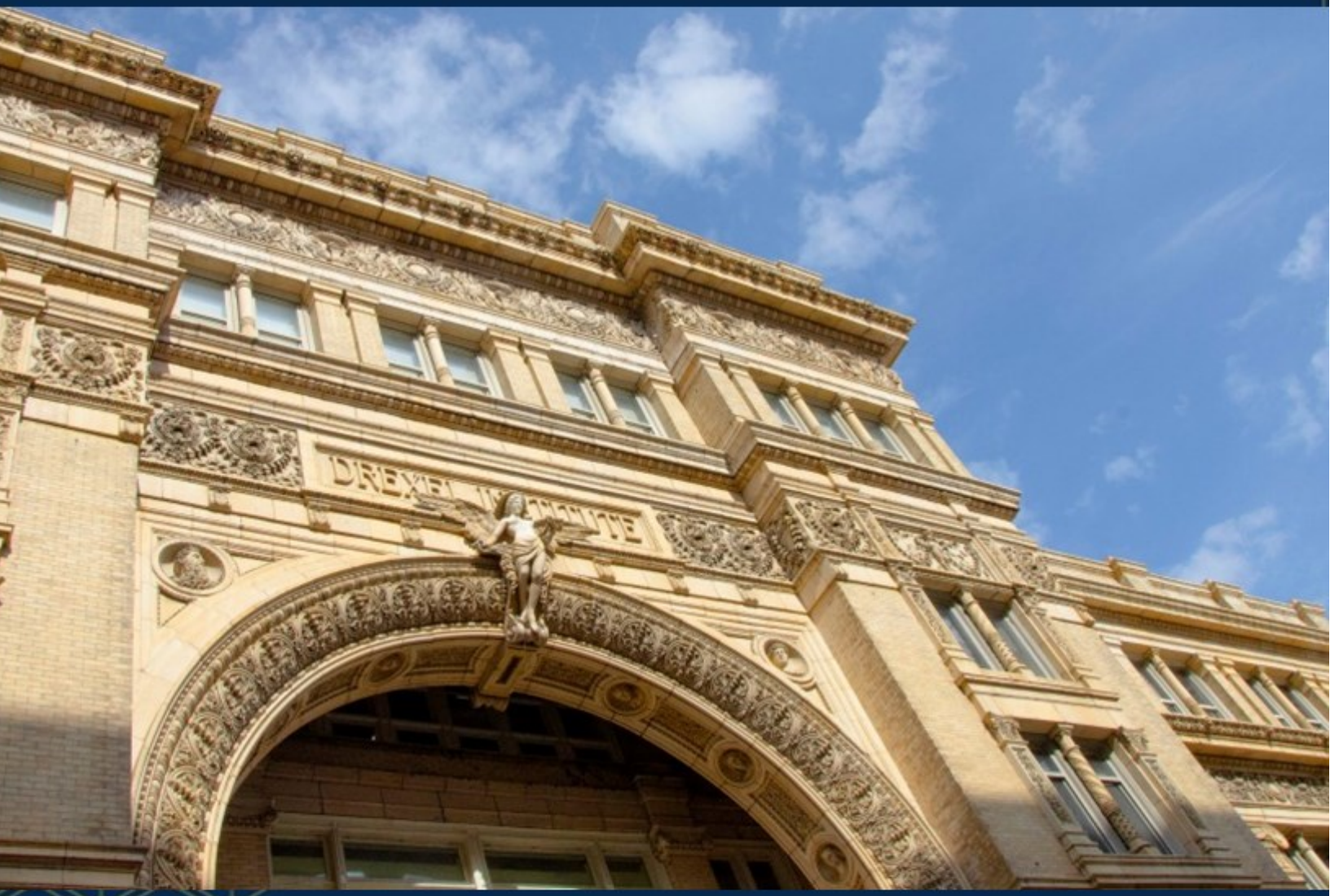
2020-2021

Celebration of Engineering Design

June 3, 2020
1:00 pm – 3:00 pm



DREXEL UNIVERSITY
College of
Engineering

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ABSTRACTS

MEM – 01

Slot-Die Coater Retrofit for Perovskite Lab Testing - Session I

Rocco Fucetola, Jagjot Singh Kamra, Jake Topel, Brian Walsh, Drake Wilson, Dr. Moses Noh and Dr. Jason Baxter

As the world looks toward clean energy sources, it is becoming increasingly important to develop competitive manufacturing abilities for renewables. While silicon-based photovoltaics currently have a hold on the solar market, perovskites, organic-inorganic alternatives, now experience competitive efficiencies and hold better processability. However, these benefits have only been realized in labs with energy-intensive processes that are not scalable to commercial production. Therefore, continued lab research calls for an apparatus that utilizes proven industry production methods to realize perovskite benefits with competitive cost on both lab and industrial scales. The objective herein is to design a tabletop apparatus to manufacture micro-scale film perovskites with commercial methods. Industrial coating methods commonly opt for slot-die coating which utilize fluid delivery from reservoirs to stationary die heads to provide uniform thickness within tens of nanometers. This project will use such a die head in conjunction with a syringe pump and motor-driven conveyor. The syringe pump will provide precision ink flow to the die head while the conveyor belt will work to translate glass substrate underneath the die head to be coated. These systems will then be integrated via a control system that provides users with a range of control over both belt speed and coating thickness. Beyond this dynamic control, a mix of machining and micrometer gauges will calibrate the overall structure to uphold the tight geometric tolerances required to sustain micro-scale film. Once produced, this tabletop apparatus will provide the template necessary to translate lab perovskite production to a competitive commercial market.

MEM – 02

Digester Design for a Commercial Biogas Appliance - Session II

Sebastian Carta, Vincenzo Cavallaro, Michael Buoni and Dr. Peter Clelland

Food waste is a growing problem for businesses and the environment. It can make up around a quarter of a restaurant's trash and usually ends up decomposing in landfills where it contributes 15% of all US methane emissions. Anaerobic digestion is the process of breaking down organic waste in a sealed environment to produce biogas. According to the International Energy Agency, anaerobic digestion is an expanding form of renewable energy that will meet 13% of the world's energy needs by 2040. However, the solutions that currently exist are limited. Large waste treatment plants require fleets of trucks to transport hundreds of pounds of food waste from many different sites. Also, current home-use digesters utilize a simple design that restricts their efficiency. The BioBox project aims to combine the size and accessibility of home-use digesters with the techniques of large-scale treatment plants. By developing a digester model and conducting operational analysis on the design, the project will verify that this digester can utilize an automated control system to efficiently produce biogas within a small digester volume. This will be done by separating different families of microbes to keep them in their preferred environment and increase methane output. The controls system will monitor the same key measurements as large-scale digesters to improve the health of the bacteria colonies and optimize performance. The digester design is an essential first step for creating a product that allows businesses to take full advantage of the energy potential in their food waste.

ABSTRACTS

MEM – 03

Control and Mechanical Limiter for Medical Cast Saw - Session III

Diana Chang, Byong Woo (David) Choi, Patrick Han, Shuo (Carl) Hu, Tao Yan, Dr. J. Todd Lawrence (CHOP), Dr. David Horn (CHOP) and Dr. Li-Hsin (Leo) Han

There have been reported incidents of burning and overcutting of a patient's skin during cast removal. These injuries are commonly caused by an increase in frictional heat on the blade as it cuts through the cast. The high temperature of the blade can burn the patient's skin. Children tend to flinch during the cast removal procedure due to sound or vibrations coming from the cast, which can cause the user to accidentally cut or burn the patient's skin. Subsequently, one-sided lawsuits are filed against these doctors costing hospitals thousands of dollars in settlement fees per case. Our objective is to minimize the Stryker 940 cast-saw-involved accidents during cast-removal procedures. This will be done by designing (i) a mechanical limiter to physically limit the distance of the exposed blade and (ii) a control limiter to warn the doctor when the saw gets too close to the skin.

The Mechanical Limiter is a blade distance limiting apparatus for the Stryker 940 cast saw to prevent injuries during the cast removal procedure. The prototype will both limit the exposure of the blade length and be compatible with other cast saws. The user will be able to control the blade's exposure by scrolling their thumb on the extruding gear on the back of the hood then clicks the gear into place, stabilizing the blade limiter. The group will use ABAQUS software to perform finite element analysis for this design.

The Control Limiter will warn the user whenever the saw touches the silver fabric. Unlike the current cast, the new design consists of three layers: stockinette, silver fabric, and fiberglass. Once the blade cuts through the fiberglass and contacts the silver fabric, the voltage will change because the fabric is conductive. The programmed Arduino will be able to detect these signal changes and provide users with feedback through LED and Buzzer. It will also count the times that the blade comes in contact with the fabric. The group will use MATLAB Simulink to run simulation tests on the control feedback system.

MEM – 04

Robotic Camera Dolly - Session I

Timothy Campanella, Kevin Connell, Samuel Estrin, Yash Patel and Dr. Bor-Chin Chang

In the film industry, camera dollies are used for precise and smooth filming with ease, which enables a 33-billion-dollar industry. The current film industry makes use of a few different types of filming solutions, which include, robotic arms, dollies on sliding rails, and tripods. However, none of these solutions provide the full range of motion that the Robotic Camera Dolly could provide. Unfortunately, current camera dolly systems are expensive, inflexible, and time consuming to operate. These shortcomings can be resolved if the camera is manipulated by a free-standing automated robotic platform. The objective of the Robotic Camera Dolly Project is to develop an alternative to existing solutions which combines the repeatability and autonomy of robotic camera arms with the flexibility of a tripod. This project will evaluate various means of robotic locomotion and camera manipulation on a robotic drive base to determine which systems provide the smoothest and most precise motion at the lowest cost and complexity while retaining five degrees of freedom. Beyond this, analysis is done into the dynamics and kinematics of the system as well as sensor fusion and system localization. This is accomplished with the aid of encoders and microcontrollers. This project evaluates each component of the robotic system, how it can be constructed, and how it can be controlled and operated.

ABSTRACTS

MEM – 05

Simpli-Fed Automatic Wet Food Feeder for Cats and Dogs - Session I

Anwar Hasan, Matthew Pellegrini, Shawn Meier, John O'Brien, and Dr. Roger Marino

Food dispensers for pets are devices that distribute a pre-determined amount of food. Typically, food is held in a containment area such as a tray or hopper until dispensed. The dispersion can be triggered by an automated sensor and dispensed via a mechanical device, or a gravity assisted system. Food dispensers are utilized by pet owners to alleviate the burden of manual feeding. This enables more freedom and flexibility of schedule with minimal effect to the pet's feeding schedule. Unfortunately, many pet food dispensers are designed to dispense dry animal food. The remaining products that dispense wet animal food display limited capability to correctly store wet animal food. This could be improved if the systems were constructed with stable refrigeration methods and the ability to dispense semi-solids. Simpli-fed's goal is to construct an automated food dispenser with built-in refrigeration capabilities to deliver cooled semi-solid foods. The core constraints of the designs were safety, hygienic, and easy to clean. The system is comprised of a thermoelectric cooler, integrated with a weight distribution control system that allows for accurate extrusion of cooled food. The findings indicate that thermoelectric coolers provide enough thermal heat transfer for the designed size. Initial research into the distribution control has validated the potential of extrusion method by experimentation. Targeted weight dispensing, with easy to set functionality will be available in subsequent tests.

MEM – 06

Room Occupancy Counter for The Covid-19 Pandemic - Session III

Alex Ley, Jay Patel, Zackary Jones and Dr. Jack G. Zhou

According to recent statistics on COVID-19 cases in the United States, the infection rate of the virus is still on the rise and remains a problem to the everyday consumer and people returning to work because of how easily the strain can spread, as well as how deadly it is to many groups.

Despite the precautions taken and products designed to prevent the spread of the virus, it would seem more still needs to be done. Therefore, the implementation of an automatic alert system in enclosed public spaces could be beneficial to everyone's health and safety, which this paper will explain.

Based on the design and functionality of ultrasonic sensors, it is plausible to make a simple device to detect the amount of people entering and leaving a building or room. As of now, there are currently several devices that incorporate motion sensing and people-counting utilizing high-tech software. While it presents a solution to the existing problem that this paper is studying, the disadvantages of these products are the design, complexity, and cost. Not many businesses can afford to utilize these products. Therefore, an alternative to them is a simple door based device for a fraction of the cost. The affordability of this design is based on its material and method of counting. The approach for this is to make use of Arduino coding. We will be presenting a theoretical and simulative method of preventing the spread of COVID-19 through the use of ultrasonic sensors.

ABSTRACTS

MEM – 07

Peripheral Orbital Robotics Tool (P.O.R.T) - Session I

Kevin Fennimore, William Landi, Adam Ruesch, Jared Scaturo, Matthew Seidman and Dr. Ajmal Yousuff

External NASA Advisors - Bryan J. Roberts, Russell M. Snyder

With the rise of commercial spaceflight, the need for modular spacecraft is at an all-time high. A common chassis for newer missions is the ESPA. Currently, explosive bolts are the primary means to detach payloads from the ESPA. Only being able to deploy a payload drastically limits mission planners and the capability of the craft. Adding the capability to berth and interact with payloads allows a single mission to be far more versatile further increasing its modularity and driving down costs. Currently used docking ports are either large enough to allow astronauts to travel through them, or small enough to dock with cube-sats. This leaves a gap in current technologies where no system is capable of berthing medium sized satellites like ESPAs, which is commonly found on rideshare missions. The addition of a traversable robotic arm allows one robotic arm to service the whole craft increasing the possible missions while keeping weight to a minimum. The port allows for payloads to be docked and undocked after an ESPA is in orbit, while also minimizing the impacts on an ESPA's payload capabilities. This will be achieved utilizing a flush mount docking interface to replace original ESPA mounts. The interface will have integral nearfield wireless antennas to allow for wireless data transfer as well as the option to add high power and fuel transfer capabilities. The traversable robotic arm will supplement the port by being able to service the entire spacecraft while maintaining a small form factor and low overall weight.

MEM – 08

Gimbal-Rotor Quadcopter - Session I

Eamon Fitzgerald, Bryan Cheung, Casey Lorimer, Noah Marshall, Edgar Maldonado Castillo and Dr. Bor-Chin Chang

The quadcopter is a type of drone designed with 4 rotors and propellers for a unique flight experience. The 4 rotors offer the quadcopter limited range of motion. Even still, they are used in many everyday applications from taking aerial photos to surveillance systems for the military. These quadcopters are limited in their maneuverability due to coupling translation and rotation inside the control system. By implementing independently gimbaled motors, it is possible to decouple translation and rotation to improve the mobility and stability of the quadcopter. The objective of the project is to investigate the efficiency and controllability benefits of this new control mechanism. This project will incorporate the drones abilities to operate under the 4 different control movements: altitude, yaw, pitch, and roll while maintaining a low time to achieve steady state. Modeling has begun and will be continued in Matlab, Simulink and Mathematica for various flight configuration testing for optimized results. The project research would advance the technology of unmanned aerial vehicles (UAV) to provide improved precision and support in a broad range of applications.

ABSTRACTS

MEM – 09

Chiral Charge Order in $TiSe_2$ for Future Information Storage Devices - Session I

Mario Frakulla, Dr. Jennifer Atchison and Dr. Jörn Venderbos

$TiSe_2$ constitutes a controversial example of a Charge Density Wave (CDW) material, as it exhibits a chiral ordered state at low temperatures. Several CDW mechanisms have been hypothesized since the first experimental signatures of a chiral order in $TiSe_2$, with the two most relevant being the exciton condensation and the band Jahn-Teller effect. Nevertheless, a scientific consensus on the origin and mechanism of chiral CDW formation is lacking and there is no proper microscopic theory that explains the phenomenology of a chiral CDW state in $TiSe_2$. Such theory would not only allow the research community to better understand CDWs but can also open the path to manipulating the chiral domain through external probes and using $TiSe_2$ in the next generation of computer memory or other information storage applications. The focus of our project will be to develop a microscopic theory for the formation of chiral CDW order in $TiSe_2$ by using two complementary approaches: a low-energy model for interacting electrons and holes that offers a more intuitive understanding of the problem in momentum space, and a tight-binding model that is more intuitive in real space. In collaboration with Dr. Karapetrov's experimental group, we are also studying the dynamics of the CDW phase as a result of a strong and sudden excitation, which will provide more insight on the light-matter interaction in $TiSe_2$.

MEM – 10

Arduino Surveillance Eyewear - Session I

Kristiana Gerxhi, Fung Lau, Tyler Massa, James Morse, Eno Shira and Dr. Bor-Chin Chang

Modern security systems have become an integral part of our society. The most common form of security systems is constant video surveillance of a target area. Security systems have become more prevalent in personal use for home security and baby monitoring. This is due to the advancement of technology, where smart devices have become more integrated in everyday use.

Home security products require a monitor to see the live video feed or requires the user to use their own smart device and the product's app to access the live video feed. This limits the mobility of the user as well as limits the freedom of the user's hands and smart devices. This project aims to develop surveillance eyewear that users can wear to see live video feed from a wireless camera without limiting the user's mobility.

This project will demonstrate the use of Arduino technology to transmit images via Wi-Fi communication within a compact system. The system will be light enough and ergonomic such that a user can adorn to their own eyewear. By utilizing 3D CAD software, the Arduino IDE, analyzing material properties, and researching the limitations of human sight, the feasibility of this project can be verified through simulation and calculation. The development of this form of surveillance eyewear will be one of the initial steps towards mobilizing the home security market for the public sector.

ABSTRACTS

MEM – 11

Outer Diameter Pipe Crawler (O.D.P.C) - Session II

Alex Min, Ivan Dragiev, Tien Vo, Kevin Miyashiro, Nicholas Rudi and Dr. Bor-Chin Chang

Power plants and refineries are major industrial operations that utilize complex piping structures. These piping structures operate under constant high temperatures and pressures, which require regular inspection and can result in plant shutdowns. The current piping inspection methods involve either performing internal inspections that require operation shutdown, or plant personnel perform manual external inspections on the pipes surface. Most of these current inspection methods require the facility to shut down. Shutting down these facilities can cost up to millions of dollars in lost revenue, inspection equipment, and personnel costs. These methods also expose plant inspection personnel to hazards. These issues can be resolved by introducing a method of piping inspection that can be completed during normal plant operations. The ODPC aims to enable these facilities to continue normal operation while simultaneously performing the necessary inspections. Capable of scaling a range of piping diameters in addition to resisting the harsh operating conditions, it will serve as a platform for various types of inspection equipment through the use of a sensor hub. The attachment mechanism utilizes a ring design that wraps around the pipe and a drivetrain system with magnetic treads that allows the device to move along the axial direction of the pipe. The ODPC's control system utilizes an Arduino MEGA to manage the motors in the drivetrain system and can be controlled remotely by an operator ensuring safe use. The ODPC is designed to solve the costly and unsafe inspection methods currently used in today's industrial operations.

MEM – 12

Eazy-E Wheel Integrated Suspension for In-Hub Motor - Session I

Adrian Zavala-Bedolla, Alex Kunsch, Eric Matrone, Eva Teplitsky, Simon Zougheib and Dr. Tein-Min Tan

Electric bikes have revolutionized biking as a way of commuting, allowing bikers to travel longer distances than ever without straining themselves. They create a fraction of the emissions of a car and are a less expensive investment. However, unlike a car with suspension, hub-driven electric bikes have unsuspended motors that subject the wheels to strong normal forces. This causes bike rims to bend, tires to pop, and other damage to the bike and motor. The consequence can be seen in forums of bikers who have given up on electric bikes entirely due to their unreliable performance and constant maintenance.

In-wheel suspension has been used by some companies to design smooth riding wheels for wheelchairs, like the SoftWheel and LoopWheel who use an array of gas-charged springs or composite loops, respectively, to suspend the wheel. While they do provide suspension, it is in multiple dimensions – causing unwanted damping due to torquing the wheel (whether by a rider or an electric motor). The spokes in both products are non-rigid, requiring a thick rim that can support itself; this is expensive and decreases performance.

The EazyE Wheel proposes to use one-dimensional suspension in the wheel of a hub-driven electric bike to dampen impact forces – resulting in improved performance and less maintenance - without sacrificing travel efficiency. The wheel utilizes rigid spokes and a normal rim – resulting in better performance than competitors at a lower cost.

ABSTRACTS

MEM – 13

Assistive Mobility Chair - Session III

Riley Chioffe, Matthew Griffin, Kyle Kent, Jerome Kiesewetter III, Patrick Masterson, Ashley Testa, and Dr. Dimitrios Fafalis

Of the 61 million adults in the U.S., 13.7 percent experience mobility issues which result in difficulties while navigating the home. Although the market has historically been saturated with mobility devices, the field is currently poised for further expansion as a new generation of adults enter the 65+ age demographic. Wheelchairs in particular have been a common choice of mobility device for many years due to their simplicity, however, wheelchairs and other mobility devices have proven to be less than satisfactory based on market research conducted among consumers. Additionally, these traditional wheelchairs can result in a number of injuries to their users stemming from transfers between the device and other surfaces such as beds. The Assistive Mobility Chair aims to provide an easier surface transfer solution for at-home users with mobility trouble. Through the use of a lift system capable of supporting a 350 lb user, the Assistive Mobility Chair lifts occupants up and out of the chair into a standing position so as to minimize the risk of injuries caused by surface transfers or mechanically demanding sit-to-stand motions from a typical wheelchair. This project aims to develop a 3-D model of the device and its lift system, and conduct performance analyses of the device before, during, and after a lift has concluded. The project's objective is to design and analyze a device that would tap into the existing market while providing users with a safe and reliable solution to their mobility troubles at a reasonable price point.

