Calvin University

Engineering

The 39th Annual Senior Projects Celebration

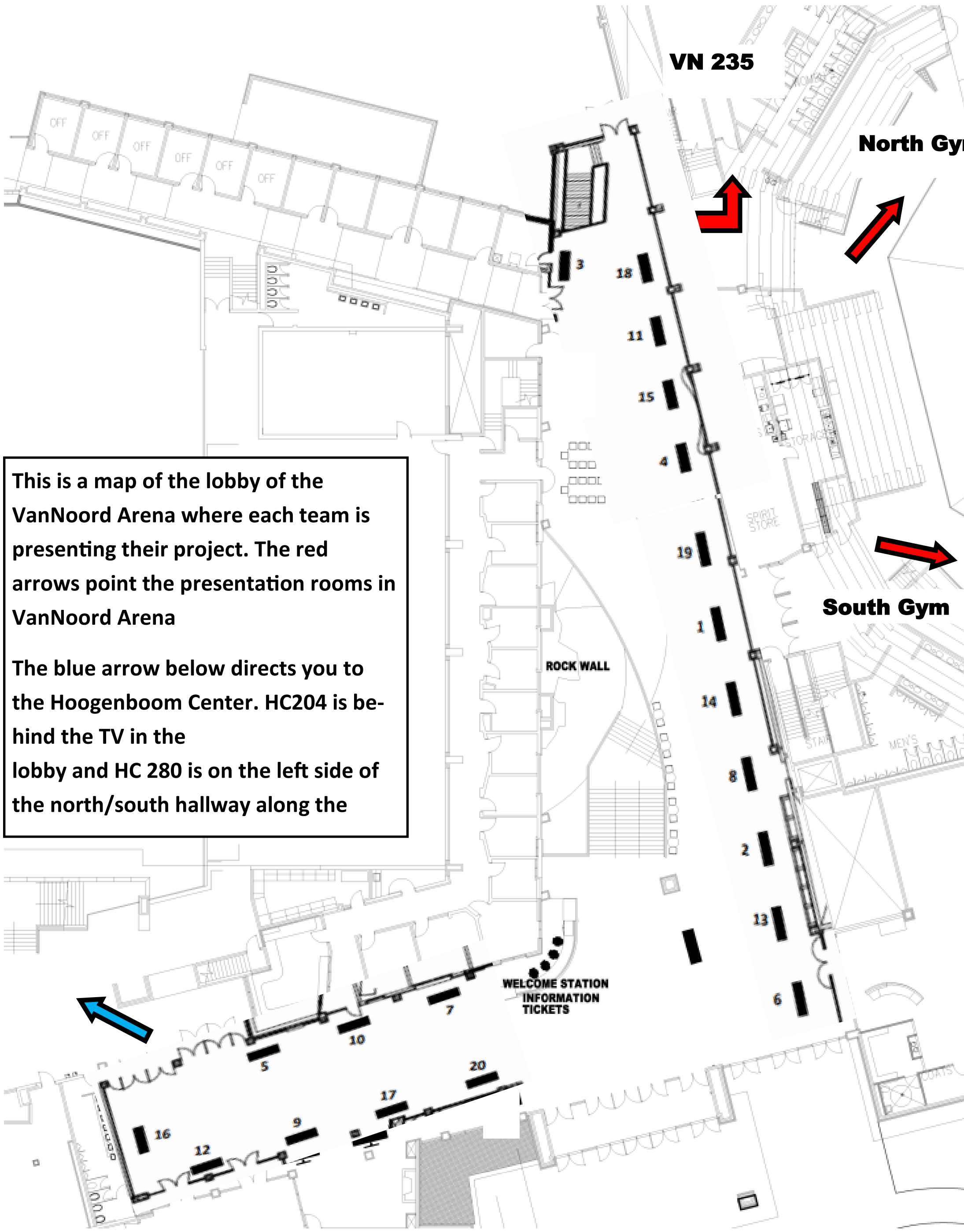
Saturday,

April 15, 2023

Calvin University 1876

This is a map of the lobby of the VanNoord Arena where each team is presenting their project. The red arrows point the presentation rooms in VanNoord Arena

The blue arrow below directs you to the Hoogenboom Center. HC204 is behind the TV in the lobby and HC 280 is on the left side of the north/south hallway along the



For anyone attending the Celebration Ceremony @ 4:00 p.m., please allow time to walk to the CFAC. Follow the arrows on the map to the main entrance of the auditorium. For those needing assistance there will be golf carts available at 3:20 p.m. in front of the main entrance to VanNoord Arena. (South entrance by the circle drive.)

Schedule

1:30—3:45 p.m. ***Prototype Open House — Lobby of Van Noord Arena***

2:00—3:30 p.m. ***Presentations of Projects***

Van Noord Arena North Gym (3 Civil & Environmental & 1 Mechanical)

2:00pm	Team #4	RECS
2:20 pm	Team #3	Hondurraine
2:45 pm	Team #1	$H_2$0nduras
3:10 pm	Team #2	High Efficiency House (mechanical project)

Van Noord Arena South Gym (Mechanical)

2:00 pm	Team #5	Duck-less Dorm Heating
2:20 pm	Team #6	[L]across[e] the Horizon
2:45 pm	Team #7	Light in the [K]Night
3:10 pm	Team #8	Light Work

Hoogenboom Center 280 (Electrical & Computer)

2:00 pm	Team #13	Pork Chops
2:20 pm	Team #12	Plantainer
2:45 pm	Team #10	GNA
3:10 pm	Team #9	Knight Pickup

Van Noord 235 (Mechanical)

2:00 pm	Team #14	Bathroom Booster
2:20 pm	Team #15	Auto Assist
2:45 pm	Team #16	Text2Touch
3:10 pm	Team #17	Free$_2$Breathe

Hoogenboom Center 204 (3 Chemical & 1 Elec./computer)

2:00 pm	Team #20	Insane in the Membrane
2:20 pm	Team #19	The PLAstics
2:45 pm	Team #18	The Cooler Guys
3:10 pm	Team #11	The Weed Assassin (electrical/computer project)

