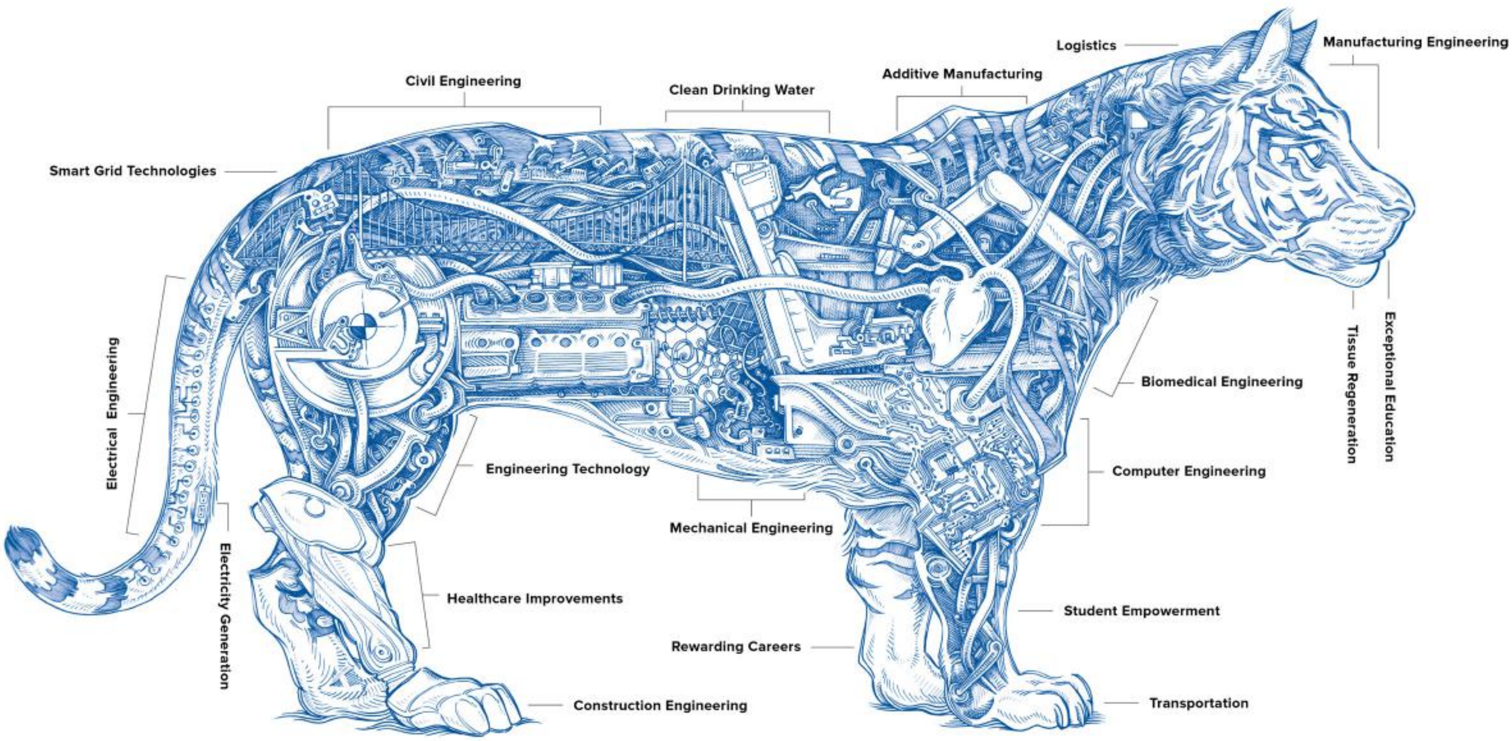

SCAN ME

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