MEM – 14

Astra Dragon - Minimum Mass Mars Ascent Vehicle (MAV) - Session I

John Crawford, Robert Howell, Justin Maranan, Anthony Torres, Eric Tran and Dr. Ajmal Yousuff

Initial human missions to Mars will require efficiency in mass and cost in the design of the associate elements. The challenges of entry, descent, and landing (EDL) on Mars are such that large payloads present extraordinary technology and launch challenges to be ready for use in the 2030s. In previous architectures, one of the largest elements of a human Mars mission has been the Mars Ascent Vehicle (MAV), with wet masses exceeding 40,000 kg. In this year's RASC-AL competition, NASA is interested in smaller MAV concepts that can significantly reduce the needs for advanced launch and EDL capabilities. The Astra Dragon is a MAV concept capable of transporting a two-person crew between the surface of Mars to an orbiter in Low Mars Orbit (LMO) without exceeding wet masses of 20,000 kg. The MAV is separated into two rocket stages, the crew vehicle and booster, in order to reduce total fuel mass requirement. Each stage can perform a controlled, propulsive landing to be used for multiple trips. The rocket engines also use a methane and liquid oxygen fuel mixture (methalox) that can be produced utilizing local in-situ resources through solid oxide electrolysis and Sabatier processes. The philosophy behind this concept was to not only optimize the vehicle mass, but to also minimize mass coming from subsequent payload missions. By eliminating the need to deliver large quantities of additional fuel and vehicles, opportunities can now be allocated to bringing other equipment to advance Mars habitation.

ABSTRACTS

MEM – 15

Vaccine Microneedle Patch Applicator - Session III

Gabrielle Dorsett, Andrew Janis, Alexander Ulin, Natalie Clark, Dr. Moses Noh and Dr. Dimitrios Fafalis

Microneedle Patches are a relatively new technology used for cosmetic purposes such as getting rid of blemishes, brightening dark spots, and other cosmetic uses. Recently, microneedle patches for vaccines have been studied for pain free vaccination for various viruses such as the flu. Unfortunately, there is no tool available to provide accurate and repeatable patch application results, making it more difficult for microneedle patch vaccines to be accessible in poor health areas such as third world countries. Our Microneedle Patch Applicator allows vaccine distribution across many medical platforms due its ease of use. The microneedle patch applicator will have a lifetime of up to 3,700 uses and a low physical profile to be an effective and desirable product. In this design, the patch is placed inside the applicator and with a push of a button, the patch is applied evenly to sanitized skin, providing painless and effective transdermal delivery to each patient equal.

ABSTRACTS

MEM – 16

Removal of Microplastic Fibers from Air via Electrostatic Precipitation - Session II

Justin Joseph, Rishi Joseph, Evelyn Kamuyu, Justin Lee, and Tyler Mil and Dr. Young Cho

Plastic is everywhere. It is in everything from household appliances, packaging, and even our clothing is made of it. One particularly concerning subset of plastic pollution is microfibers, which are produced as synthetic fabrics in clothing mechanically break down during a laundry cycle. As air is exhausted from the dryer, lint traps collect the larger fibers, but a majority of the microfibers slip through the mesh screen and into the environment. Here, they float around as air pollution until settling to the ground where runoff carries them into watersheds. The microplastics are then consumed by organisms where they release toxins and carcinogens that can be passed up the food chain. A recent study by the World Wildlife Fund has estimated that humans consume a nearly a credit card's weight in microplastic particles per week. Currently, there are no commercially available solutions targeting dryer exhaust as a top point-source of microplastic pollution. There has recently been more public and legislative attention focused on the microplastic problem, which, will likely soon produce a marketplace demand for adequate solutions. Because of its versatility and longstanding use in several industrial and commercial applications, Electrostatic Precipitation (ESP) is being proposed as a solution to effectively reduce microplastic pollution from dryer exhaust systems. ESP is a commonly used technology that collects and removes particulate matter from air streams through the manipulation of electrostatic forces. The design and operation of the ESP microfiber collection system will be verified and analyzed using 3D modeling and virtual simulation tools.

MEM – 17

Forest Fire Management System - Session III

Evan Cost, Bailey Harp, Martin Rexroth II, Dale Rhodes and Dr. Jennifer Atchison

Forest fires are becoming ever prominent throughout the U.S. and the world due to increased ignition risks. These wildfires reap destruction wherever they strike. Current measures for prevention and defense are hundreds of years old and in desperate need of modernization. The best way to avoid disaster is to focus on faster recognition and forecasting. There are public ideas and concepts that could be combined to create a process that can be molded to specific landscapes. It is expensive to identify the best method to implement sensor devices to ensure the area is covered in an effective and accurate way. Current methods in layout for data collection nodes are not optimized and are purely based on an economical standpoint. Although it would be costly to establish properly distributed node networks for existing companies, it may not be as extraneous of a process for a device that is not yet established. Therefore, time will be committed to calculating an efficient way to layout nodes for a fire detection system. The objective of the project is to create a framework for a fire detection process that in turn develops a node layout or data transmission that maximizes acreage while minimizing node count. Goals through research included finding optimized transmission layouts along with a way to seamlessly integrate the system in a non-invasive way. This leads to the understanding that deployable devices need to be integrated through a wireless transmission network for non-invasive data

ABSTRACTS

MEM – 18

Acoustic Optimization for HVAC Systems - Session II

Matthew Dwyer, Joseph Scaglione, Thinley Wangchuk and Dr. Bakhtier Farouk

Heating, ventilation, and air conditioning (HVAC) systems provide thermal comfort to both residential and commercial buildings by moving air between indoor and outdoor areas. These systems keep buildings warm in the winter and cool in the summer, while also cleaning and filtering the indoor air. Unfortunately, an unconformable amount of noise is an unwanted byproduct of such systems. This noise has been linked directly to loss of productivity in the work-space and in some cases detrimental to the health of the inhabitants. This noise is also a huge distraction in class-rooms and lecture halls. MEM Team 18's goal is to design acoustically optimized HVAC systems that have minimal noise output without sacrificing the overall performance of the systems. The team will be utilizing computational fluid dynamics to first study the acoustical performance of different orientations and different shapes of ducts, followed by then coming up with newer solutions to minimize the noise. For the computational fluid dynamics simulations, ESI's CFD-ACE+ solver package is utilized. After testing and gathering data, we will have the knowledge to create an acoustically optimized base model structure that can be used by others. While current solutions utilize reactive si-lencing techniques, this approach uses a preventative method to predict and attenuate the noise levels in the system. HVAC units produce a sound level between 70 to 80 decibels.

MEM – 19

Rover Orientation Stabilization and Correction - Session I

Kevin Driesse, Alex Kalesnik, June Kwon, Thomas Schifferli and Dr. Harry G. Kwatny

Rovers like NASA's recently landed Perseverance are space agencies' primary means of remote terrestrial explora-tion of foreign bodies. First employed in the early 1970's, their use is growing more frequent, with six out of the elev-en successful rover landings occurring within the last ten years. With remote exploration being more versatile and logistically simple than manned missions, they will remain relevant in ongoing efforts to uncover the secrets of the solar system and search for signs of alien life. However, the practicality of rovers is limited by their inability to tackle exceedingly difficult terrain. For instance, Perseverance is designed to tilt 45° in any direction without tipping but avoids inclines greater than 30° for added safety. As humans continue to expand exploratory efforts, missions to more treacherous terrain – like Mars' steep and geologically interesting scarps – are inevitable. However, such mis-sions will only be possible if rovers can safely navigate steeper inclines without tipping. This project's objective is to enable rovers to carry out missions that involve tackling inclines exceeding 45° without risking an overturn. The sys-tem consists of two robotic arms to be mounted on the rover. An automatic onboard control system will manipulate the arms to dynamically shift the rover's center of mass and apply moments to the rover chassis. The system is de-signed for implementation on a rover similar to Perseverance, but a parametric design process is employed to allow implementation to other platforms. Dynamic simulation and finite element analysis software are used to demonstrate the system's feasibility.

ABSTRACTS

MEM – 20

SAE Aero Design with Alternative Fuel Analysis - Session I

William Culbertson, Jamil Grant, Jamie Giannini, Sean Heller and Dr. Ajmal Yousuff

Team Consultant: David Harding

The 2021 Collegiate SAE Aero Design Competition has tasked students to design an electric aircraft with the primary mission of package delivery. Teams are required to carry boxes and static cargo across a predetermined course. The maximum payload of the aircraft is determined by the teams' calculations and design. Team MEM-20 has designed an aircraft, Red Dragon, to meet SAE's Micro Class requirements which promotes study on smaller sized vehicles. The objective is to carefully balance aircraft weight, thrust, payload and drag to ensure a successful take off and steady flight while delivering the cargo. In addition, there is an analysis regarding the use of hydrogen fuel cells as a power source on such a small scale. Given this challenge, it was important to conduct separate studies of structure, aerodynamics, and propulsion. These components can then be analyzed together through ANSYS and by creating automated calculations that reflect the desired design. The success of Red Dragon's design is demonstrated by its ability to maintain stable flight, provide optimal lift through the wing and tail, as well as show a strong lightweight structure suited for carrying cargo. This design was visualized using SolidWorks and CREO software. This project will serve as a continuation of Drexel's participation within SAE Aero Design and for future motivation within student club involvement in the Aerospace Engineering field. Not only does Red Dragon seek to respect tradition but to further improve upon model aircraft technology and design.

MEM – 21

Digital Threading of the Design-for-Manufacturing Workflow for the Dragon Resuscitator - Session I

Angelica Batista, Yagouba Diallo, Alvin Joseph, Zen Luckowski, Adam Taylor, Dr. Pablo Huang Zhang and Dr. Antonios Kontsos

As industrial processes for product development become increasingly more complex, some manufacturing companies lack effective methodologies that promote integration and adaptability in their processes. When considering traditional manufacturing, most companies utilize either the waterfall or agile methodology, however, to manage growing markets and changing technologies, it is critical to address the issues associated with modeling complex workflows. Current solutions offer little opportunity for interconnectivity between development phases or repetition of previous processes which introduces bottlenecks and inefficiencies. A new solution to tackle these issues as well as optimize the design-for-manufacturing workflow specifically is the idea of digital threading. Digital Threading is the concept of connecting design and manufacturing processes to provide organizational capability, adaptability, and efficiency to monitor/manage a product's lifecycle. The proposal of digital threading offers better efficiencies because it is based on principles that focus on people, results, collaboration, and flexible responses to change. While the basis of this methodology already exists, it is essential to build a structure that offers seamless implementation into existing product development processes. Several software capable of facilitating digital threading have been tested by the team with varying success. Ideally, the workflow will be capable of managing the design-for-manufacturing workflow of any given product while the chosen software will have tools necessary to implement it into a digital environment. As a case study, Drexel's Dragon Resuscitator has been inserted in the workflow to a) test the versatility and effectiveness of the workflow logic and b) facilitate the Dragon Resuscitator's next revision.

ABSTRACTS

MEM – 22

The Dragon Shoes - Session II

Dante Palantino, Stuti Majmudar, Adrian Salek, Justin Serwinski, Andre Soukhaphonh, Riley Vroome, and Dr. Dimitrios Fafalis

The use of wearable technology continues to rise, with a particular focus on personalized health, well-being, and fitness. Additionally, mobile phone usage and importance to everyday life has increased as their capabilities improve on a yearly basis. However, the increasing prevalence and use of portable technology is accompanied by a proportionally increasing need to keep these devices charged and functional throughout the day. Although there are currently physical solutions available to charge tech on the go, it may be inconvenient to carry additional devices around. In some cases, portable battery packs might also be unnecessarily bulky, and ultimately they reduce to yet another device that requires conscious effort to individually charge prior to use. The Dragon Shoe team aims to create wearable technology with the capability of harvesting and storing the energy associated with the user's own movement. By employing the use of piezoelectric materials placed in the sole, the Dragon Shoe will convert mechanical stress, created by walking or running, into electrical energy that can be used to charge devices on the go both wirelessly or with cables. Information regarding charge time and battery life will be available to users via a mobile application. Utilizing the mechanical stress naturally and unconsciously created by walking eliminates the need to carry additional devices and may promote and encourage users to remain safe while traveling and engage in healthy lifestyle habits.

MEM – 23

Sustainable Stalls - Session II

Lane Schultz, Payton Langello, Peter Lennihan and Dr. Jennifer Atchison

The first portable restroom dates to the second world war. They were initially used on ships and had a very crude design. The portable restrooms that are used today have come a long way and there are many different designs that suite a multitude of applications. These portable restrooms can be found in public parks, construction sites, private events, and everywhere in between. In our advancing society, the sanitary standards are raising along with the demand for higher quality facilities. The need for portable restrooms with modern amenities in the event of natural disasters and emergency situations is crucial to the patrons in these events. The higher quality portable restrooms used at weddings and at many other events are often housed in trailers and are equip with running water and HVAC systems. These modern restroom trailers first appeared in the mid1980's from the manufacturer Poly-John. Our team is focusing on developing a restroom trailer that can be used at sites with limited resources while keeping the higher-quality amenities. People in disaster stricken and remote areas would greatly benefit from having access to restroom trailers with modern amenities that promote proper hygiene. The stakeholders would include the trailer owners and renters. There are a few companies that have incorporated solar panels onto the restroom trailers to make them more sustainable. The leading manufacturer is not able to operate their sustainable restroom trailer past 24 hours on solar and battery stored energy. Our group is currently investigating other forms of renewable energy that could be utilized for a restroom trailer, as well as the energy requirements of the components within the system.

ABSTRACTS

MEM – 24

Prehensile Electronic Arm Crop Harvester (P.E.A.C.H.) - Session I

Eliza Aumiller, Abigail Clune, Willow Livengood, Michael Reed, and Dr. Ajmal Yousuff

In the United States, the mechanization of crop harvesting has drastically improved the efficiency and output of the agricultural sector. With the rise of labor costs and decrease in availability of workers in recent years, automated harvesting solutions are more of a necessity than ever. Despite this, in the U.S. at least 20 to 25 percent of vegetable harvesting and 40 to 45 percent of fruit harvesting is still done completely by hand. This is largely due to a lack of viable, affordable mechanical harvesting solutions on the market. Fragile fruits for example require a delicate touch that historically has only been achievable by labor-intensive hand harvesting. The goal of the P.E.A.C.H. is to address this issue with a focus on one of the most challenging fragile fruits to harvest- the peach. In addition to being incredibly delicate and easily damaged, peaches also pose the obstacle of having to reach a certain level of ripeness on the tree before being picked. The P.E.A.C.H. combats this through the use of image recognition and brix level detection to determine ripeness, and a gentle, silicone-lined end effector that closely mimics a human hand to pull ripe peaches from their trees without damaging them. Over the course of this project, the design and functionality of the P.E.A.C.H. will be validated through the use of CAD, numerical modeling, sensor testing, and simulation.

MEM – 25

The HotZone Tent - Session III

Joseph Kim, Daniel Gable, Andrew Coyle, Jacob Manera and Dr. Peter Clelland

Amid the COVID-19 Pandemic, there has been a shortage in Personal Protective Equipment (PPE) and a globally lacking response to contagion. In rural areas, this response is even slower and leads to fatal consequences for under equipped communities. A solution is necessary to make PPE reusable and provide a means to fight contagion in rural areas. An enclosure for cleaning PPE quickly and efficiently, an environment to disrobe PPE safely and a PPE package would provide workers the tools to fight contagion. The HotZone Tent is a portable, durable cleaning unit with a supplemental PPE package designed to aid in the fight for disease control in rural areas with limited access to healthcare facilities and electricity. These areas are frequently ravaged by disease due to lack of resources, willing volunteers, and knowledge to combat disease. The HotZone Tent is equipped with a UVC Sterilization system for sterilizing PPE, powered by solar energy through solar panels. The complete package comes with a supplemental PPE package to aid in the fight for disease control. The tent is simple to set up and comes with a manual detailing procedures and directions for how to utilize the HotZone Tent correctly and effectively, as well as to educate users on how to handle the spread of disease. When used correctly, the tent is an effective tool for disinfecting surfaces and garments. FEA Simulations show the durability of this product and intuitive design makes it portable. MATLAB simulations and calculations performed throughout the design process show that the HotZone tent is capable of killing 99% of COVID-19 on exposed surfaces in 30 minutes and is capable of several sterilization cycles every day on solar energy.

ABSTRACTS

MEM – 26

Grasp Glove - Session III

Sonika Arya, Hena Patel, Ryan Bromley and Dr. Dimitrios Fafalis

Exoskeleton gloves are artificial frames with tendons that enable those with limited mobility to regain function in their hands. After placing the glove on an individual's hand, it can be used to imitate the function of grip by mimicking the bending motion of appendages. Due to the high prevalence of upper limb paralysis, researchers and students have worked to study the motion of the hand and create designs to help with simple movements. Nonetheless, many of the available gloves require a handful of electrical components that have to be carried by or attached to the individual. In turn, the cost of the available gloves are too high for the average person to afford. The designs could be improved by minimizing the amount of electronics used to reduce the cost, while still maintaining the same functionality required. The intent of the Grasp Glove is to reduce the amount of electronics used to create the gripping function by utilizing a mechanical design. This project will be composed of a 3D CAD model to show the animation of the design. The mechanics behind the motion will be condensed yet feasible to produce the force required for the bending of the components. The unique aspect of straying away from being heavily dependent on electronics, but still being limited in size will open up creativity to future designs. Utilizing mechanical methods will bring attention to reducing manufacturing costs and opening up a market that is more affordable.

MEM – 27

Gloves for Neuropathy - Session III

Caspar Nguyen, Eric Goggin, Waqas Khan, Sachit Agarwal and Dr. Jennifer Atchison

Peripheral Neuropathy is a condition of the nervous system that can lead to loss of feeling and function in the hands or feet. Common complications include diabetes, trauma, degenerative and auto-immune diseases, along with infections. Despite the prevalence of this condition, there is a distinct lack of cost-effective, data-driven methods for understanding the progressions and behaviors of neuropathies. Current solutions are prohibitively expensive and primarily function in clinical settings. Monitoring and tracking the progress of a patient with peripheral neuropathy is limited with few doctors visits. Data driven analytics into the patient can and should not only be available every so often. Peripheral neuropathy can lead to minor loss or total loss of function; daily tasks must be monitored to ensure the progress of the patient. Gloves for Neuropathy's objective is to provide long-term remote data monitoring of a patient's lateral pinching ability at home. This project will demonstrate virtual simulation and calculations to map out hand kinematic motion and forces involved in daily life tasks using the lateral pinch movement, which can impact using keys to open doors, picking up a mobile phone, or gripping the steering wheel of a car. As a patient undergoes treatment for their neuropathy, this glove will help clinicians to have a better understanding of a patient's performance by providing a record data to them.

ABSTRACTS

MEM – 28

Engineers Create: Broadening Participation in Mechanical Engineering - Session II

Rasheem Clark, Kristina Jones, Quan Nguyen, Fausto Pasmay and Dr. Jennifer Atchison

Mechanical engineering is a diverse field containing countless applications. Nonetheless, this diversity is not expressed by the conformation of the mechanical engineering workforce. Most of the workforce is white men. Specifically, 80.4% of the US mechanical engineering workforce is white and 90.8% is male. Since diversity and inclusion lead to a more empathetic society and a more creative workforce, the mechanical engineering field must strive towards becoming more inclusive and diverse. It was discovered that current engineering curriculums do not give minority students a sense of identity or ideas about what mechanical engineering is. Existing curriculums also use common activities, such as designing a mouse car or building stick bridges, which fail to show real engineering applications. Previous engineering education organizations and programs have specific weaknesses: programs cover a wide range of disciplines, resources for students and teachers require previous awareness of existing programs/organizations, and bigger organizations do not have personal appeal and connections. These weaknesses would result in less in-depth information about each discipline within engineering and lack personal connection. The creation of Engineers Create seeks to address these weaknesses. The goal of this design is to create an engineering curriculum focused on mechanical engineering aimed towards Philadelphia high school students who would be categorized as underrepresented minorities within STEM. The curriculum design will consist of modules that aim to help the students understand the idea of problem solving through solving local issues such as water runoff, transportation, sustainable textiles, and renewable energy.