4:00—4:45 p.m. ***Senior Celebration in CFAC Auditorium****

***** Seniors need to make their way to CFAC no later than 3:45 p.m.

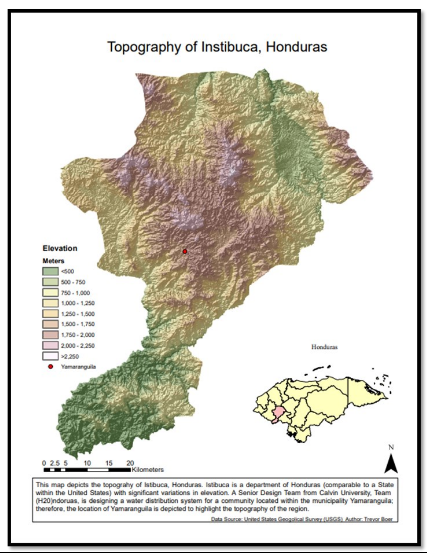
Team 1: H_20nduras

David Bulten, Matt Van Zeelt,

Trevor Boer, Jose Munoz

Team 1 has partnered with a PhD student at the University of Illinois in order to design a fully operational water distribution network for a small, rural community located in Yamaranguila, Honduras known as Las Rilles. Situated on the side of a mountain, this town houses 41 families, a school, and a church. These households currently utilize small individual springs or the river at the base of the community to gather water necessary for basic daily needs. Although spring water is naturally quite clean, there is concern surrounding the quality of water being repeatedly consumed by the community over a long period of time. By creating a unified water distribution system, the entire community will gain access to safe water without having to leave the comfort of their home. It should be noted that the scope of this work is primarily theoretical, but will serve as a starting point for the municipality in order to implement a more refined design in the near future.

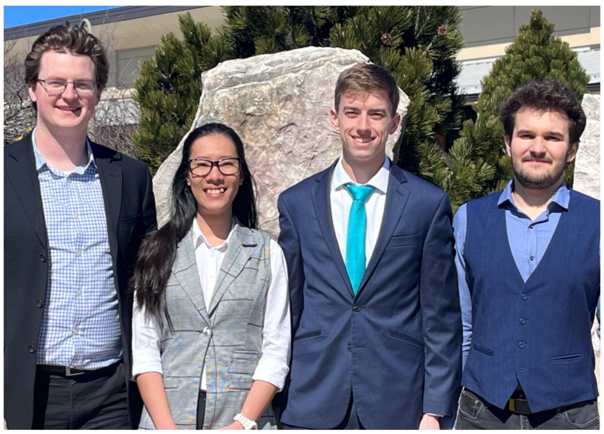
The unique aspect of this project compared to other distribution systems is the extreme topography of the region. The mountainous conditions of Yamaranguila create difficulties when designing due to the elevated pressure within the system and the friction caused by the verticality of the design



The final design of the water distribution system includes an analysis of the topography (shown to the right), a plan sheet of all the necessary pipes, pressure breaking tanks, and water storage tanks, and a spring protection plan/purification plan in order to ensure the water within the spring source is safe to consume and use by the local residents. Additional detail sheets were also drawn to specify the dimensions and material of each component used within the system.

Team 2: High Efficiency Housing

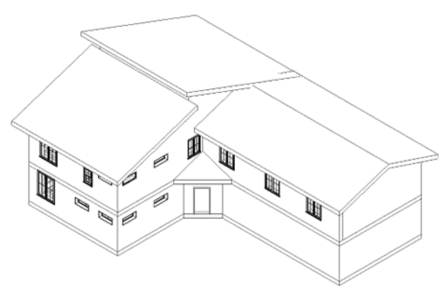
Aidan Bakker, Gia Mien Le,
Nicholas Paternoster, Alin Stoica



Team 2 is comprised of four Mechanical Engineering students who worked together to create a set of recommendations for the design of a high efficiency house. This house is designed to replace the old house that Professor Renard Tubergen and his wife Cheri currently live in. The team considered a variety of different housing systems in their analysis, including advanced framing techniques, different varieties of wall insulation, creating an effective air barrier, and implementing efficient water systems and electrical appliances. These systems were all analyzed to minimize the total cost of building and operating the house over a twenty year period.

The final products of the team's analysis include a sample house design, an example of the optimal wall assembly, and a list of recommendations including which appliances are the most cost effective, how and why to implement an air barrier, everyday energy saving tips, and other key considerations for thermal performance.

High efficiency housing is a subject that has seen great improvements over the last few decades, with new products and techniques becoming well researched and common among green builders. A highly efficient house is not only cheaper to heat and cool, but also creates a more comfortable living environment. Additionally, high efficiency housing helps reduce the CO_2 impact of residential housing, a sector that contributes to 20% of the United State's carbon emissions. Team 2 hopes their project will encourage the consideration and use of high efficiency building techniques to save money, energy, and the environment around us.



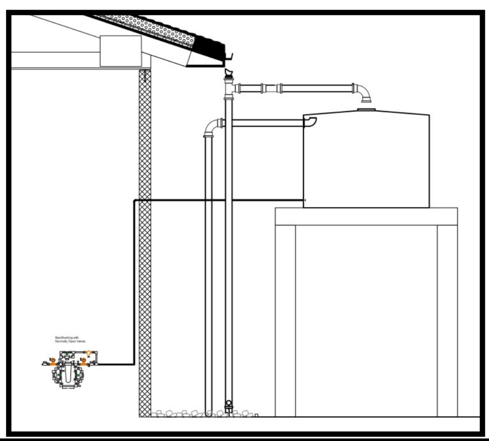
Team 3: Hondurraine

Evan Hsu, Daniela Ampuero Castilla

John Standinger, Megan Gilbert, Peter Chesebro

Team 3 consists of four Civil and Environmental engineering students and one Electrical engineering student. The team partnered with a non-profit organization called Water With Blessings, whose goal is to provide clean drinking water to those in need. Water With Blessings asked Team 3 to develop a roof capture rainwater storage tower with filtration and an automated backflushing system. When the project was first presented, the goal was to create this system for a hospital in Tegucigalpa, Honduras. However, due to communication and scope difficulties, the team decided that it would be best to create a theoretical model of the system to which Water With Blessings could use where needed within a set of parameters that Team 3 would provide.

Using Calvin University's engineering building parameters as the new location provided local access to measurements and local rainfall data. Excel, CAD, SWMM, and RAM Structural Steel were used to design a gutter system, a storage tank, a structure to support and elevate the tank, and the back-flushing piping system for the Sawyer filter. The automated backflushing system consists of Solenoid valves powered by an Arduino UNO Board, each with a parallel manual valve as backup in case of power failure. The proposed system that Team 3 designed will be given to Water With Blessings, to be reviewed and for them to use if so desired.