MEM – 29

Design of Software to Predict the Optimized BinaryRefrigerant Mixture Ratio for a Kitchen Refrigerator - Session II

Ryan Garvey, Kelsey Gombert, Michael Kyriazis and Dr. Jennifer Atchison

Non-azeotropic binary refrigerant mixtures (BRM's) are blends of two different refrigerants that do not maintain constant temperature during phase changes. This property improves the performance of blends over the performance of pure substances by reducing entropy generation of phase changes. Binary mixtures also allow engineers to create blends combining favorable properties from two different refrigerants. This ability is of particular interest since the Montreal protocol phased out many refrigerant classes. Modern replacements to these phased-out compounds are significantly more environmentally friendly, but do not have the same performance capabilities of the compounds they replace. Non-azeotropic binary mixtures are a way to bridge the performance gap between new and old refrigerants. Physically studying the many refrigerant combinations is inefficient. Developing blend optimization software will significantly reduce the time and cost required to study these mixtures. The goal of this project is to create MATLAB software that can accurately predict the optimal mixture ratio of refrigerants for various refrigeration cycles operating at standard consumer temperatures. The software will use the well understood Lagrange multiplier method to find the optimal blend mixture ratio. This optimization program will inform future physical experiments into promising experimental blends and potentially lead to the development of new blends with excellent properties.

ABSTRACTS

MEM – 30

TruScore - Session I

Justin Sweeney, Michael Peters, Vincent Foggia, Armaan Jethmalani and Dr. Andrei Jablokow

Sponsor: John Riley (Rowing Gold Medalist)

The Concept-2 Ergometer is the most popular indoor rowing machine on the market. The C2 is used by rowers of all levels to practice when rowing in the water is not feasible. The ergometer monitors the speed and force output and translates that to a pace (score) for every stroke. Coaches use this score to decide their lineups for competition. Unfortunately, a high ergometer score is not a good indication of an athlete's ability to row in the water. Poor technique favors a higher score, leading to injury and losses in competition. The ergometer does not account for suspension, two-level rowing, and check; three crucial elements of a proper rowing motion that significantly hinder the boats speed when performed incorrectly. TruScore will monitor ones' rowing motion, utilizing a video analysis software (Kinovea) to kinematically analyze and alter the data provided by the Concept-2. This software will track ones' handle position, their knee's angle, and the angle from their foot relative to the footpad. This allows for a new score to be determined by evaluating if check, suspension, and two-level rowing are occurring and to what effect. TruScore will graph several plots, such as handle position vs time. The users recorded rowing motion will be simultaneously playing next to a proper rowing motion with annotations for comparison. TruScore will provide athletes and coaches with a tool to aid ones' development and evaluate the rower's performance. This also serves as a tool for coaches to effectively decide their competition lineup.

MEM – 31

Silkscreen Machine Design - Session I

Sarah Andrieux, Ray Corriher, Jack Gavin, Ari Glick and Dr. Andrei Jablokow

Eaton Aerospace utilizes a silk-screening process to paint approximately 60 of their manufactured parts. Silk-screening offers an accurate and precise method to mark parts with relevant information. Gauges and other visual fluid-monitoring parts make up a significant portion of Eaton's manufactured parts, and all of these require silk-screen marking. With the current system, there is no reliable alignment to some zero reference. This gives rise to multiple issues with repeatability and precision, which overall increases the setup time and therefore cost for the machine to silk-screen a part. Relying on operators to manually align the screen and the part also causes a decrease in precision and repeatability. The objective of this project is to decrease this setup time and increase repeatability in the silk-screening system by designing a multifaceted package of solutions via use of relevant technology in the silk-screening and printing fields. The characteristic features that determine the repeatability of painting a part is the location of the fixture holding the part relative to the table, the fixturing of the screens relative to the machines, and finally the artworks centering relative to the frame. The overall positional accuracy of a given artwork at printing time sought by Eaton is 0.015 inches. Our package will consist of updated artwork, updated fixture designs, a trade study of candidates for a new silk-screen machine, and an updated screen frame design to decrease concerns of foreign object debris. The package will also include a detailed cost-benefit analysis of all sub-components.

ABSTRACTS

MEM – 32

Electronic Traffic Light Viewing Tool (AuxiliaryEye) - Session I

Anthony Ciampi, Brandon Smith, Josh Honey, Steven Windas and Dr. Alessia Polemi

Traffic lights are intersection safety tools that indicate which automobiles have the right of way at a given moment. However, traffic lights are often located such that the nearest driver must take their eyes off traffic, lean forward, and look up to observe the signal change. This unsafe situation contributes to the Federal Highway Administration's (FHA) report of roughly 2.5 million intersection accidents in the US per year. Modern automobile companies such as Tesla, BMW, and Toyota have been developing AI-based automated driving technologies capable of navigating traffic seamlessly. Unfortunately, these systems are only available in new, prohibitively expensive car models. Our goal at AuxiliaryEye is to provide an option to make the every-day driver's experience at intersections safer. To accomplish this, we aim to design an interchangeable car-accessory device that observes traffic signals outside the driver's view range and relays cropped image data to a peripherally-visible screen on the dashboard. This product will utilize a standard dashcam to obtain image data, an Arduino Mega 2560 R3 for image processing, and a small, 2" x 3" digital screen to display the cropped traffic light feed. The computer will utilize MATLAB to translate the raw image data into a numerical RGB matrix, identify any visible traffic lights using shape and color recognition, and relay a cropped feed of the traffic light to the dashboard-mounted screen. The AuxiliaryEye will serve as an inexpensive, reliable driving tool that allows for drivers to navigate intersections more safely.

MEM – 33

Virtual Laboratory Experience - Session II

Joshua Glynn, Ryan Burkins, Daiyan Chowdhury, Lutfi Agartan and Dr. Emin Kumbur

From HVAC systems to Jet Engines, flow measuring devices are necessary components of many engineering systems. Being so common, learning the workings of these systems through the hands-on experience offered by a lab environment is important to an engineering education. Unfortunately, due to limitations as a result of the COVID pandemic, students have not been able to attain a hands on experience with this lab. Presently, students are instead presented a set of data and only tasked with completing the calculations of the lab. Given the value of hands on experience in the learning process, a more interactive experience is desired. The COVID pandemic has shown that educational institutions are not as prepared for adaptation of in-person lab experiences to a remote environment as they could be. Our project hopes to fill this gap in preparation by providing a method of bringing the lab experience to the student without losing out on the interactive learning that a lab class provides. The goal of this project is to create an accurate simulation of the lab equipment using Unreal Engine. Students using the final simulator software will be able to perform the lab as it is in person; varying fluid flow and taking pressure readings throughout the apparatus. Creating a software-based solution allows the student to maintain the level of interactivity associated with a lab course while also allowing them to safely follow work-from-home orders in case the need for remote work occurs.

ABSTRACTS

MEM – 34

Assisted Cable Feeder - Session I

Kelvin Peng, Grant Reynard, Lucas Rousselet, Jakob Siegel, and Dr. Alessia Polemi

In 2018, homeowners spent an average of $7,560 on home improvement in the US. Over 80% of houses are at least 20 years old and require remodeling or renovation. With the onset of the COVID pandemic enforcing social distancing protocols, electricians and other in-wall cable pullers have had to perform their work in smaller groups or even by themselves. These restrictions have also encouraged some homeowners to pursue their own renovations, which may require pulling cables through existing walls. This cable pulling process is typically performed by a group of two, but it can be accomplished solo albeit it is more difficult. Currently, there are cable feeding tools that are geared towards commercial and large-scale project uses, but there are not any products serving smaller-scale electricians who prefer to work solo or in duos along with home renovators. The assisted cable feeder device will provide aid to the user by allowing them to pull cables by themselves. The device would feed cables through one end of the wall while the user would be pulling from the other end. It would sense the pulling action of the user and provide an appropriate feeding rate to reduce the amount of pulling force. Overall, this design would provide a device that would benefits users who pull cables solo or in small groups.

MEM – 35

Dragon Soles by WearTech - Session II

Brandon Mok, Nominzaya Munkh-Erdene, Jason Luu, Meet Singh, Ronit Singh and Dr. Dimitrios Fafalis

Of the almost 300 million Americans who own a smartphone, only fifteen percent carry some form of charging device, and most of the time those charging devices require a conventional electrical source that may not be available in cases of emergencies. While renewable energy harvesting methods have been and are currently being utilized, such as solar panels or wind and hydro turbines, these methods are mainly used and applied on a large scale, harvesting high amounts of energy. Although attempts have been made to bring these harvesting methods to a smaller scale, they are limited by their reliance on external energy sources (sun, wind, water, etc.) that in some situations may not be available.

The primary objective of the DragonSoles by WearTech is to provide a source of portable electrical power when other alternatives may not be readily available, by harvesting the theoretically-unlimited kinetic energy generated by human locomotion. This project will investigate and explore the relationship between the mechanical stress input and electrical output of piezoelectric technology, as well as the process by which the energy is converted. The DragonSoles insole consists of two halves of foam encasing a number of strategically placed piezoelectric pod capsules connected by wires that are routed out of the insole to a portable rechargeable battery pack. Throughout this project, the insole will be modelled, and force analyses will be conducted using simulation software to determine the efficiency of the piezoelectric plates.

ABSTRACTS

MEM – 36

Payload Deployment System (P. D. S) - Session I

Donovan Kelly, Gunpreet Singh, Dhruvin Patel and Dr. Ahmad Najafi

The NASA BIG Idea challenge has tasked collegiate teams with developing dust mitigation technologies for the Artemis III mission. For the first time since Apollo 17 in 1972, NASA will perform a crewed lunar landing in October 2024. During descent, the thrust generated by the Human Landing Systems (HLS) propulsion ejects the lunar surface dust outward at high velocities. Nearby surface assets and the Human Landing Systems are damaged by the highly abrasive lunar dust. Previous Apollo missions also report lunar dust hindering visibility, making the landing maneuver very precarious. Lunar dust interactions and research are very limited. The Drexel Big Idea Challenge team has proposed a deployable landing pad. The landing pad is released during descent flight so that it reaches the landing location before the Human Landing System. Once the landing pad hits the ground it is instantly unfolded and deployed. The Human Landing System tracks the landing pad during descent and lands on the pad. The Payload Deployment System will mount to the side of the Human Landing System, store the landing pad (which folds up in the capsule) during the mission, and releases the landing pad during descent of the HLS. The Payload Deployment System has mounting brackets, a capsule, a tilting mechanism (controls the angle of the capsule), and quick release mechanisms. There are no deployment systems for Human Landers or any other landers. A viable way to release payloads from landers or space vehicles at certain velocities and angles makes the Payload Deployment System valuable in Aero-space industries.

MEM – 37

Standalone Haptic Feedback System for Da Vinci Surgical Robot - Session III

Andrew Lim, Dominic Nguyen, Bill Phan and Dr. David Han

The Da Vinci surgical system is currently the world's most popular robotic surgical system. It provides surgeons a suite of advanced instruments and sensors. Like laparoscopic surgeries, robotic surgeries enable surgeons to perform minimally invasive surgeries. These surgeries can reduce surgical trauma and thus provide patients with faster recovery times. However, robotic surgeries are more flexible than laparoscopic devices and can operate in difficult locations. The system provides control stabilization which can help surgeons with dexterous maneuvers. However, the current Da Vinci surgical system lacks haptic feedback. This lack of information, makes familiarization harder, increases training time, and reduces the efficiency of surgeons. In the worst case, the lack of haptic feedback can degrade the quality of a surgery. There is common consensus among surgical robotic researchers and doctors that haptic feedback will be especially helpful during early training [1]. The goal of the Standalone Haptic Feedback System (SHFS) for the Da Vinci surgical robot is to create a haptic system that can provide operators of the Da Vinci surgical robot haptic feedback without modifying the Da Vinci control software. The system will allow surgeons to feel the direction and magnitude of forces applied by the robot's gripper. Using a 3 degree of freedom tactile skin deformation, this device will provide detailed haptic feedback back to the operator. This device will potentially improve training time, lower the learning curve for surgeons, and create an intuitive feeling when doing operations.

ABSTRACTS

MEM – 38

B. O. S. S. Casing and Software: Visualizing gas densities and shockwaves in the field of Volcanology and Ecology - Session II

Steve Arfuso, Burak Kumas, Matthew Herron, Morgan Kull, Dr. Loyc Vanderkluysen, and Dr. David Miller

The field of geoscience has expressed a need to visualize gas densities and shock waves from volcanoes and geysers. Being able to visualize the gases being released from volcanic features could provide valuable eruption information and increase our knowledge of these dangerous geological features. Schlieren photography has been suggested to visualize the flow of gasses before, during and after volcanic eruptions but due to the complexity of the typical schlieren set-up it has not been converted into a field capable observation station. Background Oriented Schlieren (BOS) appears achievable with an appropriately robust tripod and image processing software system. The final goal of the project is to develop a tripod and software that when used together, successfully produce gas density gradient images from field locations. Volcanologists and ecologists will be able to use the system at a range of locations to study gas densities not only in volcanoes, but also in a multitude of other applications such as geysers and wildfires. Field related challenges such as rough terrain, wind, corrosive elements, and remote field locations are problems that are addressed by the system to ensure that the resulting gas density visualizations are clear and informative. The camera casing mitigates vibration and provides a steady platform for the camera to ensure continuous alignment with the subject of imaging. The software system analyzes the images and transforms them from simple photographic images to gas density gradients maps with rich quantitative information on gas flows.

MEM – 39

Smart Solar Inverter - Session II

Jerry Xie, Randy Diep, Andrew Dang, Tianyi Ji and Dr. Baris Taskin

A solar inverter converts direct current (DC) produced by solar panels into alternating current (AC). After solar panel systems are installed, the performance of inverters can be monitored by implementing software solutions. Solar monitoring systems help users monitor their system performance and understand if solar panels are operating at their best performance. Unfortunately, solar monitoring systems are limited to only providing data to users. The capability can be significantly improved by utilizing collected data from the inverter to make autonomous decisions or suggestions that allow more efficient energy usage. The goal of the SSICM project is to utilize collected data from the solar inverter system and process the data allowing the inverter to make autonomous decisions and providing feedback to users. This project will demonstrate feedback possibilities by a communication module, the ability of the Arduino board to communicate through the internet, and collect data from the inverter through a database management tool. The Arduino NodeMCU ESP 8266 is a low-cost open-source IoT microcontroller. The IoT platform provides access to communicate the database management tool and the solar inverter. Programmed procedures stored in the database can be executed through Arduino providing autonomous control over solar inverters. Communication between SQL database and microcontroller has been verified through experimental results. Autonomous decisions and recommendations are provided by processing data through series of mathematical equations and meeting required thresholds. The smart autonomous decisions and recommendations serve as a milestone to increase the functionality of smart inverters for solar panel systems allowing for more efficient energy usage and saving costs for consumers.

ABSTRACTS

MEM – 40

Self-Closing Valve Crimping Press - Session I

Mayank Gulati, Nitish Gupta, Maggie Mulhern, Michael Wiest and Dr. Jennifer Atchison
Sponsors: Nicholas Bilancio and Brian Bucci (Manufacturing Engineering, Eaton Aerospace)

Eaton Aerospace LLC manufactures fluid-debris monitoring systems, which can be seen throughout the commercial and military aircraft industry. One of their products is the Chip Detector system, which utilizes a plug-magnet and metal self-closing valve to detect metallic debris, or chips, within gear boxes and other oil environments. In the assembly of the self-closing valve, a spring and cap must be inserted, compressed, and encased within the valve's external housing. The action of encasing the spring and cap, called rolling at Eaton, is similar to metal spinning on a lathe, but involves custom collets, fixturing, roller tooling, and custom tailstocks. In addition, the use of a manual lathe increases set-up time, contains many uncontrolled variables, and relies on operator skill. Therefore, the rolling process is currently inconsistent, and causes Eaton to lose around $7,700 per year in scrap. Using FEA analysis, mathematical modeling, and hydraulic presses, we are focused on decreasing lead time and increasing throughput by replacing the multi-step, manual-lathe operation with a single-operation, crimping die press. The dies will be custom-made based on the material and geometry of the valve housing. With this analytical data, we hope to provide Eaton with the analytical tools to remove lathe operations from similar models and applications throughout their facility.

MEM – 41

NAVSEA Photogrammetric Modeling - Session II

Ryan Hoschar, Logan Karcewski, Jonathan Sutcliffe and Dr. Jennifer Atchison
NAVSEA Affiliates: James Case, Tristan Wolfe and Salvatore Desante

The decision making process of new software technology is complex and choosing the incorrect option wastes time and money. Within NAVSEA the ADAPT.VE lab wants to utilize photogrammetry to provide accurate 3D VR-capable walkthroughs of interior areas; however, it is necessary to provide an analysis on available software and hardware alternatives that satisfy the stakeholders needs. Since the ADAPT.VE team has utilized laser metrology and 3D scanning when generating analytical models or 3D renderings of physical objects, photogrammetry will be used similarly to provide an alternative for cost effective surveying, taking inventory, and using generated models for dimensional referencing. The first phase of our project will be an AoA (analysis of alternatives) on software and hardware currently available to bring this new process of analysis to their team in a way that meets their needs. By testing available software, the team can discern the strengths and downfalls of each software using prior research on scene preparation, analyzing photogrammetric data in software, and generating working 3-D models for real world application. The analysis is to be conducted within the design process provided in "Product Design and Development" by Ulrich and Eppinger. Every step of the photogrammetry process, design pipeline, will consider the needs, specifications, constraints of the stakeholders where the possible options are weighted based on their performance with each specification.

ABSTRACTS

MEM – 42

Robotic Assistive Device (R.A.D.) - Session III

Osman Syed, Tenzin Shawa, Nicholas Savino, Derek Campbell and Dr. Tein-Min Tan

There are an estimated 500,000 service dogs which help people with disabilities in the United States. At the same time there are also over 40.6 million Americans who report having a physical disability. Despite recent advancements in battery technology, computer chip miniaturization, and general robotics the mass market currently lacks any robot assistants that are designed to aid people with disabilities. The objective of R.A.D. is to fill this need by performing basic menial tasks for people who lack service dogs. Menial tasks that this device is designed to accomplish include opening doors, cupboards and fridges as well as bringing plates and cups to the user. Propelled by quadruped wheels and powered by rechargeable lithium-ion batteries the R.A.D. will move to the desired location designated by an Android app. Besides the app an equipped voice recognition module will allow for the robot to go back to its charging station with a single word command. The manipulator arm mounted on the robot's front will be capable of picking up cups and plates over an inch in diameter. A visual sensor pre-specialized to track objects will work in tandem with proximity and range sensors to guide the motion of the R.A.D. through a household environment. With all these features packed into a frame smaller than a cubic meter the R.A.D. will serve as a low cost and robust aid for people with physical disabilities.

MEM – 43

Smart Dieting Bowl - Session III

Sean Huezo, Julian Naaman, Rachel Nguyen, Yue Shi and Dr. Gennady Friedman

The main obstacle for dieting Americans is maintaining their motivation to remain on the diet. Most stop their diet from losing motivation or meeting their target, and a high percentage of those people regain their lost weight within a few years regardless of the reason they stopped. To avoid this, the dieter must maintain a healthy eating lifestyle permanently, or at least for as long as possible.

Presently, there is a large market for products and tools that aim to aid dieters. It mostly consists of dietary mobile applications that offer convenience in helping users keep track of their daily nutritional intake and general progress.

Previous research indicates that these dietary tools help keep dieters motivated due to the convenience they offer. However, users must manually enter each meal or food item they consume into the mobile app several times a day. This could become tedious and irritate the dieter, leading to the loss of motivation.

To make the process of logging in food items more convenient, we will create a physical product that will identify, measure, and input the food data into a mobile application with minimal human input as possible. Potential solutions include creating a bowl or plate with a built-in weight sensor and a camera to identify the food. The final design will be dictated by the results of surveys conducted on the potential consumer base.

ABSTRACTS

ECE – 01

360° - Sensing Autonomous E-Scooter - Session I

Mike Angelilli, Josh Cohen, Mark Dettrey, Kush Patel, Abrar Zawad and Dr. Nagarajan Kandasamy

The exponential growth of demand for personal electric vehicles (PEVs) around the world has fueled a new market and a new need for faster, safer, and more efficient ways to get from one place to another. The electric scooter market alone is expected to reach $41 billion by 2030, and that number has only been exacerbated by the recent pandemic and trend of social distancing. Among the many growing problems caused by the increased adoption of PEVs, lack of safety is a key issue that needs to be solved. Over the past decade as the PEV adoption rate has grown, so has the injury rate along with it. The goal of this design is to use low-latency cloud machine learning technology to drastically improve the safety of using an electric scooter PEV. By successfully implementing a Level 2 autonomous driving system that can lane-keep, avoid objects in its path, and alert the driver of upcoming dangers within a 360-degree view, this platform will accomplish the goal of adding preventative safety measures to a form factor that commonly lacks such technology. When passive safety measures (such as helmets) and other protective gear are paired with Level 2 autonomous driving features, the overall safety of the vehicle and the situational awareness of the driver are radically improved.

ECE – 02

28 GHz Beam Steerable Antenna - Session III

Dillon Baun, Kevin Carbone, Matthew Sigda, Antonio Stroh, Dr. Kapil Dandekar, Dr. Vasil Pano, Oday Bshara and Abu Saleh Tajin

The cellular communications industry continues to experience increased capacity demands as more devices and data-intensive applications enter the market. To mitigate these capacity burdens, 5th generation (5G) cellular networks offering ultra-high speeds and low latency are being deployed to replace legacy infrastructure. In recent years, the 28 GHz frequency has gained momentum as a potential 5G carrier frequency given the amount of available spectrum surrounding this band. While this increases the available spectrum, radiating at such a high frequency makes the wireless signal more sensitive to environmental conditions ultimately leading to increased power loss and decreased propagation distance. To overcome these issues, the wireless communications industry has been exploring high directivity antennas that use various beam steering methods to align the propagating signal in the direction of the receiver; however, these designs often minimize the beam steering range in exchange for higher gains. In an effort to develop a solution with increased steering, we propose a reconfigurable, conformal 2x16 inset fed patch antenna array. Each column of patches can be individually activated providing the ability to form a directed beam, while the conformal structure enables 360□ of beam steering. In addition, a reinforcement learning algorithm is being implemented to control the beam direction of the antenna to ensure a sufficient link is maintained. These features make the antenna design well-suited for mobile devices that are frequently repositioned, rotated, and experience changing environments. This paper details the final state of the design of the antenna system architecture and the beam steering control algorithm.

This material is based upon work supported by the National Science Foundation under Grant No. CNS-1828236.

ABSTRACTS

ECE – 03

DVT-PD: Deep Vein Thrombosis Prevention Device - Session III

Srivatsa Ganesh, Millo Ling, Greg Olsen, Hassan El Mghari, Dr.Kapil Dandekar, Dr. Bill Mongan and Dr. Vasil Pano

Over 900,000 people annually are affected by Deep Vein Thrombosis (DVT), a serious condition that occurs when a blood clot forms in a vein, typically in the lower extremity. 20% of those affected die, and this number continues to rise with the presence of a global pandemic that exacerbates the situation for surgical patients subjected to long periods of immobilization. Because of the large influx of hospitalized patients, preventative devices on the market are being used more frequently to minimize the risk of DVT. Unfortunately, there are challenges with current solutions with regards to design and patient compliance; compression devices cause discomfort and immobilize the patient. Despite existing efforts to increase blood flow through compression, devices today have immobilized patients and proven to be less effective. Thus, their reliability can be improved through a device designed to alleviate these issues while increasing patient compliance. DVT-PD's objective is to provide an unobtrusive and affordable option that mitigates the risk of DVT for sedated patients before, after, and during surgery. Findings indicate a need for a wearable device designed to sense the user's dynamic or static movements and actuate to promote blood flow in the lower legs. A developed control system broken down into 3 classes - sensing, classifying, and actuating - will be utilized to collect muscle activity data that will be input into a machine learning model to analyze classification accuracy. The model will regulate signals and along with the control system prompt the device to actuate, effectively reducing the risks of DVT.

ECE – 04

Real-Time Image Segmentation for Robotic Platforms - Session II

Jacob Baron, Harry Chong, Paras Doshi, Brent Lee, Dr. Anup Das and Dr. Nagarajan Kandasamy

Machine learning algorithms have become increasingly popularized over the last decade due to the emergence of high-end hardware and renewed research. Computer vision is at the forefront of the machine learning resurgence resulting in many products and applications utilizing these new advancements. While traditional computer vision algorithms solve a wide variety of problems, they require expensive hardware to execute or collect user data and execute on a server at the cost of a user's data privacy protection. If the hardware constraints could be reduced, then cheaper, less energy-consuming hardware can perform the algorithms and eliminate the need to risk user privacy. This project's objective is to provide a new, state-of-the-art solution which reduces energy consumption, protects user data, and maintains the same performance. Although current solutions utilize artificial neural networks, which lack low-power capabilities, this project provides a novel use case for neuromorphic computing algorithms, which aim to mimic the neural structure of the brain to decrease energy utilization. The spiking neural network, a neuromorphic computing algorithm, is capable of implementing image segmentation and classification, both common computer vision applications. These networks will be deployed to an edge-device using quantization-based training to compare against existing models in terms of accuracy, power utilization, and performance. The developed solution networks will serve as a novel use case for neuromorphic computing by demonstrating the feasibility and benefits of using spiking neural networks to solve computer vision problems.

ABSTRACTS

ECE – 05

Multi-Target Tracking Testbed (gr-tracker) - Session III

Abhishek Adhikari, Sujoy Das, Sameer Parihar, Cody Scully, Dr. Kapil Dandekar, Dr. Vasil Pano and Anthony Treszza (Lockheed Martin Co.)

In today's age of technology, radar tracking systems play a pivotal role for many application areas such as robotics, computer vision, autonomous driving, and more. The problem with any tracking system lies in the process of tracking multiple maneuvering targets in a noisy and cluttered environment. Throughout the last decade, advances in new tracking techniques have opened numerous research venues in addition to new application areas, and Multiple Target Tracking (MTT) is one of them. Standard algorithms that have been traditionally used for tracking are Particle filters and variations of the Kalman Filter. However, even with these existing solutions, major challenges associated with the tracking of multiple targets still exist. Such challenges include mitigating momentary obstructions of the sensor (e.g., Birds flying in front of a radar), proper handling of variable number of targets, and obtaining shape/size information for the targets of interest. Therefore, it is imperative to find a method of rapidly testing MTT algorithms in real-world scenarios. Rapidly testing MTT algorithms can be made possible by leveraging the existing remote-access infrastructure of the Drexel Wireless Systems Lab (DWSL) into a testbed to learn, develop, and refine tracking algorithms. The DWSL infrastructure currently deploys Software Defined Radios (SDR) that are capable of Over-The-Air testing and wireless channel emulation. This foundation will therefore offer an approach to emulate realistic RF environments in real time which allows for a greater variety of experiments for an iterative approach towards refining and improving MTT algorithms.

ECE – 06

Wireless Energy Management System - Session III

Khurshed Ahmedjonov, Hasan Alarbash, Nicolas DiMarco, Ahad Rafi and Dr. Baris Taskin

In the United States approximately 2 Million households have Solar Panels and the number is growing rapidly. The homeowners have the solar panels connected to an inverter with an optional battery. The sources are directly connected to the main panel providing immediate power to the bus. The problem is that the users do not have any control or knowledge of their home electric consumption and statistics. Without personal hardware monitoring, residential home owners do not have a convenient way of looking at their power usage. While it can be argued that the users can connect an oscilloscope or other power monitoring hardware to the mains voltage, these methods are unconventional, inefficient, and can pose a threat to an individual lacking technical experience. The purpose of this system is to allow the user to have an autonomous system that will be able to switch incoming sources to their home, while monitoring the power quality from each respective source. Using a Raspberry Pi, the system would be able to show information about the main home line including the voltage, the current, and the power quality. In addition, the user would be able to switch between solar and grid power. The whole system control and information would be available in a site hosted on the Raspberry Pi. This would give the user complete control over their power sources.

ABSTRACTS

ECE – 07

Sleep Apnea Detection Using a Spiking Neural Network on an FPGA – Session III

Cameron Calv, Neel Jagad, Nicholas Sica and Dr. Anup Das

Sleep apnea is a potentially deadly affliction causing irregular or halted breathing during periods of sleep that many individuals will unknowingly suffer from in their lifetime. It is usually diagnosed using polysomnography (PSG) testing either in a lab environment, which is costly and accurate, or in-home tests (IHT) where it is cheaper in exchange for underestimating the apnea's severity. Machine learning has the potential to accurately predict sleep apnea severity using the same oxygen saturation levels as a PSG or IHT test. Deep learning has emerged as a vital subfield using a multi-layered architecture vaguely reminiscent of the human brain in its complexity, and it has shown to be incredibly accurate with the expense being increased power, complexity, and time requirements. The gap between PSG tests and IHTs may be reduced with a machine learning model that has the accuracy of the PSG tests and that can be implemented on the resource limited IHT kits. Bridging this gap will contribute to wider test availability while remaining economically feasible. Initially, spiking neural networks (SNN) have been observed to decrease power, computing, and time while being able to process in near real-time. Similarly, FPGAs have shown to further reduce power, computing, and time when such an SNN is programmed onto them. In addition, the FPGA's re-programmability makes it suitable to utilize any onboard SNN model. CPUs and GPUs may be used to generate these models, while the FPGA will house them and make predictions using the trained model's rules.

ECE – 08

Physiological Strength Measuring System (PSMS) – Session III

Moaaz Moazzam, Jason Ngo, Denis Ogiyenko, Eshik Rahman and Dr. Bruce Eisenstein

With the advent of the Internet, membership-based gyms, and countless fitness guides, it seems that the ability to forge a stronger physique is easier than ever. It is unsurprising that the number of gym memberships has grown every year (Gough - 2020). However, ease of access to a gym does not mean it's easier to follow a fitness regimen. In fact, half of all newly registered gym membership owners cancel their subscriptions after only six months (IHRSA – 2018). This demonstrates a significant dilemma, especially for membership-based gyms to counter against. The high early turnover rate that membership-based gyms experience implies that there is room for further improvement. The core area of improvement that should be focused on is providing a solution that will aid a user on their fitness journey. With this solution, the membership turnover rate is expected to gradually reduce. Thus, our goal is to provide chain-based gyms a device that allows members to measure their current strength, track their progress and generate a personal fitness routine based on their current needs. Our device, utilizing software and sensors, will attempt to read a user's isolated muscle strength to provide feedback on their fitness progress. The device will output data to a graphical user interface to provide information such as strength improvement, weekly measurements, and inadequacies between muscles. Finally, the device will suggest potential changes to enhance a user's fitness plan. Our end goal is to develop a system that mutually benefits both gyms as well as its attendees.

ABSTRACTS

ECE – 09

BookIt - Session II

Cheyenne Dwyer, Jason Houghton, Fernando Mendez and Dr. Mark Boady

With the rise of the internet and mobile technology came waves of innovation that changed the way people do things. Today, people order taxis with Uber, food through GrubHub, and even crafts from Etsy. However, there still exists no such technological equivalence for scheduling appointments. This was especially highlighted by the COVID-19 pandemic where professionals like barbers, hairdressers, and tattoo artists saw a decline in their revenue as they were forced to operate on an appointment-only basis.

To better understand why an effective solution has not yet arisen, a market survey of existing scheduling softwares and service provider marketplaces was conducted. From this research, BookIt was created to be the most fitting marketplace solution for modern-day service providers. BookIt will remove the barrier to entry that is imposed by existing platforms by offering a market-unique pricing model in the form of a monthly fee that is capped and proportional to the amount of appointments scheduled by the service provider. Further, BookIt will more appropriately model the relationship that service providers have with their place of business. BookIt will offer free schedule-management software with which service providers can optimize their schedule. Service providers will also be able to list their schedules on its marketplace for potential clients to view and insert themselves into an available time slot. BookIt will use these innovations to transform how people schedule appointments.

ECE – 10

Pitch - Session II

Nael Albaki, David D'Apice, Riccardo Maio, Daniel Martini and Dr. Christopher Peters

Pitch's mission is to bring musical democracy to situations where people are listening to music together. Pitch introduces a music recommendation system to allow users to suggest and vote on songs, empowering them to voice their music taste. With live feedback data collected from participation and movement measurements, users can tangibly determine community enjoyment. By combining creation, hosting, and management processes, Pitch is able to streamline the digitalization of music listening sessions. Whether users find themselves in a car ride with friends, at public establishments, or hosting a party, Pitch makes it possible to turn everyday situations into community-driven, music-centric events. With music recommendations, live feedback, and easy event orchestration all in one mobile app, Pitch revolutionizes the music listening experience.

ABSTRACTS

ECE – 11

Classifying Patents - Session II

Harpreet Cheema, Julius Park, Simon Szymanski and Dr. John Walsh

Patents need to be classified into categories before they can be reviewed by humans. The United States Patent and Trademark Office (USPTO) uses the Cooperative Patent Classification (CPC) system, with patents being assigned at least one classification term under this system. This is a multi-stage process with an initial pass by subcontractors to the USPTO, which is later verified and refined by examiners at the USPTO. This whole process is very labor intensive and requires expertise as well as experience on the part of the examiner. Many examiners specialize in very narrow subsets of their field. In order to utilize their time as efficiently as possible, the USPTO will try to route patents to the examiners based on their skillset and examination history. Our patent classification software solution aims to aid this process by introducing an automation step in the patent classification pipeline. By using machine learning techniques such as Natural Language Processing (NLP) and text classification, this software solution will be able to generate and affix sets of classifiers to patents. The system constructed under this project addresses important problems, such as being able to have more than one classifier per patent, scalability across a large sample space, as well as flexibility to changes in pre-existing schema. The constructed software solution automates the most labor-intensive aspect of patent classification, ensuring optimal use of the examiners time by efficiently routing appropriate patents to them.

ECE – 12

Visual Impairment Aid Device - Session III

Hai Le, Dao Nguyen, Dinh Nguyen, Hoang Nguyen and Dr. Nagarajan Kandasamy

Visual impairment refers to the disfunction of human's vision where people can only see everything in blur or in some case, they can only see a black screen called blindness. The group accounts for a 3.44% of worldwide population which is increasing over the time and they depend heavily on the tools to help with daily lives. However, despite the huge technology innovation over the past decades, the visual impaired community is still using the old tools which are not performing well and have a lot of limitations. The visual impairment aid device project is a pair of glasses device that utilizes the new AI technology development into object detection and voice commands to aid the visual impaired community with navigation. The device will use different concurrent technologies such voice assistant tools, object detection AI, Google API services and combines them into a pipeline that will produce voice instructions to help the visual impaired people and improve their living standards with independence. Distance to the objects will be measured from the data obtained from the object detection AI model. A test application will be built on Android mobile phone which uses the phone camera to capture and fetch the video and voice stream to the application where the AI models and Google API services will process the stream data and produce accordingly voice output as instruction. The end goal will help the visual impaired community to live independently and provide them one step closer to the modern society.

ABSTRACTS

ECE – 13

The AiWitness App - Session II

Mohammad Adib, Saugat Dawadi, Prasenjit Gaurav, Charles Nischal, Dr. Anup Das and Dr. Nagarajan Kandasamy

People are unwittingly exposed to incidents like violence and racism everyday. It is desirable for victims or witnesses to capture evidence of such incidents and notify others nearby to ensure that other people avoid danger. There are applications in the market which help in reporting informing people about these incidents. However, they use human reviewers to analyze and review the incidents, causing delays in getting the report out. For such applications, it is highly desirable to minimize the delay between incident reporting and subsequent broadcasting by automating the review workflow. The AiWitness App's primary objective is to reduce the delay between the reporting and the posting of such incidents by autonomous analysis of incoming audio and video streams using machine learning models. The models are trained to recognize objects such as guns in the video, and keywords in the audio and review the incidents. This minimizes the element of human delay and thus helps in getting reports of incidents out earlier which will prevent the involvement of bystanders in the incidents. The designed application also includes useful features in emergencies such as app startup via shortcut buttons, audio & video streaming and broadcasting, and location sharing which increases the chances of help getting to people in incidents. The streamed content is also stored in a cloud which is accessible to the user in the future. The AiWitness App's functionalities, coupled with the use of Machine Learning analysis to analyze incidents, will help reduce the delay between incident reporting and incident posting.

ECE – 14

Solar Feasibility Study for Biaka University Institute of Buea - Session II

Alena Augustine, Roberto Baratta, Glen Brown, Alison Reed and Dr. Kevin Scoles

Biaka University Institute of Buea, located in Buea, Cameroon, is a university serving over 1300 students on a campus with eight buildings, including St Veronica's Medical Center. Cameroon's primary electricity source is hydroelectric power; however, due to prolonged dry seasons and inconsistent management, these plants do not produce enough electricity year-round. To compensate, the university has two diesel backup generators to pick up load demand during frequent power outages. These generators are now at the end of their useful lifespan. Therefore, Biaka University is looking for an affordable alternative that is reliable, quiet, and sustainable. This team's objective was to conduct a feasibility study to see if the university can replace their generators solely with solar photovoltaics and battery storage or if continued generator use as a solar backup is necessary. The approach involved modeling multiple hybrid energy systems and evaluating each option's electrical performance and cost. The reliability of each system was compared based on their ability to meet load demand and surplus in case of emergency. Hybrid system component options include solar panels, generators, batteries, or combinations of these using real market options. These were modeled through satellite images, 3-D models of each building, and the system layouts. Simulations use local solar, wind, temperature data, local fuel prices, and estimated building energy loads. Preliminary simulations and research showed that it was feasible for the university to meet their load requirements with solar panels and battery storage. However, with the university's new expansion plans, other sources of generation may be needed.

ABSTRACTS

ECE – 15

F1TENTH LiDAR Based Autonomous Vehicle Control - Session I

Kevin Atwell, Theo Butler, Alex Cilento, Jessica Dixon, Jonathan Palko and Dr. Thomas Chmielewski

Based on current trends within the consumer market, autonomous vehicles are projected to fill roadways with their convenience factor and ever decreasing cost. This is largely because autonomous cars allow for easier and safer transportation. However, autonomous cars need proper software and testing to reliably work under highly diverse and varying conditions that may put human lives at risk. Using the F1TENTH platform, autonomous vehicle scale models can be easily implemented and tested, which can influence the development of large-scale autonomous vehicle implementation. Using the F1TENTH platform, LiDAR, and various other sensors the autonomous operation of a car can be tried and tested on a smaller and less expensive scale. This project involves assembling and testing the Traxxas RC kit that was provided by the Drexel ECE Department and then making hardware and software improvements to maximize its performance within the constraints of the F1TENTH specifications and competitions. Algorithms are used to rapidly respond to sudden disturbances, avoid collisions, and increase reliability. Another important factor in the performance of an autonomous car is aerodynamic efficiency. For this design aspect, a shell for the car will be modeled and fabricated to minimize the effect of drag. The success of this project will be measured by analyzing the performance of the car as a whole. The performance metric will be how quickly the car navigates through predetermined 4-meter courses while avoiding obstacles. Achieving this will lay the groundwork for future F1Tenth, and autonomous vehicle operations as well as research at Drexel.

ECE – 16

Self-Playing Guitar - Session I

Mariam Gamtsemlidze, Jonathan Oppenheim, William Sweren, Stephen Voellinger, Johnson Zhao,
Dr. Youngmoo Kim and Andrew Wiggins

People have been making automated instruments for as long as the mechanical parts could be obtained. This project looks to build a device that automates the playing of a physical guitar, allowing the user to hear the play of a guitar as opposed to a digital sample. There are various implementations of automated guitars utilized to make design decisions. Currently existing designs are static to a dedicated guitar, while the Player Guitar will be transferable to any electric guitar. A common component are solenoids for fretting; this design will implement wider solenoids, at a fraction of the cost of other projects. The picking mechanism will use servo motors like other player guitars and in addition, achieve desired damping through extended rotation. Most designs for stringed instruments done historically have generally had all of the strings fretted at once, while one or several strings were played. While that might work for a violin or viola, the needs of a guitar require the additional challenge of having each string be fretted individually. This paper will discuss the methods used to automate the play of a guitar and describe the challenges faced when designing such a device -- making the device physically compatible with the instrument; and executing the necessary functions to create music, like fretting and strumming the guitar. The process of making preliminary and final decisions for design and implementation will be demonstrated, and the technical details of the chosen design will be explained. Finally, the aspects of execution, including budgeting and testing prototypes, will be laid out to inform a baseline for market production.

ABSTRACTS

ECE – 17

Wearable EEG Devices - Session III

Erica Cooper, Timothy Cross, Joseph Theoharakis, Dr. Allon Guez, Dr. Bruce Katz and Zhuo Wang

Electroencephalography (EEG) is a test used for recording electrical activity of the brain. These tests take place in a clinical setting, with patients' heads connected to a device through multiple wires. Using EEG, doctors are able to monitor their patients and support their diagnoses, such as epilepsy and sleep disorders. Noting these benefits, there is current interest in developing wearable EEG devices that can be used outside of a doctor's office and for non-medical applications. However, existing wearable EEG devices are bulky, unattractive, and expensive. These designs discourage their use, limit data collection, and ultimately, overlook the goal of wearable devices. Therefore, new designs should focus on appearance and comfort to promote and expand the use of EEG. The goal of this project is to create two ergonomic wearable EEG devices that are functional and appealing to a wider pool of users. Based on previous research, EEG signals could be gathered when making contact with one's ears. Therefore, chosen designs include over-the-ear headphones and inner earpieces. Quality performance is ensured by comparing prototype devices and an existing device within a signal-processing application. The application is effective at reading EEG data from the existing device and using that information to quantify the level of a patient's focus. It will verify that the prototype devices are capable of measuring EEG data that results in positive user experience. Upon completion, this project could be improved for intent to sell and used as inspiration for more affordable wearable EEG devices.

ECE – 18

Using HTCondor to Scavenge Wasted Compute Power - Session II

Mahfuz Anam, Douglas Balish, Aaron Lee, Andrew Marx and Dr. Gail Rosen

Every year, computers in university labs, libraries, and offices sit idle for thousands of cumulative hours, wasting CPU cycles and compute time that could instead be leveraged through cycle scavenging. On top of this, students and staff may be paying for dedicated high throughput computing services to run simulations and calculations that could sometimes be accomplished in-house for a fraction of the cost or with more efficiency. Despite the potential benefits, there is a relatively widespread lack of implementation. This project aims to analyze the advantages, weaknesses, and performance of the cycle scavenging software HTCondor to determine its viability as a solution to the problem of wasted compute resources. Another main objective of this project will be to implement a custom high-throughput computing solution on Drexel's network of computers for academic use. This solution will allow for the effective use of unused and readily available computing resources, handle the scheduling of jobs on the system, and allow users to run complex algorithms and simulations on multiple devices at once. This system will run in the background and will guarantee that users of the underlying computing resources will not be throttled or inconvenienced by these tasks. The high-throughput system will be designed to be scalable to a large network with many computers in its system and configurable to the desires of administrators and the requirements of policies. The project will demonstrate these features through a small-scale demo before going forward into larger-scale implementations.