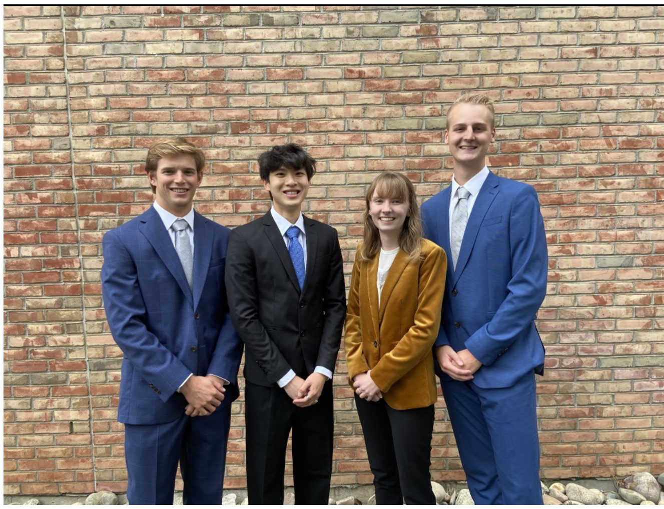


Team 3 is grateful for being one of the recipients for the Eric De Groot fund. They are grateful to Professor DeRooy, Professor Wildschut, Professor Michmerhuizen, Professor Brouwer, and the staff of Water With Blessings for assisting with the project in many ways.

Team 4: RECS

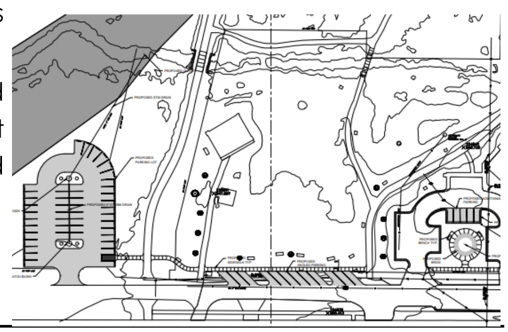
(Responsibly Enhancing Cedar Springs)

James VanHekken, Adrian Poh,
Emma Graham, Jacob Koning



Team 4 consists of four Civil and Environmental engineering students. Team 4 is working with the Community Building Development Team (CBDT) in Cedar Springs, MI to improve the current Heart of Cedar Springs Park. The Team designed new features for the park including a parking lot, on street parking, a pedestrian bridge to replace an existing culvert, and a location for a historical sculpture. In the design process, the Team considered ways to mitigate stormwater runoff from the park, but upon further research, the high water table in the park did not allow for the implementation of Low Impact Development (LID).

Throughout the design process, the Team presented ideas to the CBDT for feedback. The Team partnered with Fleis and VandenBrink Engineering and Moore and Bruggink Consulting Engineers for resources such as general details and a site survey using a LIDAR-equipped drone to generate a surface to be used in AutoCAD Civil 3D. As part of this survey, an orthographic photo was generated for design assistance to locate existing features within the site. Through this process, a final design for the site was drafted and a construction sheet set was produced, with the goal of using these plans as a base for future phases of the park.



Team 4 hopes that this project will help build community in the Cedar Springs area and attract more people to the Heart of Cedar Springs Park and the surrounding businesses.

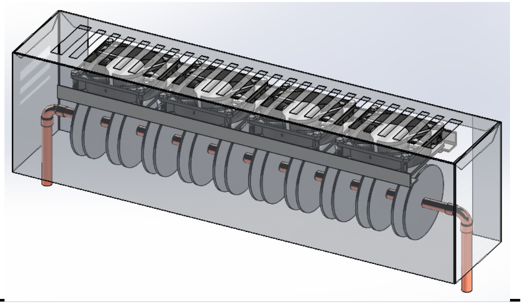
Team 5: Duck-less Dorm Heating

Samuel Hoover, Nicholas Grossmann,

Dat Cao, Zachary Runhaar

Team 5 is comprised of 4 Mechanical Engineers. The goal of this senior design project was to create a new heat distribution system for Calvin University's dormitories. The current system utilizes an array of radiators that distribute heat provided to the system by hot water. The benefit of this system is that it is cost effective, easy to install and easy to maintain. The problem with this system is that there is no effective and efficient way to control how much heat is dispersed into each room. To counteract this, many students open their windows and let the extra heat escape out the window. This practice wastes money and energy by releasing the excess heat to the environment. When thinking about a solution to this problem, Team Duck-less heating wanted to ensure that the new system is cost effective, environmentally friendly, less resource intensive than the existing radiator systems, and puts control of a room's heating back in the hands of those who live and work there.

The design utilizes an array of fans to vary the velocity of air over the radiator. The velocity of airflow over a radiator has a direct relationship with the convective heat transfer coefficient of the heat distribution system. Since students will be able to vary the convective heat transfer coefficient of the system, they will also be able to control the amount of heat being distributed to their room. By using a smaller radiator than the current system with an array of fans, this design will provide students with the ability to effectively control the temperature of their dorm room. This will help Calvin increase the efficiency of the dorm heating system and help the University move towards its goal of becoming a carbon neutral educational institution.

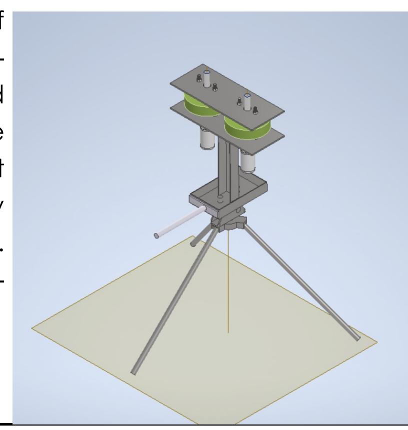


Team 6: [L]Across[e] the Horizon

Sarah MacCarthy, Jessica Camp,
Anne Ghata, Izuchi Ebeku

Team 6 is comprised of mechanical engineering students. Team 6, inspired by the needs of the Calvin lacrosse programs and the insight from lacrosse player, Jessica Camp, decided to create a mechanism to assist in the warm up of lacrosse goalies. With lacrosse, especially women's lacrosse, being an emerging sport in Michigan, it can be very difficult to find a coach qualified and accurate enough to efficiently warm up a goalie. Some of the problems seen are the inaccuracies in warm up shots, as well as shots that are too slow to be beneficial. To combat this, Team 6 decided to build a machine to be operated at variable speed while shooting at multiple locations in a lacrosse goal. The machine would typically be placed 8 meters from the goal to accurately simulate a "free-position shot" in a women's lacrosse game, but it may be placed closer to the goal during the presentation for proof of concept.