ABSTRACTS

ECE – 19

Education Robotic Platform (ERP) - Session II

Siwei Cai, Cao Han, Song Hao, Bruce Jiang, Manjun Li and Dr. Bruce Eisenstein

Robotic is a booming industry as millions of companies invested in this area, thus, they need more young engineers to advance the industry. However, the current college education doesn't have a platform for students to experience robotics in full. Our idea is to create an "indoor robotic hardware SDK" for education purposes. Students who are interested in robotics can not only explore the depth of automation but also expand the possibilities with their own design. We are going to make this design open source in order to make it more accessible to the public, thus lower the overall entry barriers. Our project will consist of both the hardware and the software development of the robot. That means we will include instruction and also examples of sensors, motors, and drivers we used, as well as code for autonomous. During this process, we will.address many possible designs and discuss their pros and cons and also record any trouble we run into during the process. Apart from the physical design we will also show implementation of the Robotic Operating System(ROS), SLAM, path planning, neural network, and feedback control as they are the key for modern autonomous robotics that drive this industry. This platform provides a glimpse of what is done on the cutting edge in the industry and gives an engaging experience that students can carry into their future career.

ECE – 20

Custom RFIC and 3D Printed Antenna Designs for FMCW Weather Radar Operating at 36.9 GHZ - Session III

Sabir Ahmed, Jean-Luc Cassagnol, Benjamin Coons, Joe Nestor, Alexander Shoff, Dr. Afshin Daryoush, Nick Bromhead, Kevin Singh and Joseph Fasbinder

Frequency modulated continuous wave (FMCW) weather radar systems are used world-wide to detect cloud movement and predict storms and other catastrophic weather events. Stationary weather radar systems require the use of large moveable radar dishes to sweep across an area. The manufacturing and deployment of conventional weather radar systems is limited due to their high manufacturing costs and large power needs. Thus, conventional weather radar systems must prioritize areas of high population density in order to service the greatest amount of people. Rural areas, or areas of lower population density, are often neglected accurate weather coverage due to stationary weather systems being unable to cover large swaths of land. Mobile FMCW radar systems can service remote areas, but the cost, weight, and low resolution of these systems make them economically unviable. These systems operate in the X band with electronic components surface-mounted onto PCBs. Utilization of 3D printing and radio-frequency integrated-circuit (RFIC) fabrication allows for cheaper systems while moving to a higher frequency band. Our design is a 3D printed phased array antenna working at 36.9 GHz. The higher operating frequency increases velocity resolution and power received over conventional weather radar systems. Microwave frequencies also allow for use of distributed element components that can be printed on RFICs with more precise tunability than surface-mounted lumped elements. These RFIC designs are also smaller than typical designs offering a reduced form factor and cost due to the smaller-wavelength frequencies.

ABSTRACTS

ECE – 22

Smart Parking - Session III

Maryna Bencharska, Jay Dave, Animesh Sarker, Jerin Varghese, Dr. Steven Weber and Dr. Nagarajan Kandasamy

According to a traffic-analyzing study, Americans on average spend 17 hours per year searching for parking using the current parking system. These systems consist of expensive sensors, outdated equipment and require constant maintenance. As a result, these systems are not adopted by most parking garages. Hence, drivers spend more time finding parking spots which lead to more carbon emissions and traffic congestions, especially during rush hours. In an independently conducted survey, more than 85% of drivers believe that current parking solutions are inadequate and would prefer a more effective way to find parking. The objective of the Smart Parking project is to come up with a system that leverages existing infrastructure in parking garages with low-cost sensors to keep track of available parking spaces. The system would use cameras that are already installed in parking garages to detect parked vehicles using object detection algorithms and essentially calculate free spaces. The low-cost sensors would be easier to install because of their simple architecture. This Smart Parking system will also make use of a mobile application that a user can use to find available parking space at their nearby parking garage, reserve and pay for their spot through in-app payments. The mobile application would make it easier to identify and choose the best price offered among nearby parking garages. Overall, the system will direct users to their chosen parking garage through the mobile app, and hence, save valuable time, reduce carbon emissions, and alleviate traffic congestion.

ECE – 23

Plat'r A Reusable Tray Warewashing System - Session II

Adam Bengis, Clara Fancher, Ismael Herrera, Thomas Kish, Travis Sewell and Dr. Christopher Peters

Engineers across all industries are striving to find local solutions to the current climate crisis. The scientific community has become surer of the impact of humanity on climate. Research continues to affirm the dire future consequences for the planet if waste and recycling practices are not changed. The production, use, and disposal of Expanded Polystyrene (EPS) foam, commonly known under the brand name Styrofoam™, has many detrimental effects on the environment and the people who come in contact with it. EPS foam is prevalent in food takeaway containers, especially for small-scale vendors that cannot afford to upgrade to more expensive sustainable packaging options. The locations where food trucks congregate are hotbeds for Styrofoam™ usage and could produce waste with magnitudes in the thousands of food containers per day, contributing to the demand for manufacturing EPS products and the inevitable pollutive impact these products will create. This paper explores the logistics and design of a system to provide a reusable food tray service to small vendors and consumers. While also recognizing that food trucks constitute an important cultural facet for their communities and should be maintained. Creating a positive impact on the environment and food truck culture is paramount to this team's success. This report details the design of a reusable food tray lending system utilizing an automated industrial warewasher. This system will allow vendors to check out stacks of reusable trays and distribute them to their customers. The customers may then return the trays to the lending machine to be cleaned and sanitized. Using reusable trays in a previously inaccessible market will reduce the environmental impacts caused by discarded EPS foam.

ABSTRACTS

ECE – 24

Improving the Customer Migration Process with Database Mapping - Session II

Dan Dunkers and Dr. Andrew Cohen

I am the lead software developer at Brytemap, a company that specializes in software tailored to the cannabis industry. Brytemap provides point of sale software for dispensary owners to be able to manage their retail business. As a growing business it is important to be able to migrate customers over to our platform quickly. Brytemap's projected growth this year includes 56 retail dispensaries. It takes a week to migrate a customer over to our platform if they are coming from another competitor. Data migration is a large part and is currently a manual process that involves mapping the data given to us to our database. Automating the data migration process would be able to reduce our onboarding process time by half, enabling Brytemap to meet their growth projections. My senior design project plans on automating this process by creating a smart database mapping algorithm that matches data based on the content of the data and the field name using semantic pattern recognition. Creating an algorithm that matches on the field name of the data element and the content of the data element overall will create an accurate and quick way to migrate customers over to our system. I am going to create a mapping algorithm using my method and compare it to the current mapping program that was created at Brytemap to measure accuracy and speed improvements over the current system.

ECE – 25

Lunar Sample Aggregation Module 1 (L-SAM 1) - Session I

Abdul Rahman Al-Saadi, Anthony DelGuercio, Manpreet Parihar, Surya Saket and Dr. Gennady Friedman

Research on the composition of the moon's soil and what rarities it could hold is largely unexplored. With the upcoming Lunar missions such as the Artemis program, it is now more important than ever to understand the composition, structure and quantity of different minerals located on the moon. This is necessary to plan safe lunar habitats in the future as these minerals could provide vital resources needed to sustain human life. To better understand the moon's surface, samples of lunar soil need to be collected to perform the required research. Our project aims to build an architecture concept for a system that would land a drill vehicle on the moon, collect samples of the crust, and return to the international space station (ISS) for research. This project theme is inspired by NASA's 2021 RASCAL competition. The theme of the challenge is Distributed Lunar Sample Aggregation, Analysis, and Return to ISS. The project would involve making orbital mechanic calculations and designing a sample transport system. The system will collect samples from multiple locations on the moon to cover a large range. The samples will have to be shielded from external sources like radiation and non-lunar materials. The goal is to enhance the capabilities of current space technology & push the space frontier forward.

ABSTRACTS

ECE – 26

Visually Impaired Assistance Cane - Session III

Zayim Abdul-Wakeel, Trevor Jackson, Ross Kelly, Samer Younes and Dr. Bruce Eisenstein

Blindness occurs either naturally or accidentally. Normally visually impaired people use a cane and depend on it to help detect obstacles when on the move. Though they rely heavily on it, it does have certain drawbacks as well. A very common deficit of canes is that they are not efficient at detecting things such as potholes, so blind people are at an increased risk of injury from such occurrences. Furthermore, because of spatial awareness issues people can veer from a straight line, causing them to turn towards a hole that they didn't notice because it wasn't originally in front of them.The Visually Impaired Assistance Cane (VIAC) will allow the user to be more aware of their surroundings, detecting obstacles ahead up to 2 feet away. Users will experience a safer navigation by receiving haptic feedback on what is ahead of them. The VIAC will utilize the use of an ultrasonic sensor and thermal camera to detect and determine living or nonliving objects in front of the cane.

ET-01

Low-Cost Thermal Mask Sanitizer — Session III

Edgar Jimenez, Huy Nguyen, Nick Senich, Manyah Kohli and Dr. Finley Shapiro

Covid-19 spread like fire, taking any individual under its wrath. The vaccine is out and is actively being injected to people, but less than 50% of the population is vaccinated. We have been asked wear two masks. In addition, at least one new strain of the virus has been detected. Our responsibility to create a low-cost thermal mask sanitizer has increased in order to reduce the number of masks being produced and disposed of. N-95 masks have proven to be the most effective mask, with dry heat being the best method to sanitize them. We are in the process of creating a desktop size face mask sanitizer which is easy to use. The device sanitizes up to 30 masks in a cycle of 30 mins. Possible consumers could range from schoolteachers to healthcare professionals. Widespread use of this sanitizer could greatly reduce the impact on the N-95 supply chain and allow a broader distribution of effective N-95 respirators. Reusing N-95 masks would also reduce the total number of masks that end up in landfills, which is a growing problem.

ABSTRACTS

ET-02

Fire Surveillance Drone — Session III

Sturfford Alfred, Luke Houseman, Sebastian Brooks, Kai Sung Chen, Dr. Irina Ciobanescu Husanu and Dr. Yalcin Ertekin

Fire departments across the nation face different challenges depending on their geographical locations. Two important environments that pose a threat to fire response units are large rural areas where wildfires occur, and urban areas where dense residential fires occur. In recent years, we have had some of the largest wildfires ever recorded, destroying over one hundred thousand acres of land. Although fires in urban environments are not as prevalent, there are constant improvements to the communications and intelligence systems that are used. There has been an increase in the adoption of drone technology within fire departments to capture and provide information to first responders. One of the main tasks of fighting large-scale fires is identifying areas of the fire boundary that have the potential to flare up, causing significant damage to the landscape and structures, or scatter embers that can reignite already burned areas. We have identified a demand for a quadcopter UAV that can survey large areas of land in both the visible and infrared spectrum so that fire crews can collect critical real-time information about the nature of the operating zone as it changes over time. Drones increase safety by allowing firefighters to better evaluate the scene through different vantage point as well as increasing the distance from the fire.

ET-03

Solar Powered Autonomous Rooftop Greenhouse — Session III

Calvin Dai, Daniel Goldenberg, Grandin Hammell, Dana Jones and Dr. Finley Shapiro

This project will utilize renewable solar energy to power an autonomous greenhouse, isolated from the grid with minimal human labor required. There is an increasing demand for locally grown produce and a need for self-sufficiency. The goal of the project is to design and model a solar powered, autonomous, rooftop greenhouse for use in urban areas. This project targets urban populations that would benefit from increased availability to home-grown produce, but may not have the time, space, or expertise to tend their own garden. Deliverables include a comprehensive SolidWorks model of the greenhouse, as well as mathematical calculations and computer simulations of power generation, power consumption, thermal management, and plant yield expectations. A motorized, conical bio-wall structure will be used as the foundation of a hydroponic growing system, maximizing plant yield through efficient nutrient and sunlight exposure. For power generation, this project considers the risks and benefits of both traditional, non-transparent solar panels as well as semi-transparent solar panels that are not as commercially available yet. This interim report will include details on the most current SolidWorks model, and progress made with the solar, electrical, thermal, and structural simulations and design validation. We will also discuss next steps, as we look to conclude in Spring of 2021.

ABSTRACTS

ET-04

Squeezy Boi Pipettes — Session III

Guy Sappington, Ayanna Gardner, Andrew Ward, Anthony Catalano-Johnson and Dr. Irina Ciobanescu Husanu

We have been tasked with the optimization of process parameters and mold design for a small micro-fluidic pipette used in the medical testing industry. The current process uses separate operations for the formation of the stem and bulb portions of the pipette, our proposal will consolidate these into a single operation that will be faster and more reliable. We were able to determine optimum process parameters for the compression style of seal, through testing of various ambient conditions, clamping forces, and molding temperatures. Our optimized mold design merges what used to take two operations into a single operation for the entirety of pipette geometry formation. Our solution is to take the two stations that form the bulb and consolidate them into a single station by changing the method that the seals are made. Heat will be applied to the top and bottom mold. Based on these optimizations, and our calculations for our Economic Analysis, we project that Drummond will generate a 10-15% increase in overall production volume.

ABSTRACTS

CAEE – 01

Sustainability and Disaster Resilience of Community Design in the Caribbean

Advisor(s): Prof. Simi Hoque, PE

Manon Flamini, Helena Kim, Spencer Kociba, Ina Sison, Monica Zaman

Disasterologists around the world would agree that there is no such thing as a natural disaster. They would argue that there are natural hazards like hurricanes, earthquakes, flooding, and tornados, but "disasters" are not dependent on climate alone. With climate change projected to be even more severe without international commitment to effective policies, the most vulnerable communities will continue to be at risk of these hazards. The San Cristóbal Community of Resilience and Sustainability was a research and design project from Esperanza Verde that developed a process and prototype for community design in the Caribbean. The project was rooted in the sustainability principles of participatory governance, passive design, and disaster resilience. The project goal was to incorporate these principles in every possible aspect of the design. A community program was developed alongside an overall site plan for residents to have access to all necessary resources and amenities within the community. Some of these amenities included a community center, single-family residences, medical facility, school, and additional spaces designated for future use. The project's sustainability and success relied heavily on developing the design process: the process can be repeated and altered according to varying parameters and applied to sites worldwide.

CAEE – 02

Hunting Park Community Center

Advisor(s): Prof. Jin Wen

Ilana Gorberg, Joseph Weber, Wonho Jeong, Ziqing Zhong

Locals near Hunting Park are subjected to heat emergencies in summer. The city uses public buildings to provide cooling centers for such neighborhoods. However, since the pandemic, these facilities have been closed. The project goal was to design a community center near Hunting Park with an enhanced HVAC system that can lower the air-born viral transmission and provide safer conditioned indoor space. Because a nonprofit organization will operate the facility, the building is designed to have lower operation coasts. The Northlight window, green roof, and stramp are included to lower energy costs.

For the HVAC system, variable refrigerant flow (VRF) and dedicated outdoor air system (DOAS)were selected based on system flexibility, energy efficiency, etc. The two systems are decoupled, where DOAS brings in conditioned100% outdoor air into the space, and VRF provides desired heating/cooling. The equipment was sized and selected based on peak thermal and ventilation loads and system capacity. Also, ventilation and distribution layouts were designed. The community center was made of wooden roof trusses over the larger rooms, so columns would not be needed. The rest of the building was framed with wooden beams, girders, and shear walls. Based upon the type of building, support from a strip foundation will make up the community center. The ground to cover with respect to stormwater inhabits green infrastructure that gives optional alternative solutions as well as aesthetic appeal. All operations, labor, and materials within the scope the work enlisted were developed in a detailed schedule and bill of materials.

ABSTRACTS

CAEE – 03

Combatting the Coming Water Crisis with Cogeneration

Advisor(s): Dr. Charles Haas

Noah Weiss, Francesca Johnson, Nolan Murphey, Reenish Shah

The City of Buckeye, Arizona is one of the fastest growing cities in the United States. While the region is plagued with low rainfall and increasing water demand, there exists a high solar irradiance and large reservoirs of shallow brackish groundwater. Using the available natural resources, the design team investigated the feasibility of a sustainability focused cogeneration plant. The plant combines Concentrated Solar Power (CSP) for electrical generation and Reverse Osmosis (RO) for water desalination The environmental team focused on an aquifer drawdown analysis over the lifetime of the plant (30 years), RO pre-treatment system design, waste management plans and a detailed construction timeline. A well system that spans two separate aquifers was proposed to avoid excessive drawdown. A pre-treatment system consisting of two treatment trains was proposed in order to remove arsenic and silica, featuring coagulation, flocculation, and sedimentation. The sludge produced from pre-treatment will be sent to a local wastewater treatment plant, while the rejected brine waste will be treated in evaporation ponds. The mechanical team focused on system CAD drawings, a thermodynamic and sensitivity analysis for the CSP plant, and capital and operating expenditure tables. The system was optimized to accommodate condenser scaling to improve overall cycle efficiency of the CSP steam loop.

CAEE – 04

Philadelphia International Airport (KPHL): Runway Storm Protection

Advisor(s): Prof. Robert Swan

Tyler Banas, Dylan Cohen, Bailey Allmond, Megan McKenna

The Philadelphia International Airport is currently constructed on a flood plain located on the Delaware River in Philadelphia Pennsylvania. Because of the location of the airport, as well as rising river and groundwater levels, the airport is becoming subject to a higher frequency of storm surges that have a major impact on the airport operations. Not only are the short-term effects of storm surges a problem, but also the long-lasting damage to underground infrastructure is becoming an increasingly prevalent problem for facilities management to maintain.

The Philadelphia International Airport is currently battling this problem with storm surges impacting airport operations. This then leads to flight delays and cancellations, which in turn leads to loss in tax revenue for the airport.

MBDTS analyzed high liability areas such as runways and taxiways through geological, weather, and transportation capacity exploration. The final design consisted of an Underground Stormwater Detention System, which will be located on the grounds of the Philadelphia International Airport. This solution was determined to be the best alternative to the project based on project life, efficacy, and payback period.

Included in the final report are analyses regarding the following areas: financial, hydrological, and geotechnical. These analyses were used to assemble finalized documents which include the final design, construction operational plans, value engineering, and overall construction costs.

ABSTRACTS

CAEE – 05

CAE Engineering Building

Advisor(s): Prof. Dr. Lo

Stephen Pettit, Rowan DuBois, Will Tompkins

S&TB Engineering Co. designed the architectural, structural, mechanical, and electrical systems of a proposed Drexel Engineering building on campus. The CAE Engineering Building will be located what is currently Lot F in between Ludlow Street and Chestnut Street. This building will be split into two adjacent buildings: the academic building and the commercial building. The academic building will be the home of the Civil, Architectural, and Environmental Engineering Department, and the commercial building will be leased to different businesses to help fund the building. For the past year, the world has had to overcome the struggles of a global pandemic. Schools across the country had to close their in-school operations because of the spread of the virus. Most of these schools were not designed to meet the guidelines the Center of Disease Control (CDC) put in place. S&TB Engineering Co. provided unique engineering designs that would allow Drexel to open this building in the event the world faces another global pandemic. These designs include a temporary wall design for capacity limitations, and a unique mechanical design for healthy indoor air quality. If there is another pandemic, a secondary mechanical system will pretreat and provide additional outdoor air to the primary system which will deliver cleaner air to the building. S&TB Engineering Co. hopes that these engineering solutions will be implemented into more building designs in the future to prevent less building shutdowns in the event of another pandemic.

CAEE – 06

Multifunctional Heat Mitigation in Hunting Park

Advisor(s): Dr. Franco Montalto

Marissa Coolidge, Emily Hoing, Caroline Houlihan, Melody Wu, Anna Younger

A multifunctional cooling solution for the Hunting Park neighborhood of Philadelphia, the residents of which disproportionately experiences extreme heat, was researched, modeled, and designed. Cooling methods were researched and analyzed for a block on Franklin Street. Four design concepts identified to be suitable for exploration were the following: cool roofs, planters, wet pavement, and trees. These four heat mitigation approaches were chosen due to their multifunctionality in providing co-benefits that contribute to the ecological, aesthetic and social landscape on the street. To assess the efficacy of the design concepts to cool the outdoor pedestrian space, a microclimate modelling software called ENVI-met was utilized. A simulation of the microclimate during a recorded extremely hot day was conducted for each of the concepts. Once the simulations were run, data regarding the mean radiant temperature and predicted mean vote was extracted and visualized. The mean radiant temperature (MRT) is the temperature at a point which captures the flux of shortwave and longwave radiation. The predicted mean vote (PMV) is a comprehensive measure of thermal comfort which takes into consideration biological experiences to heat. The data regarding MRT and PMV were extracted for the pedestrian level to understand the theoretical effects of implementing these strategies. Upon comparing the simulations, it was notable that the planter benches and trees had the most impact on Franklin Street. Finally, the recommended planter benches and trees were developed in design drawings and site plans using Rhinoceros 3D and AutoCAD so that construction could begin.