In addition, Team 6 hopes to foster sustainability in their design by using more sustainable materials and practices. For example, Team 6 used steel (which has lower carbon emissions during manufacturing and recycling) for the majority of the components except for the drive shaft. To further promote the sustainability of the mechanism nicknamed "ReLAX", Team 6 performed a life cycle assessment on the device to show the recyclability of the device. when it comes to the end of its life. By making the device mostly one material, the device can be recycled and reused. They hope this device will help broaden the game of lacrosse through accessibility and trust in training tools.



Team 7: Light the [K]Night

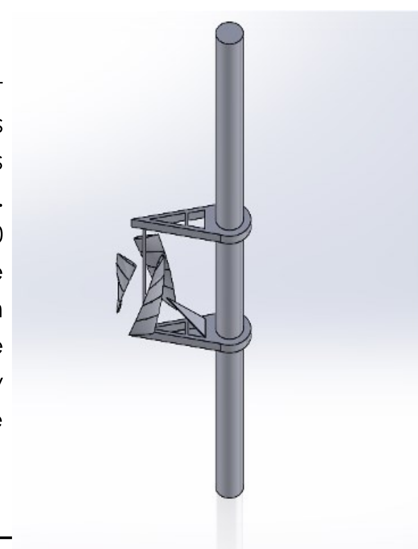
Andrew VanderPloeg, Matthew Carlson,
Kai Barboza, Thomas Noble, Alayna Spiering

Driving at night is inevitable which means the need for lamp posts will never go away. Lamp posts are seen on most roads, but their presence are less frequent on roads that are further away from a grid due to their innate costs. With solar and wind becoming competitors with natural gas, it allows for a natural source of energy to be used.

Team 7's goal is to find a way to power lamp posts using green energy, wind. This will allow for places that are unable to receive the proper amount of light for driving at night to be achieved. Through designing a vertical axis wind turbine, it allows for electricity to be generated through both the wind that comes around the lamp post along with from the velocity of cars.

<u>Design</u>

The vertical axis wind turbine uses 3D printed blades that are connected to a drive shaft that has two ball bearings to allow the rotation from the wind. From this shaft it goes down to the bevel gears, which translate the rotation 90°. It will then travel through gear boxes that achieve a 1:50 ratio for the turn speed. From this it will go through the generator which will turn the rotation into electricity, then will be scaled. The electricity will go through a charge controller that will regulate the output to the battery system. The battery system consists of two batteries, one that will be charging and one that will be discharging.

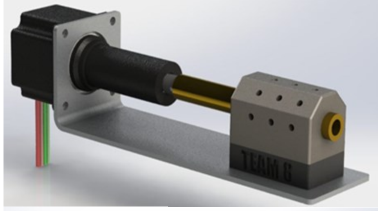


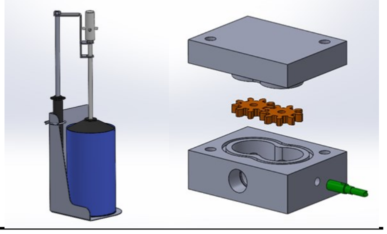
Team 8: Light Work

Ben Casey, Jake Heeres, and James Viel

Team 8 consists of three mechanical engineers from left to right, James Viel, Jake Heeres, and Ben Casey. The team has designed a grease distribution system for an automotive lighting company, Innotec, in Zeeland, Michigan. Currently, Innotec has a manual heavy process that is inefficient with time and resources. If air bubbles are introduced into the system, it causes a vacuum, which stops grease from being applied to the parts. Innotec approached the team in the summer and discussed designing a grease distribution system that could be used to send a measured amount of grease to each part individually during one of the other automated process already in place at Innotec. During this phase, grease needs to be applied to 4-16 parts depending on the size of the mold of the particular part being produced.

The design utilized a high pressure grease pump that would "crush" the air down to a size where it was no longer an issue. The team then designed a station to join the grease pump with a pressurizing cylinder to keep a constant pressure on the grease keg. The grease then flows through a metered flow device that the team also designed. The metered flow device utilized passive gears. It was coded with quadrature to measure the amount of grease that will be distributed by counting the teeth as they passed an inductive proximity sensor. The grease then feeds into the manifold seen below and to the right. This is a CAD example of our 16-cavity manifold with a 17th line with the purpose of purging air-ladened grease out of the system. This manifold design utilizes a grease inlet in the brass spool that flows to a mid section that has a channel for grease to exit. Depending on the linear location of the grease groove, the line which grease will flow out of is determined.

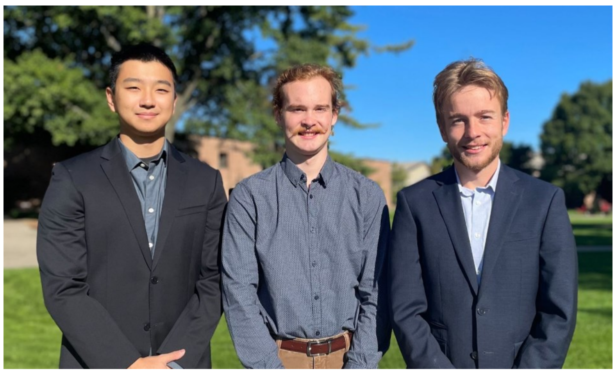




The team tested several different prototypes and concepts to arrive at this idea, and testing proved that the idea works well for dispensing grease effectively.

Team 9: Knight Pickup

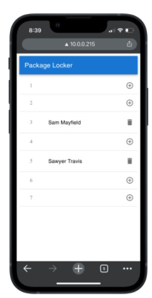
Sam Mayfield, Peter Peng, Sawyer Travis

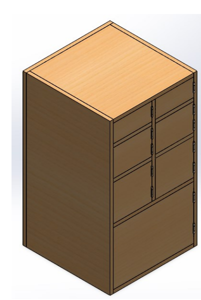


Team 9 designed a parcel locker system prototype for the dorms of Calvin University. The current package delivery system in the dorms limits package pickup to the operating hours of the front desk in each dorm. The process of logging packages also required package information to be entered manually and the prototype was designed to streamline the delivery process.

The locker was built to be portable while highlighting the functionality of the software design during the proof-of-concept phase. The locker was designed to hold seven packages of various sizes. To unlock the correct lockers, an RFID card scanner is connected to a Raspberry Pi single-board computer to allow for scanning of Student ID cards. The design of the locker system allows for students to simply scan their ID card at the locker system of their dorm after receiving an email notification of delivery. The system will then automatically open the lockers linked to the scanned student ID.

For the delivery application, the Team designed a web application that allowed for quick deliveries into the locker. The application allows the delivery driver to view the current status of each locker along with specific information about each package. To make a delivery, the driver would click on an available locker, scan the package barcode, and place the package in the locker that opens automatically.





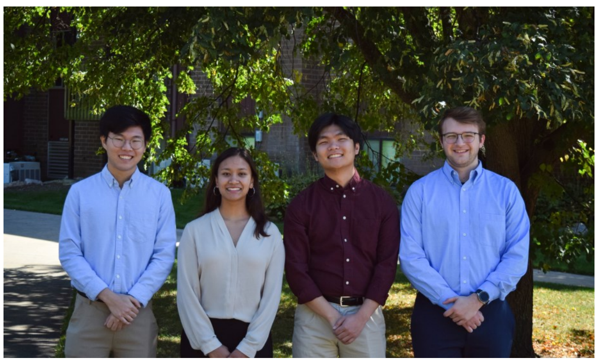
For additional expandability, the locker has been designed so that additional lockers can be placed into a network of lockers that send package delivery data to a centralized database. Each interaction with the locker network is logged in a Google Sheet.

The Team would like to thank Mark Michmerhuizen, Chris Sorenson, Eric Walstra, and Calvin Mail Services for their support.

Team 10: GNA

Ezra Kim, Micah Lee,

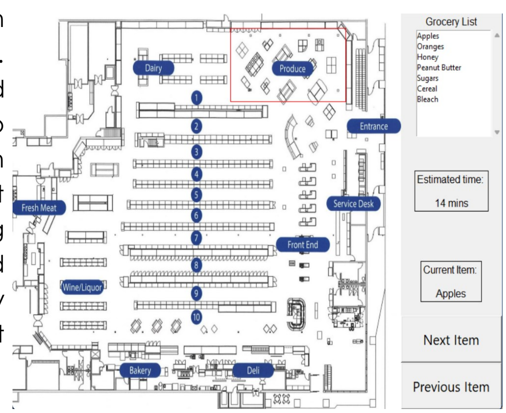
Anjana Sainju, Matthew Sulka



Team 10 consists of one Mechanical and three Electrical engineering students. The team's objective is to create an interactive, digital interface capable of reducing the overall shopping time for grocery shoppers. The device is called "GNA" (Grocery Navigation Assistant). It will be attached to a shopping cart in the store and help the user navigate to their desired grocery products, with each product's general locations highlighted on a digital display on the device.

Our team chose a design that primarily revolved around communication between a Raspberry Pi 3 Model B (a compact, single-board computer for prototyping) and a customer's personal mobile phone. The customer would create a grocery list on a mobile application developed by our team. In the initial screen, the shopping cart would greet the user with a QR code, which they would scan using their mobile application, sending the grocery list from the phone to the GNA. The grocery list would then be automatically sorted, generating an optimal pathway for minimal shopping time.

The device has been optimized for ease of interaction between the customer and the product. Communication between the mobile application and the GNA is established through a lightweight server to minimize the customer's effort and time consumption while transferring the data. The mechanism that mounts the GNA onto the cart utilizes a clamping system similar to a workshop vise for longevity and simplicity. The 10-inch touchscreen display additionally allows for ease of interaction with the device, without the need of other bulky peripherals.

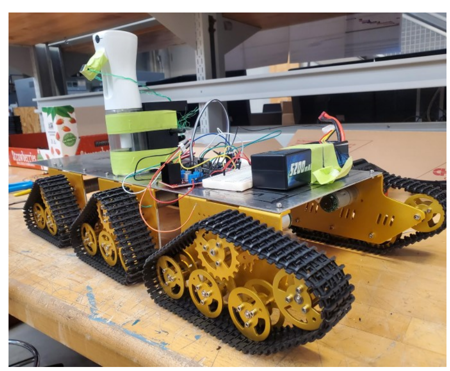


Team 11: The Weed Assassin

Amanuel Chanie, Chima Ochiagha,
Mark Bekhet, Nana Ama Atobrah

The agricultural industry has seen massive improvements in crop production efficiency over the past 30 years with technological advancements. This led to a global increase in the crop yield per acre but also introduced some technologies that threaten to put our environment at risk. Over the past 10 years, there has been an emerging focus on implementing environmentally friendly designs to maintain this increased efficiency while being mindful of the environmental impact.

In the same vein, team 11 has set out to tackle one of these novel technology applications with the design and implementation of The Weed Assassin. This automated ground vehicle is designed to move between rows of crops to identify and spray weeds with herbicide. This would allow farms to efficiently dispense herbicide, reducing the time and cost of manual weeding or reducing the cost of mass spraying of herbicides. Furthermore, the targeted herbicide usage would reduce the problematic situation created by excessive herbicide runoff polluting the ecosystem near farmlands.



The vehicle is powered by a lithium-ion rechargeable battery. Once placed at its initial starting point at the beginning of a corner row, it navigates through each row. It identifies the weeds using machine-learning model software integrated with a camera system. It is also equipped with an automated nozzle system to spray the herbicide upon recognizing weeds.

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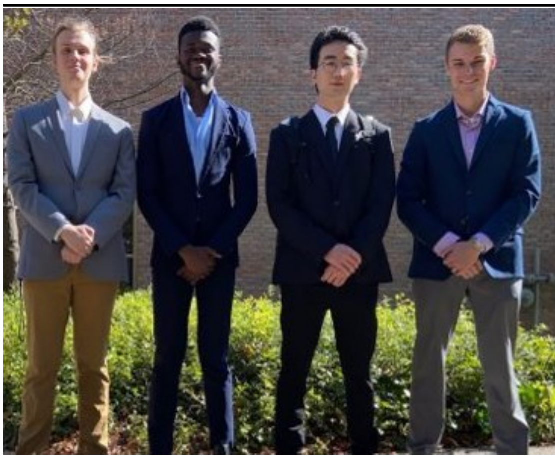
Team 12: Plantainer

Eric Brouwer, Haocheng Jin,

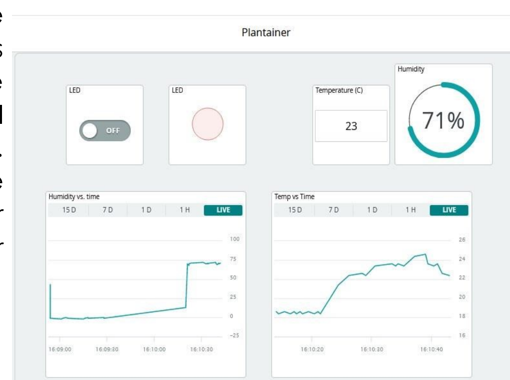
Jaden Vanderwerff, Omari Nyarko



Team 12 is comprised of four Electrical and Computer engineering students. The name of Team 12's project is "Plantainer," meaning a small container for plants. The Team has designed an automated system that delivers light and water to small plants, focusing specifically on data collection and presentation.