ABSTRACTS

CAEE – 07

Fresh Prince Park

Advisor(s): Prof. Eugenia Ellis

Shannon Belfield, Cassidy Bornemann, Evan Cook, Milan Harris, Holly Hughes

SMECH & Phamily (SMECH) have been hired by the Will & Jada Smith Foundation to renovate an existing empty plot of land on the shore of the Delaware River into an ecological community center and surrounding community park. The site is located at 4501 Richmond Street in Philadelphia, Pennsylvania. This project is focused on meeting the needs of the community, bringing nature into the city, and completing the project with a sustainable focus. The site will feature a rain garden, wetlands restoration, and enough solar panels to meet the energy demand of the community center. Amenities for the public will include over 5,500 feet of walking trails and bike lanes, boardwalk trails spanning through the wetlands, and an amphitheater for public events.

CAEE – 08

Remediation and Risk Assessment of Fallujah, Iraq

Advisor(s): Dr. Joseph Hughes

Alexa Cassar, Tyler Doratt, Karan Sethiya, Sean McGinnis

This report includes a phase I and phase II risk assessment of Fallujah, Iraq, as well as a remediation design for Fallujah. This project was a response to the numerous medical studies done in this region that showed a concerning deviation to the normal gender ratio and abnormal amounts of birth defects. Additionally, case studies were performed which tested the hair of groups in Fallujah's population that correlated these abnormalities to the concentration of metals, such as lead and uranium, found in their hair samples. The group then tediously researched Fallujah and Operation Phantom Fury which was the American war with Iraq and was able to calculate approximately how much lead and uranium was present due to the war. The group also calculated an approximation of lead that was present in Fallujah outside of the war effort. Using these calculations, a risk assessment was performed that proved at these levels, the health abnormalities present in Fallujah's population were from the inhalation and ingestion of these metals. Lastly, after evaluating all the sources of lead in the risk assessment, the remediation design was based upon the information which showed that there were pathways of lead coming from outdoors and indoors. Therefore, the remediation design included both mitigating the risk from the outdoor environment and inside the homes of residents. This process included the most logical design based upon Fallujah's environment, as well as their resources. Overall, this project's goal was to reduce the health risks present in Fallujah through engineering design.

ABSTRACTS

CAEE – 09

Physical and Consistent Numerical Modeling of Bridges

Advisor(s): Prof. Aspasia Zerva

Victoria Porter, Xiaochen (Gavin) Du, Alec Hodgin, Steve Capogna, Brian Oh

Numerical modeling of a bridge in Mossy, West Virginia was done and hand calculations were performed to analyze the accuracy of the model. The 3D model was constructed to visualize and coordinate the stages of numerical modeling in the testing phase. The numerical modeling took place in SAP2000 as well as a dynamic impact load analysis in to determine the effect of scouring on bridge strength. The results of the analysis showed a decrease in bridge strength due to scouring. In addition to the structure being modeled, the effect of climate change will be quantified by analyzing the rising water levels attributed to more frequent and severe rainstorms in developed areas. From these findings, the effects of scour will be evaluated through various calculations and recommendations will be made on the best ways to remediate and mitigate existing and future scouring. The full-sized bridge in West Virginia will be evaluated and a lightweight concrete partial depth rehabilitation of the bridge deck will be scheduled and estimations for labor and equipment will be provided. Scheduling will follow a two-phase approach to allow maximum traffic flow whil work is being completed. Finally, a thermal analysis was performed on the test bridge in order to conclude if fluctuations of the room's temperature can be negated in the making of the model. Furthermore, the thermal comfort of the space will be evaluated to determine system parameters. Then the HVAC system will be examined to see if those parameters are obtainable.

CAEE – 10

Community Driven Design: Community Center & Football Field in Manbij, Syria

Advisor(s): Dr. Joseph Hughes

Abigail Gard, Sophia Laino, Elvira-Marie Mikhael, Sary Nicolas, Nicholas Paparo

The Zomia Center requested design services for the land development,□geotechnical engineering, structural□design, and transportation planning of a 1-story reinforced concrete community center and football field complex in Manbij,□Syria to promote peacebuilding and reconciliation through safe gathering spaces. Two lots in Hazawna were selected based on damage analysis of the city, accessibility to other amenities, and stakeholder input. The community center facilities were dictated by community needs and include a kitchen, classrooms, bathrooms, storage spaces, gardens, gathering areas, and an underground shelter that is accessible by staircases and an elevator. Structural design under gravity and lateral loads was completed to meet IBC 2018 requirements for slabs, beams, girders, columns, shear walls, and basement walls. Well-graded engineering fill, sourced from the excavated building rubble, replaced the existing soil and a 12-inch mat foundation was designed based on structural demand and soil bearing capacity. Blast resistance for a 12 psi blast load was incorporated into the building through emphasis on ductility, redundancy, and withstanding load reversals from blast pressures. Keeping safety paramount, a scanning plan for unexploded ordinances (UXOs) and landmines based on priority level was created. Both the community center site and field site were designed to be ADA accessible and transportation design of parking areas, crosswalks, and ADA ramps ensured users can traverse safely between sites. The field complex includes spectator seating, storage, and bathrooms as requested by the client. This concept model was influenced by the geopolitical, socioeconomic, cultural, and religious dynamics that define the community.

ABSTRACTS

CAEE – 11

Drexel University Student Union Building

Advisor(s): Dr. Simi Hoque

Mika Awai, Brian Huynh, Amanda Kolar, Daniel Moton

A Student Union Building was designed for Drexel University's University City campus. The client, Dean Sharon Walker, in collaboration with President John Fry, approved the design of the building at the location of the existing Firestone Building, 3161 Market St, which is in the heart of the academic portion of the campus. The scope of the project includes the design of the architectural system and various engineering trades, such as the structural, mechanical, electrical, plumbing, and fire protection systems, for a 5-story mixed-used building to aid in interdisciplinary learning. The student union building will have a multi-use makerspace, individual and communal study areas, conference rooms, and recreational spaces for clubs and student organizations. In addition, the ground floor features hospitality and retail space, such as food vendors and a mailing and copy center, that are accessible to students, faculty, and the public. Indoor and outdoor event spaces also allow the space to be used for admission, alumni, and student organization social events. The overall goal of the design process was to create a one-stop location that addresses the wide array of needs of each member of the Drexel community in a way that focuses on sustainability and the needs of the future.

CAEE – 12

South Philadelphia Technical High School

Advisor(s): Prof. Abieyuwa Aghayere

Gabriel Alves, Mia Lowe, Michael Sciarra, Volodymyr Babiy, Andrew Norris

With only five public technical high schools existing in the Philadelphia School District, our team designed a technical high school in the South Philadelphia area. Building a technical high school in this area will provide lower income students with an economical alternative to university education and fulfil the need for more skilled trade workers that are essential to society. The five story South Philadelphia Technical High School will be built on a vacant lot with an approximate area of 200,000 square feet. The school will offer programs in automotive, health, human service, carpentry, welding technology, plumbing, electrical, sports marketing, culinary, and graphic design. The design includes architectural, transportation, geotechnical and structural systems. Architectural design mimicked surrounding buildings by combining new and historical elements which were represented on interior and exterior layouts. Subsurface geotechnical analysis presented a challenging deep urban fill layer for which a hybrid foundation of a mat supported by bell-pier drilled shafts was designed. Heavy pedestrian and bus traffic required sidewalks to be redesigned for ADA compliance and modifications to traffic light timing on Broad Street. The structure was designed as a steel frame with 25ft by 25ft bays and large open spans on the first floor that required the design of a welded built up plate girder. The lateral forces were combated with HSS member cross bracing and reinforced concrete shear walls. The total cost of construction is estimated at $43 million and is projected to take 136 weeks to complete.

ABSTRACTS

CAEE – 13

Energy Efficient Data Center

Advisor(s): Prof. Ellis

Mat Tuszl, Andrew Shields, Tyler Mirra, Michael DeAngelis, Jack Litzke

Data Centers have become a necessity for today and in the future, and its important that they are as energy efficient as possible. Team 13 has proposed building a data center in Limerick Township, on an abandoned site. The data center is designed with multiple systems that will reduce energy more than an average data center. The primary problem with data centers is the amount of heat and energy they produce and how to properly cool the building without using a large amount of energy. To effectively do this, JMATT proposes a hot-cold aisle system that includes water-sized economized cooling. This will allow for hot air from the machine exhaust to be vented upward into an air plenum on one side while the machines will be cooled on the opposite side. This creates hot and cool aisles lessening the amount of square footage of the building that will need to be cooled. A steel braced framing system will be used for the structural system, which allows for efficient and flexible layout of the servers and its equipment. The building also includes a green roof to lower the ambient temperature of the building. There will also be a stormwater basin on site to minimize discharge from the site into the Schuylkill River.The state-of-the-art technical campus will have an adjacent office building that is constructed out of glulam members, the office building has ample daylight and efficient building materials, such as hempcrete and kalwall.

CAEE – 15

REC Center in Mays Landing, NJ

Advisor(s): Prof. Joseph Martin

Julia Coleman, Ryan Keeney, Abigail Kryszan, Savina McGarrity

Mays Landing is located in southern New Jersey. The area is densely populated with growing families. Since the real estate market is expanding, the need for a space for school-aged children is rising as well. The project proposal includes a demolition of an existing unoccupied building, and construction of a new, modernized building with adequate parking and a storm management plan. The floor plan was developed using basic criteria set by the structural designer's column spacing, IBC specifications, and personal recommendations based on the usage of the structure. The foundation of the new building was designed to be supported on structural fill with a shallow foundation. The remainder of the site was designed to provide spacious parking for 100 vehicles, including four ADA-accessible (American with Disabilities Act) spots and one ADA van-accessible parking stall. The storm management plan was designed to mitigate the rainfall runoff to minimize the effect on the current sewer system while simultaneously filtering the water before reaching the sewer. Air exchange rates for the proposed building's HVAC design were included in the base proposal as well. Included in the project was an alternate to the base proposal, which was developed to provide the community with additional activities in the summer months. The alternate includes an in-ground pool and a subsurface stormwater basin constructed with R-tanks. An estimated construction schedule and cost of the labor, equipment, and materials for construction were included in the proposal as well. The overall goal was to create a safe and educational environment for upcoming generations, while providing current generations with opportunities for community engagement and personal enrichment.

ABSTRACTS

CAEE – 16

Renovansion

Advisor(s): Prof. Waring

Kendi Only, Reece Masucci, Elrod Owusu-Asumeng, Ashlyn Rimsky

A private client approached Renovansion in September 2020 to design plans for the conversion of a 1998 Ford Econoline van into a sustainable mobile living space. The client requested that the vehicle be modified to allow for comfortable off-grid living for two occupants, with a total capacity of six people. The scope of this project included the evaluation and design of electric, plumbing, HVAC, and architectural systems. The constraints for the project included limited square footage, limited weight capacity, Pennsylvania van conversion codes and registration, the exterior combustion of fuel for heat, electric and water load limitations, local climate, budget, and time. To achieve this, Renovansion proposed a three-phase engineering approach, with phases defined as follows.

Initially, key criteria and constraints were defined with input from the client, and a site visit was conducted to acquire detailed measurements. Additionally, the team conducted a detailed systems feasibility analysis with recommendations provided for the electric, plumbing, HVAC, and architectural systems. A preliminary project budget and timeline were also provided. In the next phase, system loads were quantified, a digital model was generated, and detailed system specifications with preliminary flow diagrams for the electric, water, and HVAC systems were provided. In the final design phase, the team finalized the flow diagrams for the electric, water, and HVAC systems. Further, a carbon footprint analysis, systems evaluation, and a finalized construction cost were provided.

CAEE – 17

Desalination and Distribution System in Port-au-Prince, Haiti

Advisor(s): Prof. Shannon Capps

Jordan Cutting, Caleb Acheampong, Moyenda Alston, Samuel Myers, Matthew Kelly

Port-au-Prince has a damaged and unstable water infrastructure system, and about half of the residents currently do not have access to potable water. To combat this, a reverse osmosis plant will be implemented using the Port-au-Prince Bay as the source, with a goal of supplying 4 gallons per day to each resident. A comprehensive process cleans and disinfects the water to ensure potability. The brine byproduct will be treated and transported to the evaporation ponds for disposal. Given the highly saline environment, seawater pumps transport seawater throughout this desalination system. The water will leave the treatment plant through six pipelines, each of which will serve one of six distribution centers located throughout the city. At these centers, residents will be able to collect water. The building for the treatment center is a multistoried, hybrid structure comprised of steel, concrete, and timber. The building was designed to withstand gravity loads due to equipment, lateral loads, and uplift forces. The soil in Port-au-Prince is primarily sandy, with some layers susceptible to liquefaction. A deep foundation system was designed to support the treatment center given the soil conditions and design loads. Vertical and inclined prestressed, concrete driven piles were designed to resist heavy gravity and large lateral loads at the treatment center. Port-au-Prince offers its citizens less than 20 hours of power daily. To create a reliable source of energy for the plant, floating solar panels on Lake Azuei will power the system and diesel generators as backup power.

ABSTRACTS

CAEE – 18

Retrofitting Falls Bridge for Sustainability and Accessibility

Advisor(s): Prof. Dr. Joseph Martin

Daniel Bowers, Anjali Desai, Weid Hassan, Rebecca Mann

For this project, the team chose to modify an existing bridge to best handle modern demands in a heavily populated and trafficked area. Falls Bridge has not seen any major improvements since repairs in 1973. It is a very important bridge, as it is one of the few crossings of the Schuylkill River upstream from the city that has any sort of bicycle and pedestrian accommodations. Improving these accommodations would have helped promote a more active community while maintaining access for vehicles between Kelly Drive and W River Drive. The main focuses for the intended effects of the improvements were sustainability, accessibility, and safety, as well as the preservation of the historical aspects of this bridge. The scope of this project included a full structural and transportational rehabilitation of the bridge, where the superstructure and paint were replaced, while incorporating sustainable improvements. The bridge was additionally designed to have a suspended bike path cantilevered off the east side of the original bridge structure to allow for the increase of bicycle traffic along the bridge. This bike path was further designed to include sustainable aspects in terms of the materials used to pave the pathway as well as to embellish it. The overall cost for the rehabilitation and construction of the bridge was estimated at approximately $1,000,000.00 and was planned to be completed in 5 phases over the course of 3 months.

CAEE – 19

Revitalization of Water and Wastewater Infrastructures in Sparta, Georgia

Advisor(s): Dr. Joseph Martin

Hung Nguyen, Selene Presley, Yan Li, John Gillich

The Atlas Engineering Group was tasked with the revitalization of the Water and Wastewater Infrastructures in Sparta, Georgia. The mayor has asked for solutions to their wastewater treatment plant, valve, and inflow/infiltration problems. The wastewater treatment plant has not been properly maintained since its inception. The lack of valves requires large zones to lose access to water. The sewers have large amounts of inflow/infiltration.

Atlas Engineering Group's main focus was to provide a sustainable and easy to maintain upgrade for wastewater treatment in Sparta and the solution was adding a secondary wastewater treatment for a cleaner discharge into Sparta's surrounding area. With Sparta currently discharging wastewater into spray fields after primary treatment in the lagoons, adding a constructed wetlands to further remove toxic substances would allow for discharge directly back into a nearby river. Per request from the mayor, the team also was to find suitable locations for valve installment. Since the current water distribution system currently has very few, additional valves would be needed to allow for smaller zones to lose access to water during maintenance. Inflow/infiltration can be reduced by replacing the oldest pipes in the system.

The team found that if the town of Sparta decides to implement these changes to the Wastewater Treatment Plant and the installation of Valves, then the estimated cost will be around $5,520,000. It would take 18 months to upgrade the Wastewater Treatment Plant. The installation of valves will vary based on how many valves are installed and where.

ABSTRACTS

CAEE – 20

Sustainable Wood Designed Building for Dormitory at Drexel University Located Adjacent to the Dornsife Center at 35th and Spring Garden Streets

Advisor(s): Dr. Abieyuwa Aghayere

Thomas Stief, Pritesh Prajapati, Tristan Hall, Connor Dodson

As college education becomes more desired and accessible, student populations continue to rise, introducing unique problems, as urban environments have space restrictions that make new housing difficult, most local area is already developed, and less developed areas are far for students to easily reach campus via mass transit. Additionally, further developing urban areas can encroach on communities and cause environmental complications, like increased stormwater and carbon emissions. To address these problems, this project presents design recommendations for construction of a mass-timber dormitory for Drexel University at 35th and Spring Garden Street next to Drexel's Dornsife Center, cornerstone of Drexel's commitment to the surrounding community.

The proposed 120'x160' (19,200 square feet), 8-story (85-foot) building was designed as a hybrid mass-timber structure using CLT panels and glulam columns with a first-floor concrete podium functioning as a parking garage. The exposed mass-timber design has better aesthetic and faster/cheaper constructability than traditional construction as well as the ability to sequester its carbon emissions, attributes that help increase student health. The foundation utilizes strip footings, a wall supporting exterior columns, square footings for the interior, and a concrete pad underneath concrete-core shear walls. Reinforced concrete elements sit on Rammed Aggregate Piers®, lowering excavation costs. AutoCAD was employed to produce site plans for design/application of ADA driveways, PennDOT traffic control standards, and more. The stormwater generated by the dorm was mitigated using a garden, swale, and cistern, which reuses stored water to reduce reliance on public water. The project's budget was estimated as $45.83 million.

ABSTRACTS

CAEE – 21

Hospital in High-Risk Wildfire & Seismic Zone

Advisor(s): Prof. Brehm

Jeff Forbes, Anchit Jain, Vishist Jain

With growing populations and the demand for low-density housing not going away engineers in the coming years will look to improve or establish infrastructure in areas previously not as desirable to build in. Our goal was to create a hospital in an area prone to natural disasters, specifically St. Helena, California, which is exposed to both wildfires and earthquakes. The design challenges are such that we designed within the safety standards and importance factors of a Category IV medical structure while also considering the natural disasters present. The building served as both a functioning facility as well as a structure when the natural disaster threat rose. The goal of the shelter portion was to convert the ICU into an area of housing all patients and nearby first responders that were unable to be evacuated due to medical or physical circumstance.

Our team used digital modeling and analysis to create the structure on both the architectural and structural side. Digital integration and mechanical experience also allowed for the consideration of these systems in limited capacity.

CAEE – 22

Transformation and Reclamation of PECO Delaware Power Station into Entertainment Venue

Advisor(s): Prof. Ahmad Hamid

Michael Berchick, Kyle Carstensen, Haley Herron, Amanda Zurybida

The engineering problem of unsustainable building practices due to new construction has been addressed by an adaptive reuse and rehabilitation project. As the construction footprint in Philadelphia increases, the negative environmental and social impacts also increase. The proposed solution included the reclamation of the existing PECO Delaware Power Station, located in the Fishtown neighborhood of Philadelphia. Situated on the Delaware River, it is in close proximity to the Northern Liberties neighborhood and the Benjamin Franklin Bridge. The site has much opportunity for public access and appreciation. The existing facility was converted into a multi-use entertainment venue, fit for holding concerts and other events. As a registered National Historic Site, the team explored retaining many of the original structural and architectural features, while transforming the interior of the building into an entertainment space. The disciplines analyzed included site/civil, architectural, structural, and mechanical systems. A focus on sustainability was especially important due to the nature of the existing grounds and location within a floodplain. Architectural design was coordinated with other project disciplines to ensure a feasible layout was achieved. Further, acoustic design was included considering the building's purpose. The primary focus of the structural design was to evaluate existing conditions to support new additions and renovations, achieving a safe and occupiable concert venue. Mechanical systems were designed to meet all necessary codes and requirements, with sustainability and pandemic conditions in mind. Coordination between all disciplines was necessary to attain a complete and comprehensive design of this adaptive reuse.

ABSTRACTS

CAEE – 23

Solar Powered Desalination Plant

Advisor(s): Professor Ellis

Thomas Novia, Liam Hoey, Micah Sheldon, Janayjah Dunmore

This project focused on the design of a solar powered desalination plant based in San Clemente, California. Despite the water shortages in California due to droughts and unsustainable depletion of the groundwater table, the California Ocean Plan heavily regulates and restricts desalination via reverse osmosis. The goal of this project was to create a community center on the beach that would be self-sustainable and educate the public on the desalination via reverse osmosis process. The location of the plant was chosen to be San Clemente Beach, adjacent to the Marine Safety building and the San Clemente Pier. The community center was designed to be zero water and zero energy, using the desalinated water to flush toilets and run sinks, using a passive ventilation system which includes movable blinds and solar chimneys, and using solar energy to power the desalination process. The solar energy generation system was designed as a boardwalk along the beach, using a combination of PV panels and microinverter technology. The total generation of the solar system was 2 megawatts/day, which required 1335 PV panels and microinverters. The desalination plant was designed to be primarily a showcase only capable of producing 15,000 gallons of fresh water per day. The desalination plant was drawn to be in the center of the community centre and designed out of transparent fiberglass with progressing cavity pumps, multi-stage filtration and with UV light for disinfection.

ABSTRACTS

MSE – 01

Screening of MXenes for Photothermal Therapy

Advisor(s): Dr. Yury Gogotsi (MSE), Dr. Margaret Wheatley (BMES)

Elizabeth Moroz, Benjamin Chacon

A recent development in cancer treatment is photothermal therapy, where near-infrared (NIR) light is absorbed by a photothermal agent and converted into heat, causing the ablation of cancerous cells around 40-50 °C. Nanomaterials have proven to be good candidates for this therapy because of their high photothermal conversion efficiency (PTCE). MXenes ($M_{n+1}X_nT_x$) are layered 2D carbides and/or nitrides with unique electronic and optical properties, coupled with natural hydrophilicity and biocompatibility. Due to their plasmonic properties, they have characteristic absorption values ranging from the UV region to the mid-IR. The primary goal of this project was to develop MXenes that would be most appropriate for photothermal therapy. Five MXenes with different compositions and structures were synthesized and characterized through optical measurements in the UV-vis-NIR region. A custom photothermal testing set-up was designed to measure the photothermal performance of each MXene and photothermal conversion efficiency was calculated via MATLAB®. All the MXenes tested in this study experienced thermal heating in response to a 785 nm NIR laser with low power density (0.020 W/cm^2), with PTCE values ranging from 13 % to 76 %, depending on the solution concentration. Additionally, the incorporation of MXenes into hydrogel composites showed no loss in heating capability, justifying their functionality for combination therapies.

Name of Outside Sponsor: National Science Foundation (NSF).

MSE – 02

Hybrid Nanovesicles Made of Cell Membranes and Phospholipids

Advisor(s): Dr. Hao Cheng

Akul Behl, Joseph Gooch

The goal of this project was to synthesize nanovesicles composed of egg phosphatidylcholine and cell membranes harvested from mice blood. The main application for these materials lies in immune disease treatment. These nanovesicles exhibit increased targeting specificity and are better camouflaged from the body's defense system. There were two major findings from this investigation; the first was that the nanovesicles can be processed to be smaller than 100 nm in size, and the second was that these two components were able to be formed into a homogenous product. The size was important because nanovesicles need to be small enough to drain to the lymph nodes within the body. Homogeneity was necessary because this is how the nanovesicles will exhibit the combined properties from both of the original components. The size of the vesicles was confirmed through the use of Dynamic Light Scattering (DLS) and the solution was confirmed to be homogenous using fluorescence resonance energy transfer (FRET) analysis.

ABSTRACTS

MSE – 03

Stereocomplexed Nanofiber Shish-Kebabs for Sustainable Polymer Nanocomposites

Advisor(s): Dr. Christopher Li

Arianna Rivera, Kezia Manoj, Arienne Saldanha

This project was designed to produce highly crystalline stereo-complexed PLA with a nanofiber shish-kebab (NFSK) morphology as a polymer alternative to combat pollution. Plastics and their by-products are exponentially polluting cities, oceans and waterways, and contribute to adverse health effects in humans and animals. The extended lifetime of plastics is significant, as these materials can last from 10 to 10,000 years within landfills. This will result in dramatic consequences for natural habitats, given that current industrial production relies predominantly on petroleum gas and oil reserves. During manufacturing processes, greenhouse gases are also generated from fossil fuels as well as during recycling, which in turn have irreversible repercussions on the global climate. To mitigate the adverse effects of industrial manufacturing of commercial plastics, poly (lactic acid) (PLA) was investigated as a more sustainable solution. Its bio-compostable nature presents an opportunity for its use as an environmentally-friendly polymer alternative to current plastics. The intrinsic brittleness of PLA, however, renders it unsuitable for a broader range of industrial manufacturing applications. This project aimed to design, develop and toughen PLA through stereo-complexation mechanisms, and studied the crystallization kinetics and morphology of PLA to optimize the mechanical and thermal properties. Base PLA nanofibers were electrospun, followed by incubation in super-saturated polymer solutions to produce the NFSK structure. Characterization techniques including scanning electron microscopy (SEM), differential scanning calorimetry (DSC) and X-ray diffraction (XRD) were used to confirm proper formation and improvement in the thermal stability of the stereo-complexed PLA.

ABSTRACTS

MSE – 04

Solid Polymer Electrolytes (SPE) for Lithium Metal Batteries

Advisor(s): Dr. Christopher Li

Andrew Shevchuk, Zein Alali, Evan Dubrunfaut

Due to increasing demand for energy in applications like electric vehicles and robots, current Li^+ ion batteries have proven inadequate. Lithium metal batteries are potential alternatives, offering higher energy densities through use of a lithium metal anode. There are, however, problems innate to using lithium electrodes, including volume changes and dendritic growth, which pose safety and efficiency issues. A solid electrolyte is thus required to retain high conductivity between the battery terminals, while preventing dendritic growth and anode volumetric changes. Network SPEs were selected due to their tunable network structures, high conductivity and moduli at high current densities and temperatures. Multiple SPE samples were synthesized to compare the electrochemical performance of various types and ratios: 2:1 PMA-PEG, 4:1 PMA-PEG, and three PMA-PEG-PCL with varying PCL mole fractions (2, 5 and 10 %). Samples were synthesized by dissolving the polymers with LiTFSI, casting onto a glass slide in a vacuum oven, and curing for 24 hours at 85°C. The SPEs synthesized exhibited conductivity values ranging from 1E-2 to 1E-5. Transference number, or t+, was calculated as 0.26 for 4PMA-PEG, while the 2PMA-PEG system was calculated to be 0.181. 2PMA showed a trend in conductivity values, however, it exhibited a lower transference number. Despite the theoretical promise of PCL for increasing Li-ion transfer, the values for 2%, 5%, and 10% were 0.224, 0.171 and 0.157, respectively.

MSE – 05

Photoluminescent Fibers as Smart Textiles

Advisor(s): Dr. Wei-Heng Shih, Dr. Caroline Schauer

Kirstin Snodgrass, Monica Keilsohn, Samantha Dehais

Organohalide perovskite nanocrystals (PNCs) fluoresce under ultraviolet (UV) light, have impressive optical properties, but are unstable and degrade in the presence of polar solvents and white light. To protect the PNCs, polystyrene was electrospun using a PNC precursor solution to create photoluminescent nanofibers. The hydrophobic polymer was dissolved in a solvent and combined with a PNC precursor solution that typically would have been used to precipitate traditional PNCs. A high voltage was applied to the combined solution, causing it to be drawn out of a syringe needle, followed by rapid solvent evaporation and whipped through the air, then gathered on a collector plate, forming nanofibers. As solvent evaporated, PNCs nucleated to form nanocrystals embedded within the fibers. $MAPbBr_3$@PS and $MAPbI_3$@PS fibers were optimized by changing electrospinning parameters including applied voltage, flow rate, collector-plate distance, collection time, and precipitant concentrations. This experimental design found that 7 wt. % PS and 1 wt. % $MAPbBr_3$ dissolved in dimethyl-formamide (DMF) produced dense fiber mats. Photoluminescent stability of fibers in the dark, under constant white light, and in water were evaluated. Encasing the PNCs in a hydrophobic polymer provided adequate protection from constant white light and water for up to two weeks. The morphology of the fibers was evaluated, showing an average diameter of 5.69 ±2.75 µm, with all PNCs fully encased within the fibers. There was an ~86 % enlargement in fiber diameter after the addition of PNCs, believed to be due to increased charge interactions within the solution.

ABSTRACTS

MSE – 06

Photoluminescent Nanocrystals for Photodetectors

Advisor(s): Dr. Wei-Heng Shih

Max Eubinag, Tiffany Franco

Organo-halide perovskite microrods, such as methylammonium lead triiodide ($MAPbI_3$), exhibit enhanced electrical conductivity properties when exposed to an external light source, which allows them to act as a semiconductor photodetector. While microrod synthesis and direct experimentation could not be carried out due to the COVID-19 pandemic, the project focus shifted to the design and development of an analytical model based on previous research. The electrical conductivity behavior of organo-halide perovskites exposed to light is due to the generation of electron -hole pairs induced by photonic excitation. Previous research showed that this concept was due to a change from an electron's ohmic (linear) behavior to a space charge behavior (nonlinear or "square") that could be represented by a current density or J-V curve, representing current density versus voltage. Through an understanding and application of these Space Charge-Limited Current (SCLC) models, a theoretical J-V curve for microrod performance was generated using variables and properties specific to the organo-halide perovskite of interest, $MAPbI_3$. The project goal was to explain and quantify the current density of $MAPbI_3$ perovskite microrods using different SCLC models. Comparisons to prior experimental work and research conducted at Drexel University were also made to explain the observed increase in free electron concentration produced by induced light.

MSE – 07

Numerical Modeling of Selective Laser Melting *via* Finite Element Analysis

Advisor(s): Dr. Antonios Zavaliangos

Jonathan Hollenbach, Carolina Barbosa-Velazquez, Shixuan J. Li

Additive manufacturing (AM) is gaining momentum as new technology is being introduced. AM is being used for applications such as rapid prototyping and the manufacture of production parts. There are many different kinds of AM processes and the current study focused on creating methodologies for the simulation of the SLM process using ABAQUS. The 3 main divisions of this study were: SLM simulation processes, Mesh design and Analysis, as well as a comparison between existing case studies. The AMModeler plug-in proved to be an important part of the simulation of SLM although the plug-in was not completed finalized at this time. Various methods of meshing were designed and implemented, resulting in the conclusion that an external program needs to be investigated in order to have more control over the adaptive remeshing function within ABAQUS. The analysis of the SLM process via thermal models was shown as well as a validation of current methods applied to a case study provided by NIST.

ABSTRACTS

MSE – 08

Synthesis of MXenes Through Molten Salt Etching of MAX Phases

Advisor(s): Dr. Yury Gogotsi

Son Pham, Jared Perry-Smith, David Parchment, William Reil

This design project focused on synthesizing two-dimensional carbides and nitrides, known as MXenes, through novel means. The MXenes were created by etching A-layer atoms (Al, Si, Ge for example) from ceramic MAX phases. This material can be used in a variety of applications, ranging from electrode materials and conductive inks to loudspeakers. Conventionally strong acids were used remove the A-site elements, but this route presented limitations for suitable precursor materials and safety. A new method was proposed which emphasized the use of molten salts as the agent for etching the A-layer atoms. Molten salt etched MXenes were produced via a "safer and greener" route which in turn enlarged the pool of viable precursor materials and the chemistries of the materials produced. Ti3C2 , Ti2C & Ti2N were produced through the molten salt etching method. The combined use of X-ray diffraction (XRD), scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) provided evidence that supported the successful formation of the corresponding Mxene phases. Further attempts to synthesize MXenes with a formula of Ti2(CyN1-y)Tx were also conducted. A new process that utilized benign reagents in order to reduce these layered 2-dimensional structures to single flakes was also developed. Although the procedure had been developed, further optimization is needed to fully achieve the single flake structure that offers the desired versatility in the application of these materials.

ABSTRACTS

MSE – 09

Complement Activation by MXenes: Biometrics of MXenes

Advisor(s): Dr. Hao Cheng, Dr. Michel Barsoum

Jacobus Burger, Oliver Jantz

While best known for their excellent mechanical and electrical properties, MXenes have recently also emerged for applications in the biomedical field due to their large specific surface areas, variety of surface termination groups, and outstanding photothermal conversion efficiency. Pure $Ti_3C_2T_z$ MXene nanoparticles, however, are easily cleared by the immune system due to their hydrophilic nature and tendency to aggregate in water and biological media. For this reason, the surfaces of single-layer MXenes were modified by covalently grafting polymers such as polyethylene glycol (PEG) and methacrylic anhydride (MA) onto the MXene -OH surface terminations. To ensure successful surface modification, PEG- and MA-MXene were compared with pure MXene control groups using fluorescence, ^1H – nuclear magnetic resonance (NMR) and Fourier Transform Infrared Spectroscopy (FTIR). These polymer surface grafts in turn protected the MXene nanoparticles from complement protein adsorption, resulting in increased circulation time and slower clearance by the immune system. Then, to better understand the protein adsorption characteristics of nanoparticles, SDS-PAGE/silver staining and Western Blott analysis was carried out on pure MXene and GO nanoparticles, followed by the addition of the polymer-modified MXenes.

MSE – 10

Analysis of Electrospun Polyacrylonitrile Nanoyarn

Advisor(s): Dr. Caroline Schauer

Anna Clare Desch, Neil McNair, Ryan Boman

Expanding the field of smart textiles for applications such as piezoelectric, conductive and sensing technologies requires nanoyarn properties. To date there has been a paucity of reports on the fabrication of continuous twisted nanoyarns produced via electrospinning since fabricating electrospun nanofibers into nanoyarns is still a fairly new technique. In order to expand the field of smart textiles, the microstructure of nanoyarns must be further understood since the properties of yarns are a function of their structure. The final density of nanoyarns is an important characteristic of nanoyarns due to its direct influence on their mechanical properties. There is, however, limited understanding of how the nanoyarn process parameters influence the final density of nanoyarns. The goal of this project was to investigate how the deposition rate and ring collector speed of the nanoyarn fabrication process impacted the final density of polyacrylonitrile nanoyarns by influencing key structure aspects such as twist angle and number of fibers. By understanding these relationships, the electrospinning and nanoyarn process can be better designed and tailored to fabricate nanoyarns of the desired density for smart textile applications.

ABSTRACTS

CBE – 01

Lower Green Gases Emission Nitric Acid Plant

Advisor(s): Ed Andjeski

Abinishaa Sivaraj, Amy Tran, Hein Duong, Roy Anthony Calleja

The objective of this project is to reduce greenhouse gas emissions from nitric acid production. The capital cost of the project is $160.43 million and the operating cost is $6.53 million per year. The payback period is estimated to be well beyond the plant life. The internal rate of return is 4.07% at a discount rate of 14%. The net present value of the project is $211.16 million loss. This project uses the Ostwald process for the manufacturing of nitric acid. The first step of this process is the catalytic oxidation reaction of ammonia to produce nitric oxide (NO). The NO from the ammonia oxidation is then further oxidized into nitrogen dioxide (NO2). The NO2 then enters the absorption tower to convert to nitric acid (HNO3) by absorbing into water. A stream of air enters the column to re-oxidize the NO that is produced from the absorption process into NO2. Oxidation of ammonia and absorption of NO2 produce the most NOx emissions. The project focuses on reducing those emissions that contribute to global warming. The ammonia oxidizer uses a N2O destruction catalyst to treat the nitrous oxides internally. The nitric acid manufacturing plant is located in Freeport, Texas. Freeport is an industrial city with the largest integrated chemical manufacturing complex in the Western Hemisphere. The plant produces 700 MM lb of 68% nitric acid per hour, which is 0.5% of the nitric acid production in the US.

CBE – 02

Biodiesel Production from Algae

Advisor(s): Dr. Sales, Rich Mallon-Day

Hubza Syeda, Sudipti Attri, Brahmleen Chagger, Garima Baral

Biodiesel will be produced in a plant located in Houston, Texas, United States, near a glycerol and biodiesel distillation plant. The United States has a big market for biodiesel and is expected to rise as alternatives to petroleum are encouraged. The plant will produce other by- products such as organic matter (biomass), crude glycerol, and crude biodiesel. Thus, it is recommended that management finds partnership with other distillation and farming manufacturers to bypass transportation costs. Because the biodiesel is created by lysing microalgae cells through water remediation, the plant will be processing 100 million gallons of water to produce 15,500 pounds per hour of biodiesel with a purity of 99.99% using a transesterification process in a CSTR after process optimization. This process uses a sodium hydroxide catalyst. The calculations were preformed using the Soave-Redlich-Kwong method. The plant is expected to make 136 million pounds per year of 99.99% biodiesel by cleaning polluted rivers and processing close to 400 billion gallons of water per year. The plant will also utilize 18.65 thousand pounds per hour of methanol and 226.133 pounds per hour of sodium hydroxide. The biodiesel will be sold at $0.44 per pound. Along with biodiesel, the plant will also sell its biomass waste stream for $0.22 per pound at 562 million pounds per hour. The plant will be functional for 20 years once fully operational. The upfront capital investment is a total of 44.4 million dollars. After conducting the financial calculations, this plant is economically feasible.

ABSTRACTS

CBE – 03

Using Birch Wood as a Feedstock for Petrochemicals

Advisor(s): Dr. Cairncross

Ngocanh Ho, Nancy Pan, David Kneiss, Alexander Baradziej

The proposed system explores the flow-through reductive catalytic fractionation (RCF) technology for a continuous process in the commercial-scale production of phenol and propylene from birch wood biomass. The growing demand for these typical petrochemicals could be met using a renewable feedstock, avoiding the need to further accelerate the increasing demand for petroleum oil. The technology is capable of extracting phenolic monomers from the birch lignin which can then be catalytically manipulated in order to yield biophenol and biopropylene. The process also produces two recoverable byproducts: a carbohydrate pulp rich in cellulose and hemicellulose and phenolic oligomers. The carbohydrate pulp has multiple potential uses, including its incorporation as a delignified wood feedstock at pulp/paper mills, and the phenolic oligomers can be used to make resins which may have a market in the printer ink industry as a substitute for resins. RCF uses methanol at high temperatures as well as a catalyst to simultaneously depolymerize, extract and stabilize the phenolic compounds that are derived from the lignin polymer. The effluents are separated from the methanol through distillation, and the monomers are separated from the oligomers through liquid-liquid extraction using n-hexane. The extracted monomers are purified, and subsequently sent through two different catalytic reactions (hydroprocessing and dealkylation) to yield phenol and propylene, which requires further purification to reach 89% and 97% purities, respectively. The design attempts to use a flow-through system to incorporate a semi-batch RCF reaction into continuous downstream processing. Most research on RCF has been performed on it as a batch process, but recent discoveries have shown that the two fundamental processes that comprise RCF are independent, and therefore they can be isolated from each other in a flowthrough mechanism to optimize each section individually. By operating the RCF as a flowthrough process, many disadvantages associated with the batch processing are avoided, but the complication with the flow-through mechanism is that the lack of large-scale studies leave many unknowns with respect to how the process will behave in commercial scale production. If the assumptions behind the design of this process are valid, this process may show promise to be a more environmentally-friendly method of producing propylene and phenol, but economically it would require further analysis and optimization before it could become a viable replacement for the profitable production of these chemicals.

ABSTRACTS

CBE – 04

Continuous Bioreactor Production High Purity Ethanol

Advisor(s): Dr. Alvarez

David Rendeiro, Matthew Harp, Zachary Hoffman, Zachary Hopp

Ethanol is produced at a plant in Florida, USA, co-located to a sugar mill. The raw sugar stream is sterilized in tank TK-101 before being combined with a concentrated stream of S. Cerevisiae yeast cells and dilute sugar water. After this mixing point, the overall stream has a target yeast concentration of 15% active dry weight, 20 Brix sugar concentration, and a total volumetric flow of 653 gallons per minute. An inline mixer ensures good dispersion of yeast cells prior to entering R-101 plug flow bioreactor. The bioreactor will convert 80% of the available sugars to ethanol and CO2, resulting in a daily reactor output of 111,000 gallons per day of ethanol. For a 270 day per year operating season, this is sufficient for 30.0 MM gallons of ethanol per year out of the reactor. Following R-101, reactor effluent will enter TK-103 acid flocculation tank. In TK-103, the yeast cells will die and flocculate, increasing their mean particle size prior to flowing through a series of disc-stacked centrifuges. CF-101 and CF-102 filter out the yeast to less than 5 wt%. The centrifuges will exhibit bleeder valves on the top of the units, allowing insoluble CO2 to vent into the vacuum line for D-101 A/B/C/D. The extracted yeast will be dehydrated in tray dryer TD-101 to be sold by the ton as biofertilizer. The permeate stream will proceed distillation column C-101 which will purify the ethanol stream to 94%. The distillate will be dehydrated to anhydrous ethanol of greater than 99% purity via a pressure swing adsorption molecular sieve operation. Anticipated Earnings Before Tax (EBT) are $12.01 MM per year, with a raw material revenue of $121.2 MM per year and a raw feedstock cost of $102.6 MM per year. See base case Economic Feasibility section for detailed explanation of assumptions and calculations. For a 20 year plant life, the Net Present Value (NPV) is currently estimated at $69.9 MM. The After Tax Rate of Return (ATROR) is computed at a value of 22.6%, exceeding the target Minimally Attractive Rate of Return (MARR) of 13%.