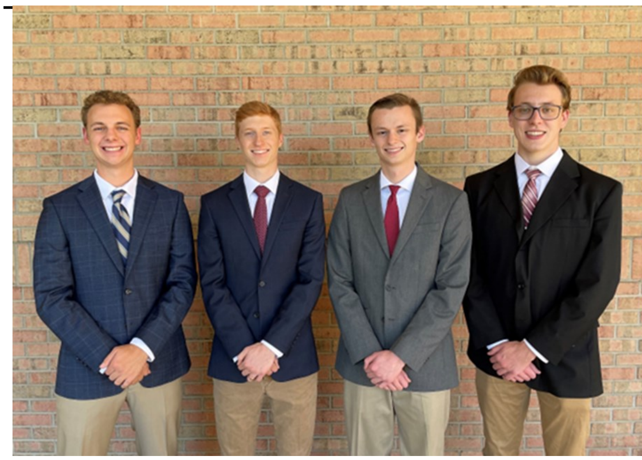
The goal was to build a system that provides useful data to the customer about their plant and requires minimal input from the user during the plant's growth. The four main areas of the design are automated lighting and watering, data collection, capturing pictures of the plant, and an external user interface that presents data to the user. The system allows for the full growth of a plant with as little intervention as possible from the user. The design consists of a container for a plant in addition to an Arduino microcontroller, 2MP ArduCAM camera, temperature sensor, humidity sensor, overhead LED's, and a small submersible pump. Irrigation, lighting, and data collection processes are all automated. The only necessary input from the user is the refilling of the water reservoir, in addition to normal maintenance for the plant (changing soil, etc.)

A user interface accessible via WiFi displays the live data from the sensors. With this product, users will be able to learn more about the plants they're growing and learn how to best care for them, all without needing to remember to water the plant. The target customers for this product are anyone who wants to learn about the conditions their plant needs without needing to constantly water the plant.



Team 13: Pork Chops

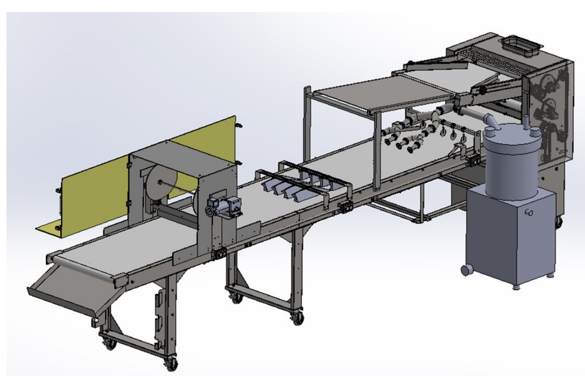
Braden Kopenkoskey, Ryan Storteboom,
Jacob Van Wyngarden, Jonathan Washburn



Team 13 is partnered with South Olive Christian School in Holland, Michigan to create a pigs in a blanket making machine. In order to help keep their tuition affordable for lower income families, South Olive Christian School produces and sells pigs in a blanket to the community as a year-round fundraiser. Manually producing pigs in a blanket is a time intensive process that requires a lot of work from volunteers. An automated machine to create the pigs in a blanket will help the school increase production to meet product demand.

Team 13 built the machine on a twelve-foot conveyor that takes dough lumps, flattens them out, and sends them down the conveyor. Dough cutters cut the dough into four strips and a sausage stuffer extrudes sausage through piping onto each strip. Then the dough is flipped over the sausage to fully enclose it. Finally, the pigs in a blanket are cut with a vertical chopper to create the final product. This allows the machine to produce four pigs in a blanket at a time, producing 1200 pigs in a blanket per hour.

Considerations were made to ensure the machine met all FDA food codes and OSHA regulations. Emergency stops were implemented to cut power if guarding was not in place. Along with the final machine, the team delivered a maintenance guide that details all components along with common maintenance instructions and troubleshooting tips.



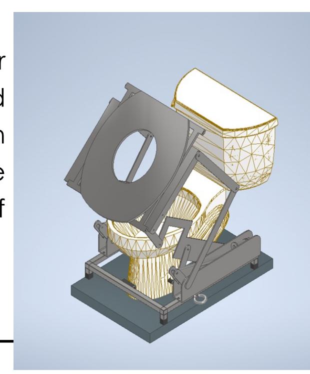
Team 14: Bathroom Booster

Jordan Tuter, Caleb Styf,
Claire Sheppard, Sawyer Masselink

Team 14, comprised of four Mechanical Engineering students, have designed the Bathroom Booster. This project has created a power assisted toilet seat lift, designed to aid in the transitioning of an individual, with limited lower mobility, to a seated position on the toilet and then returning them back to a standing position. Optimized for a residential setting, the Bathroom Booster allows for easier and safer use of bathroom facilities while also providing independence and comfort. This design project was inspired by each member's personal experience with elderly relatives suffering from lower geriatric issues and mobility in hopes of creating a more affordable product option.

The design of the Bathroom Booster was developed from a combination of models from power lift recliners and a chair lift concept from the IEEE (Institute of Electrical and Electronics Engineers). Team 14's design uses three distinct four bar linkages machined from cold rolled steel, connected in tandem, and driven by two linear actuators. This design was chosen as it best mimics the path of motion that a human uses when sitting and standing, avoiding additional stresses on the legs. There are stabilizers connected to the base frame so there is a reduced chance of tipping over, in addition to a reworked walker frame to provide additional points of contact and security.

The operation of the Bathroom Booster is very simple. Both linear actuators are powered by a single remote control to raise and lower. It is powered using a traditional household outlet that can be found in any bathroom. Upon completion of the product, the Bathroom Booster will successfully aid in the raising and lowering of an individual from the bathroom seat.

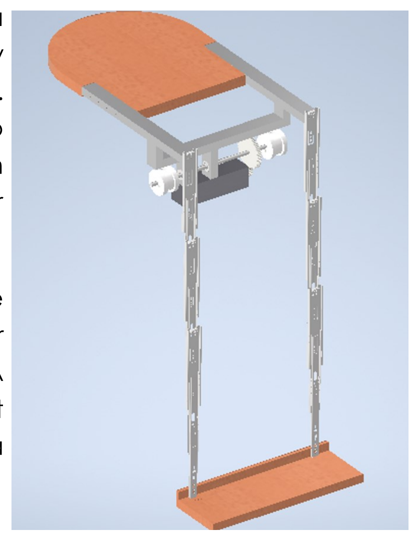


Team 15: Auto Assist

Ryan MacIntyre, Sara VanSolkema,
Elise Miera, Ian VanderKooi,

Members of the elderly population face difficulties when entering and exiting vehicles. Due to this challenge, the elderly are unable to travel easily and do regular, everyday tasks. Team 15 aimed to solve this problem by designing a safe and simple device that straps onto the passenger seat of a vehicle. The specifications for Team 15's client, Jeanne Lewter, included a system which would lift her feet over the threshold of the car and rotate her to a forward-facing orientation.

After a few different design iterations, the final design consisted of a swiveling seat and a motorized pulley system—powered by a 12-V battery—to lift the feet of the user. The foot-lifting action was designed so that the user's feet would be raised in a comfortable and safe manner by ensuring that the lifting speed was within a desired range. High-strength rope was used in the pulley system due to its flexibility and load-bearing capacity. Drawer slides were used as a guide for the rope and to provide stability as the feet of the user are raised. An Arduino and an intuitive controller interface allow the user to operate the device's lifting mechanism.



The Auto Assist device was purposefully designed to be compatible with the Lewter's Buick Envision so that no major modifications would need to be made to the car itself. A proof of concept prototype was constructed and built within the constraints of the car's dimensions, ensuring a proper fit for safe use.

Team 16: Text2Touch

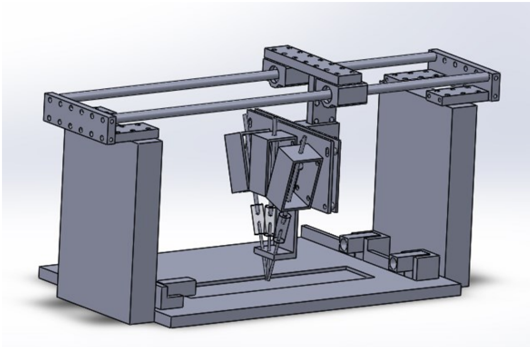
Anthony Nykamp, Aubree Jo Peters, Christine Van Oyen, Owen Pruim

Team Text2Touch designed a braille printer for the visually impaired. The team recognized that braille printers are far too expensive for the typical household and are uncommon in public facilities such as libraries. The team sees this limited access to resources as an injustice and set out to create an affordable braille printer that fulfills a need in the visually impaired community.

The team consists of three mechanical engineers and one electrical engineer that worked together to design and construct a prototype of this printer. The project consisted of building a printer using an XY translating table with an embossing mechanism mounted to it. The mounting system was designed in a CAD software and 3D printed. The embossing mechanism is comprised of three solenoids that perform the punches of the braille characters.

The printer is controlled by an Arduino Uno board, which is programmed to receive text via serial communication, translate the text to braille, and print the text that it receives by moving and firing solenoid punches. The punches are moved using a stepper motor that is controlled using the Arduino board and a motor controller chip. The three solenoids are controlled individually from the digital outputs on the Arduino, and transistors were used to switch the solenoids on and off.

Affordability and sustainability were at the forefront of the design. Strategic decisions were made in selecting recyclable materials to consider the end-of-life of the printer. Furthermore, the printer is estimated to cost a fraction of the market price, giving individuals the opportunity to print and read braille documents at their convenience.



Team 17: Free$_2$Breathe

Nate Anderson, Jordan Alexander,
Anna Giboney, Ben DeWeerd

Despite advancements in health and technology, 3.2 million people die each year from air pollutants, particularly carbon monoxide, sulfur dioxide, ozone, and nitrogen dioxide. Exposure to high concentrations of these gases can result in death within minutes but many illnesses, including chronic obstructive pulmonary disease, lung cancer, and respiratory infection, occur due to long-term exposure to lower concentrations.

A comprehensive solution to reducing air pollution concentrations would involve a large-scale reduction in the burning of fossil fuels, a method of cleaning the air, or some combination of the two. However, the first step in solving the problem is identifying and confirming that there is a problem. While some people living in large dense urban areas may suspect that they are surrounded by dangerously high levels of air pollutants, only expensive, overly-complicated measuring devices are available to verify that suspicion. Without confirmation of dangerous conditions, people are unlikely to change their lifestyle. To reduce the number of lives at risk, the first step is equipping everyday citizens to detect hazardous levels of these air pollutants.

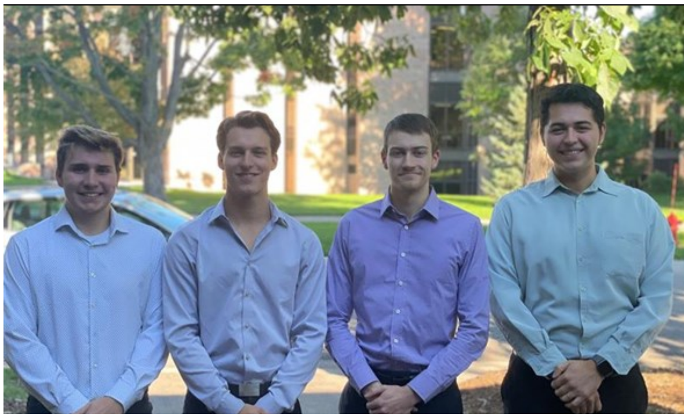
Team 17 is comprised of two mechanical engineers and two electrical and computer engineers. Their detector, Free$_2$Breathe, informs the user of the surrounding air quality, without requiring prior technical knowledge.

With access to a Free$_2$Breathe device, communities can be informed about the dangers in their environment and either adjust their lifestyle to reduce exposure or avoid areas with concentrated air pollution.

Team 18: The Cooler Guys

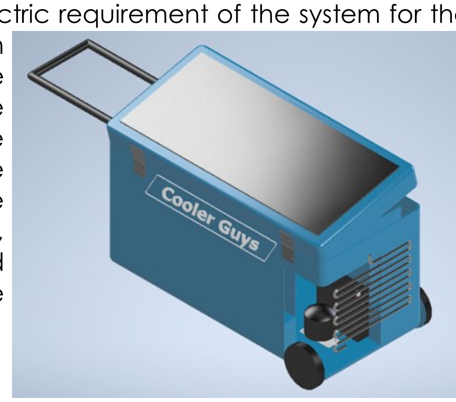
Jared Ruba, Reid Veneman,

Liam Austin, Yeoshua Villars



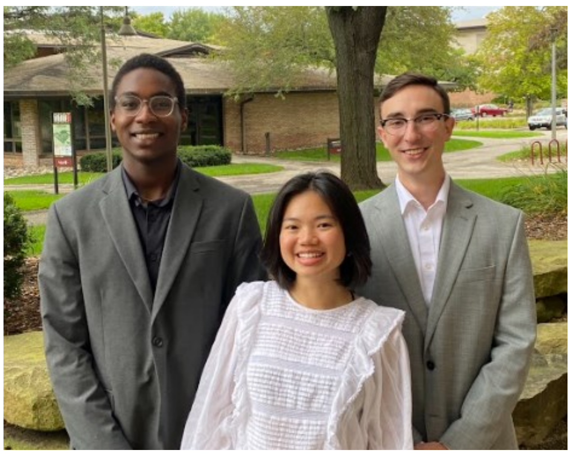
Refrigeration is a serious global problem, specifically in developing countries or areas which have been the site of natural disasters. Both of these scenarios lack a stable power grid, which makes refrigerating key items such as food, medication, or vaccines near impossible, as they must be kept at specific temperatures. As a way to combat this issue, Team 18, The Cooler Guys, designed a portable refrigeration cooling system that can be charged using photovoltaic panels. The team used a compressor and evaporator as the base of the refrigeration system, a solar panel, signal rectifier, and signal inverter as the electrical power system and a conventional cooler as the casing. A sealed lead-acid battery of 12V and 18Ah was connected to a 12V DC-120V AC inverter to power the compressor. The team decided to utilize the free and mostly accessible energy that the sun provides to power the battery by using a 100 W photovoltaic panel and a signal rectifier to retroactively charge the battery while there is sunlight.

They calculated R-values to determine the heat loss of the "cooler" to see how often the compressor needs to turn on, as well as the heat transfer rates to determine how long it needs to be on for. The team also calculated the electric requirement of the system for the compressor to work properly and how much electricity must be generated from solar to charge the battery to completion. The team designed the concept in Inventor to know how to install all the components together to consequently install all the equipment together. The final design needed to be trustworthy and safe, so the team researched OSHA, NFPA/NEC, and UL safety requirements and incorporated safety protocols to protect the operator.



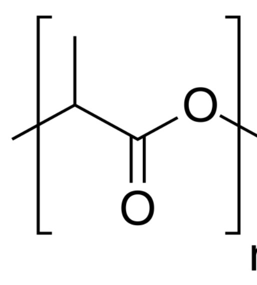
Team 19: The PLAstics

William Toomey, Audrey Tran, Adam Gagliardo



Team 19, comprised of three Chemical engineering students, designed a hypothetical plant to manufacture polylactic acid (PLA). Polylactic acid is a biodegradable polymer derived from renewable sources, such as corn or sugarcane. PLA has comparable mechanical properties to fossil-based resin which makes it ideal for 3D filament, food packaging, textiles, or medical applications. Industrially compostable products like PLA, or other types of bioplastic, follow an innovative concept called "Cradle to Cradle". This means that the materials get fed back into the Earth at the end of their life cycle, creating a closed-loop cycle that eliminates extra waste.

The design involves a 2-step process: lactic acid to lactide through condensation, and lactide to PLA through polymerization. The quality of L-lactide, and the chemical changes induced in polymerization are all crucial parameters for controlling the properties of the PLA pellets. In the first reaction, unwanted products such as M-, or D-lactide are minimized by running reaction at a high temperature and low residence time. For the second reaction step, a zinc complex of (imidazo[1,5-a] pyrid-3-yl) phenol was used as the catalyst. This new catalyst option from published literature offers an advantage of a high reaction rate, while also being a more environmentally friendly option compared to the commonly used $Sn(Oct)_2$.



In order to enter the established market of biodegradable plastics and generate a reasonable profit for this design project, we have scaled our plant to produce 11,300 tons of PLA per year.

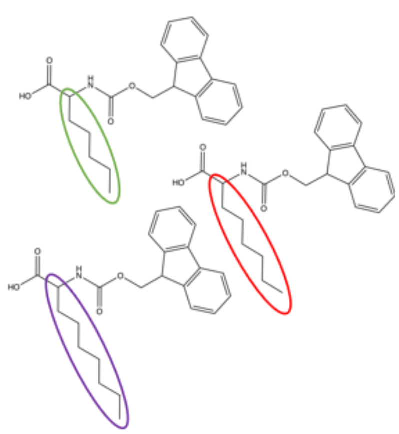
Team 20: Insane In the Membrane

Carson Warners, Isaac Timmer, Dane Hubers

Team 20, Insane in the Membrane, designed and simulated a process for the production of three aliphatic artificial amino acids, two of which are novel compounds not yet on the market.

Many medical solutions are delivered ineffectively throughout the body. This can lead to expensive resources being wasted as well as negative side effects for patients. These problems can be solved through the use of specialized amino acids which carry drugs to specific cells by using a custom side chain that targets cell membranes. Team 20 worked diligently to design a chemical plant that was safe and flexible, allowing for the production of custom amino acids on request by consumers.

Team 20 designed a multi step batch process to convert readily available carboxylic acids into high value custom amino acids. The plant was designed with interchangeable equipment in order to minimize any down time in production due to equipment failure and maximize fluidity between the production of the three unique products. Additionally, the interstage separations allows the process to recycle the vast majority of unreacted reagents in each step.



Our plant was designed to fit on a property in East St. Louis where there is access to delivery via river, railroad, or truck. This location allows us to be near producers of our feed materials to help save money and reduce carbon emissions in shipping. Team 20 also made sure to help give back to the surrounding community through awareness of local needs and working to meet these needs.

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