CBE – 05

Metal Recovery from Electronic Waste Recycling

Advisor(s): Dr. Fafarman, Steven Schon

Shannon O'Dwyer, Julian Adams, Dylan Berryman, Ololade Bello

Electronic waste, which is mostly composed of mobile phones, computers, and televisions, is a constantly growing quantity due to the rapid growth of technology globally. A majority of this e-waste is either dumped or incinerated which is harmful to the environment, in addition to it being harmful to employees at these facilities. The current practice of disposing electronic waste is wasteful of the valuable precious metals that general electronic scrap is composed of. Precious metals such as gold and silver, in addition to copper, will be produced from this e-waste mining plant and sold for profit. The plant will be built in Bucks County, PA to allow for proper spacing for the process and assure safety for locals within the county, as well as ensure a consistent supply of electronic waste by being close to highly populated and industrial areas. The solid e-waste input stream will consist of televisions, computers, and mobile phones at a feed rate of 800 lbs/hr. E-waste will be sourced through local contracts with waste municipalities and businesses with excessive e-waste. This electronic waste will be pulverized, separated via a series of magnetic conveyors to distinguish stainless steel, non-metals, and ferrous metals from the process line. Then, the remaining non-ferrous metals are leached using specialized bacteria that create ion-rich leachates. These leachates will go through electrolysis in order to precipitate solid precious metals at high purities to be sold for profit. This e-waste mining plant is expected to produce 99% purity copper, silver, and gold at rates of 421,473 lbs/yr, 2,394 lbs/yr, and 279 lbs/yr, respectively, in addition to isolating steel and plastic from the process at rates of 90,091 lbs/yr and 2,814,880 lbs/year, respectively. The plant has a capital investment cost of nearly $3 million, however, the plant is expected to produce $4.6 million worth of precious metals, plastic, and steel within the first 3 years of production. The cumulative cash flow for the full plant life of 20 years reaches just above$40 million. The discounted after-tax rate of return (ATROR) was determined to be 35.53% while the hurdle rate was 17%, making the process an attractive investment.

ABSTRACTS

CBE – 06

Recycling of Waste Solar Cells

Advisor(s): Dr. Baxter

Glen Nieman, David Raczkowski, Sara Corson, Alexander Ligier

Global greenhouse gas emissions are at an all time high and are projected to continue to increase. Consequently, energy generated from fossil fuel alternatives, like solar panels, are gaining popularity. However, the increase in solar panels is leading to an increase in end-of-life solar panels which typically are being sent to landfills, wasting the valuable materials that are used to make up solar panels. The Solar Cycle plant's goal is to recycle end-of-life solar panels and turn them into their base elements for reuse in either future solar panels or other products. When creating a plant that recycles solar panels, there are many important things to consider. It is important to minimize the distance that decommissioned solar panels travel to the facility since each mile that the solar panels travel adds to the carbon footprint of the panel. Because of this, the plant was chosen to be located outside of Phoenix, Arizona. The plant will be constructed to process a maximum of 20,000 tons/year of end-of-life solar panels. Since there is no industry standard for solar panels, the end-of-life solar panels will be crushed. This is a quick and effective way to prepare the panel for additional processing. Once crushed, physical and chemical separation methods are used to refine the panel into its components. Crushed glass can be separated using light separation while the majority of the metals will be recovered with an electrowinning cell. Although the plant makes a profit in its first year of production, the DCFOR is -6.1% caused largely by the capital costs. In order to overcome this, government subsidies would need to be in place to aid in reducing the capital cost.

CBE – 07

Sulfur Based Specialty Polymers

Advisor(s): Mike Grady

Gabriel Sable, Kun Zhang, Jason Wilson, Kai Zhang

This project focuses on designing a chemical plant that uses sulfur as a main reactant to make a new generation of polymers. These new polymers with a sulfur backbone have several unique benefits and properties which make them appealing for future use. This paper will examine four sulfur-based products and the feasibility of commercialization. The production size for each polymer is designed to be 0.5-1% of the specific polymer's market size. The total annual production of this plant is 61 kilotons. Resin prepolymers are produced in batch processes that feed 4 different final product production lines. This allows for each reactor to make different products, and leaves room for more to be implemented in the future. The batch timings of each have been determined. After each process, the prepolymers go to separate processing units. These processes vary depending on the properties of the prepolymer and final product. For example, one prepolymer requires curing in an over for 24 hours, while another requires mixing with sodium chloride before washing it away to create a porous structure. A cash flow analysis was done based on capital estimates of equipment and operating costs of the process. The operating costs includes raw materials, labor, and utilities. The project is expected to have an annually net positive profit but decreases as time goes on. This makes the 10-year NPV $238 million with an IRR of 32%. The most economical optimization came from a theoretical scope change. From this optimization, the plant could have an IRR of 52% with an NPV of $408 million after 10 years. The Monte Carlo simulation showed that this project will return a positive cashflow 82% of the time with an average NPV of $180 million.

ABSTRACTS

CBE – 08

Coal Gasification to Produce Electricity and Chemicals

Advisor(s): Ed Luckiewizc

Tania Sanelly, Dylan Au, Hagyeong Gim,

This report summarizes a feasibility study for the gasification of coal to primarily produce steam for electricity. Coal gasification is the preferred method because it results in much less pollutants than combustion [1]. The process is based on an integrated gasification combined cycle (IGCC) where steam, high purity oxygen gas, and coal are added under high temperatures and pressures to a gasifier to produce syngas efficiently [2]. The plant is designed to have an operating capacity of 400 MW of electricity from steam generators that operates 24/7 for 50 weeks. The plant will be located in North Dakota which has raw lignite coal that the coal composition and properties are based on in this process. The close proximity of lignite coal will help minimize the transportation costs and risk. Lignite coal is preferred because it is abundant, cheap, and has high reactivity compared to the other types of coal [3]. The plant is expected to take 2 years of construction and to operate for 20 years. The estimated project cost of manufacturing is $98,365.5M which includes raw materials, utilities, waste treatment, annual operating labor, supplies, and indirect costs. The projected discounted cash flow rate of return (DCFROR) is 28.62%. The total profit is $500M over the project's 20 year lifetime. The payback period is estimated to be around 6 years. In conclusion, the profitability of the project indicates that the project is feasible. It is recommended that management move forward with this project due to the profitability and low risk.

CBE – 09

High Octane Fuel from Commodity Wheat

Advisor(s): Dr. Fafarman

Madeleine Pelchat, Emma Snelling, Ryan Barrett, Phu Phan

The plant is built at the center of a 1000 acre farm, where all of the carbon stored in the product originates in the form of wheat. 73,333 bushels of wheat can be grown throughout the year without the need for mass fertilization, which is then harvested and delivered, milled, and stored in a large grain silo. Grain is removed and mashed in batches to convert and dissolve sugars and proteins into water, which is then fermented continuously via a multistage continuous culture fermentation (MCCF) to produce a beer with an alcohol-by-volume (abv) of 0.12.Beer is filtered and distilled using two distillation columns: the first column only has four trays and is designed to separate any residual solids and produces a vapor stream still lean in ethanol and rich in water while the second column separates water and ethanol up to an ethanol mole fraction of 0.84. This crude ethanol stream is pressurized and evaporated before being reacted over a γ-alumina catalyst at 98 % conversion of ethanol and near-unity selectivity for ethylene. The resulting ethylene is cryogenically separated from water and is reacted over a bed of 1%Ni on silica- alumina to dimerize ethylene into n-butene. This reactor effluent is split into two streams: one stream consisting of 75 wt% of the fresh ethylene/ butene is mixed with hydrogen and a recycle stream and reacted over a mixed catalyst bed of nickel- mordenite and chlorinated alumina to hydrogenate n-butene to n-butane and convert n-butane to isobutane, respectively. The effluent of this reactor is distilled at high reflux to separate isobutane and n-butane; the n-butane-concentrated stream is sent back to the reactor while the isobutane stream is mixed with the 25 wt% split of fresh ethylene/butene and another recycle stream. This mixture is then reacted over a mixed bed of 1%Ni on silica-alumina to further dimerize ethylene into n-butene and 0.1% Pt on zeolite to alkylate isobutane with n-butene. Distillation of reactor effluent produces a product stream (106 lbs/hr) of chiefly 2,2,4 trimethylpentane and the balance divided evenly between three other TMP isomers, while the distillate is recycled back to the alkylation reactor and consists mostly of isobutane and ethylene. One goal of this process is to produce a sustainable alternative to traditional alkylation products whose carbon comes entirely from fossil fuels. The economic analysis shows that this plant design is not economically feasible.

ABSTRACTS

CBE – 10

Polypropylene Carbonate Production Facility

Advisor(s): Mike Kain

Victoria DeLissio, Oluwatamilore Ogunranti, Alexandria Mach, Shannon Wilbraham

Many polymers manufactured today are not environmentally safe and fill up landfills because of their slow degradability. This has led to research into more sustainable and biodegradable polymers, like polypropylene carbonate (PPC). PPC is commonly used within ceramics, lithium- ion batteries, and biodegradable plastics and can also serve as a substitute for thermoplastic polymers like polyethylene and polystyrene. Making PPC includes using greener alternatives like carbon dioxide (CO2), which is a common greenhouse gas, for its production. PPC is a solid, biodegradable polymer, with long term mechanical stability. It is an amorphous clear processible plastic that is made up of about 43% CO2 by weight and is resistant to light. Based on the growing sustainable polymer market trends, a new plant in southwest Texas was investigated for PPC production with a maximum capacity of 20,000 metric tons. PPC is formed through the copolymerization of propylene oxide (PO) and carbon dioxide (CO2) with metal salen complexes or zinc dicarboxylates as the catalyst. This process's CSTRs operate at 70 °C and 25 bar at a residence time of 10 hours to produce PPC with a MW between 100 - 300 kg/mol, which is comparative to competitor's specifications. CO2 and PO are charged to the reactor at a ratio of 1.5:1 to maximize conversion of PO and minimize the cost of raw materials. The molar conversion of PO as it moves through the reactor is 75%, with yield of PPC expected to be 70%. From the reactor, the stream containing CO2, PO, PPC, and PC moves to vapor-liquid separators where most of the CO2 and PO are separated from the products. The CO2 is purged from the vapor stream while the PO is condensed and recycled back to the reactor.Therefore, research was done to address the safety and environmental concerns. CO2 is released into the atmosphere at 510lbs/hr, which is below the emission limit. Additionally, this is a carbon negative process since the CO2 purged is much less than CO2 fed. PO is highly flammable, and several process safety layers are used to prevent any incidents. The resulting PPC and PC are separated by mixing with water (as PPC is immiscible) and sending the product/water stream to a disk stack centrifuge to remove the PPC and a flash drum to remove the PC (>95% purity). The PPC stream is sent to twin screw extruders, where the PPC (99% purity) is cut into pellets and solidifies. The PPC product is sent through a dryer and packaged in customer containers or sent to the storage silo. A maximum capacity of 20,000 metric tons per year gives a revenue of $297 M with raw material cost of $2.6 M. The total fixed capital investment for the necessities for this plant (equipment, buildings, land, etc.) is about $42.7M. This project is a feasible investment because of its high ROR (412%), low costs for raw materials (due to using other facilities waste CO2), and manageable investments needed to run the plant.

CBE – 11

Biodiesel Production from Bank Note Waste

Advisor(s): Ed Andjeski

Joshua Baboff, Edgar Koby, Jared Yext, Charles O'Brien

This design of this process was inspired by the large amounts of money spent and waste created by governments across the globe replacing currency unfit for circulation. A process that can take the unfit currency, clean it, and send it back into circulation could drastically reduce the cost incurred by the government of replacing unfit bills. The conception and design of the following project is scaled up from a laboratory experiment in which supercritical carbon dioxide was used to extract sebum, the oily residue which accumulates on banknotes causing them to be unfit for circulation. A highly pressurized and customized batch cleaning vessel was designed to clean the paper currency. Then, a second part of the process was designed to convert the extracted sebum into biodiesel which could be an additional revenue stream. The sizing of the plant was done based on a maximum processing capacity of 50% of the unfit bills destroyed each year in the United States. The plant location will be Fort Worth, TX due to its proximity to the Bureau of Engraving and Printing which is where the bills will be sourced. In conclusion, there is a very good opportunity for profit in the field of laundering unfit currency.

ABSTRACTS

CBE – 12

Quark Power Plant

Advisor(s): Ed Luckiewizc, Chris Peters

Marissa Richardson, Marta Martinez Yus, Jared Reichl, Shaun Oliver

The Quark Nuclear SMR (Small Modular Reactor) Power Plant is presented. This plant will operate at an electrical capacity of 50 MWe and a thermal capacity of 160 MWt, which entails the end product. In the inlet, the flow rate amounts to a total inlet flow of 3,000 MW of energy, and 32 M lbs/hr of steam. These quantities are divided in 4 to 1 to each reactor module, then divided again by 10, since there will be 10 reactors in the plant. Moreover, around 93,000 gal/min water (steam) is needed to perform the westinghouse. Some of the initial cost and sizing of the plant needed to be adapted as new information was presented. Some of the changes that were made was getting new information on how to successfully have the positive NPV for our project. The corrections helped out with the initial cost of the plant starting at 3.6 billion (dollars) and ending with 11.4 billion (dollars) in the course of five years. With these changes that have occurred, the two calculations for the NPV have had a positive trend with both payback periods being four and five years, respectively. The sizing of the actual plant itself is where the major concerns were and most of the changes happened. With that being said, Nuscale (The company that the Philadelphia Project is basing their reactor design on) is a newly launched reactor with a limited number of dimensions and specifications at their disposal. The plant contains in one than just multiple small reactors, it also needs a longer set of support equipment which will be detailed in this report. The Four major pieces of equipment that were sized for this project are as follows, a pump, two heat exchangers, and a demineralizer, which are key components of the Steam Turbine - Generator System process that creates the allocated 160 MWt thermal capacity that was previously stated.

CBE – 14

Recycling Lithium Ion Batteries

Advisor(s): Dr. Tang

Rayna Newkirk, Anjali Patel, Renee Saraka, Maxwell Martine

Lithium-ion batteries are currently being mass produced to be used in consumer electronics, electric vehicles, and many other devices. Once these batteries reach the end of their lifetime, they will need to be properly disposed of since they contain hazardous materials. They also contain valuable metals that can be recycled and remade into battery cathode materials. A process was created that takes a feedstock of spent lithium-ion batteries of various sizes and shapes and reclaims the metals used in the battery cathodes. The process starts by a physical separation of shredding and sieving the batteries with commercialized equipment to remove the plastic external casings and separators. The metal scraps are then smelted into a singular metal alloy. The remainder of the process introduces new chemicals to the solution to remove manganese dioxide through precipitation, solid cobalt through membrane separation and electrodeposition, solid nickel through membrane separation and electrodeposition, and finally lithium carbonate salt through precipitation. The hazardous waste streams produced, the emissions stemming from equipment usage, and material waste were pertinent to consider in accordance with the EPA and OSHA regulations. An evaluation of the plant from a safety and sustainability standpoint was conducted to mitigate potential risks and address environmental impact.This process will operate at a financial loss each year of operation unless the technology to recycle reagents is discovered. In order for the plant to breakeven, $13.70 would need to be charged for every pound of waste given to the plant. Assuming that by the time of construction reagent recycle technology will exist, the plant will profit over $230 million annually. This profit, combined with the steady economy for the most profitable products makes this plant a worthwhile investment.

ABSTRACTS

CBE – 15

Methaforming: Low Cost Gasoline from Low Octane

Advisor(s): David Kolesar

Nicholas Banks, Mohamed Ahmed, Thomas Heiser

Methaforming is a process that converts low-octane gasoline feed to high-octane gasoline blendstock in one unit - the Methaformer - as opposed to multiple units. The special Methaformer unit is meant to replace a multi-step reforming process, which includes a hydrotreater that achieves the same results as the Methaformer by using extra steps such as isometrization, benzene reduction, and reforming. The Methaformer skips the extra steps and converts straight from a naphtha and methanol feed to a mixture containing target C8 aromatics. Those C8 aromatics would then need to be separated from the rest of the mixture. Annual cash flows before taxes were estimated to be $1.85 billion. The total capital cost of the plant is initially estimated at $38 million. The yearly operating cost is $42 million. The DCFROR (Discounted Cash Flow Rate of Return) is 41%.The simulation of the process went through four different versions. The first version was meant to lay out the process and the material balances for the entire flow sheet. The second version added real process units such as distillation columns and flash drums. The second version, however, had seven different distillation columns, which did not achieve the desired separation goals. The third version addressed all the separation shortcomings of the previous simulations, reducing the number of distillation columns from seven to three. The final version implemented realistic heat exchanger design, replacing all of the Heater blocks with HeatX blocks meant to simulate shell-and-tube heat exchangers and air coolers. The reflux ratio of each distillation column was reduced in the final version, saving on operating costs. Floresville, Texas was selected due to its proximity to waste disposal services and a neighboring oil company; obtaining naphtha and methanol should be possible at this location. The weather in Floresville is humid from April to October; earthquakes are not uncommon and tornadoes are potential hazards. In addition, many waste management services are nearby. Access to water and electricity can be received once pipes and wires are laid down. The plant will be built from the grassroots.The current target of the plant is to produce 3.96E+09 metric tonnes/yr of methaformate, which is 1% of the total global gasoline production. The product flow rate of the final version of the simulated plant was 400,358 lb/hr, or 1.53 million metric tons per year, 0.38% of the target flow rate determined at the beginning of the project. The octane number of the methaformate produced was 107, considerably higher than the premium value of 92.

CBE – 16

Polychloroprene Plant

Advisor(s): Steven Schon

Thu Tran, Trang Nguyen, Thiha Thway, Hoan Dao

Polychloroprene, a versatile synthetic rubber, will be produced in Chocolate Bayou, Texas, nearby a butadiene producer, Amoco Chemicals Co. With 2.31% CAGR and approximately 20% global market share of chloroprene rubber in North America, the United States is an attractive market for polychloroprene due to growing construction industry. The plant is projected to produce polychloroprene at 110 million pounds per year which will meet 11.9% of global market share. With the average polychloroprene price of $2.91/lb, the plant will generate sales revenue of $320 million per year. The process will be modified based on Nairit's production unit of BP/Distillers original process, developed in the UK in 1971. The plant consists of five main units – chlorination, isomerization, dehydrochlorination, polymerization and rubber recovery. The plant will run in a hybrid operation mode with chlorination, isomerization and dehydrochlorination units as continuous processes and polymerization unit as batch process with four parallel batch reactors. The raw materials include 8,900 lb/hr butadiene, 10,600 lb/hr chlorine and 24,000 lb/hr caustic soda, which cost $167 million per year. The initial capital investment is expected to cost $96 million per year for equipment, utilities, labor, and waste treatment. The anticipated economic life of 15 years with tax rate of 45%, discount rate of 10%, a desired rate of return of 10% and indirect cost of 30% to sales revenue, the project will generate Net Present Value (NPV) of $7.8 million, Internal Rate of Return (IRR) of 12.13%.

ABSTRACTS

CBE – 17

Fuel Production from Waste Polystrene via Pyrolysis

Advisor(s): Dr. Cairncross

Joseph Korger, Jacob Winter, Caylee Estep, Thomas Mulry

The purpose of this facility is to transform unused waste polystyrene into a usable resource in a variety of three separate fuel oils. Once the polystyrene is received, it will go through pretreatment to ensure that it has been properly crushed and washed to not cause harm to downstream processes. The pyrolysis reactor will take the washed and heated polystyrene and decompose it down into a composite stream of varying hydrocarbons. The conversion requires two self-agitating fluidized bed reactors. Due to the high temperature requirement inside the reactor, it will be heated with a thermal liquid to ensure accurate temperatures and overall efficiency. Nickel oxide catalyst is utilized in the reactors to help promote lighter hydrocarbons to be generated, which are often used in gasoline blending. The products of the reactors will go through an initial series of separation steps in order to remove the char from the process. Once the char is removed, the streams can now enter the series of distillation columns in order to remove chlorine from the process and to separate the gasoline, diesel, and heavy fuels into their own streams. In the environmental and sustainability analysis, the energy intensity of 10.315 MJ/kg and a mass intensity of 0.128 were calculated for the plant. Optimizations for several process equipment were conducted after completing the base case, with distillation columns and heat exchangers resulting in a noticeable improvement. However, even with the optimizations, an internal rate of return for the project was evaluated at -41.17%, which varied greatly from the initial target of 15%. Economic analyses showed that large costs from manufacturing and equipment were not able to be offset by the revenue from the sale of the fuel products. It is thus recommended that the project should not be implemented as it is not economically feasible.

CBE – 18

Hydrogen for the Hydrogen Economy

Advisor(s): Mike Keane

Leah Clark, Siobhan Montenegro, Ellende Chongolola, Michael Kanner

The need for hydrogen gas for fueling cells is constantly growing as the market for hydrogen fuel cell electric vehicles expands and as the hydrogen infrastructure develops. Hydrogen gas will be produced in a plant located in Van Nuys, California, next to the Budweiser brewery from which the raw materials are retrieved, and hydrogen fueling stations to which the product will be shipped. This plant will produce 80.5 million pounds of hydrogen and 1.06 billion pounds of byproduct carbon dioxide per year. The feed stream of the brewery wastewater flows at 13.7 Mlb/hr which is concentrated into a 10 wt% glucose solution before entering a co-current plug flow reactor where the solution will undergo biomass gasification. The produced carbon monoxide from this process, along with unreacted water, is fed into a second plug flow reactor that utilizes a ferrochromium catalyst for a water-gas shift reaction. This reaction produces the hydrogen gas product which is separated to 99.99% purity. The initial investment of this project, including cost of equipment and installation, is expected to be $33 million. The manufacturing cost is expected to be $2.5 billion, the majority of which is the cost of wastewater, including transportation, which is expected to be $2.3 billion. The hydrogen gas will be sold for $2.20/lb. Recommendations to management include developing partnerships with the breweries to sell back unused purified water as a means of making this plant more environmentally and economically sound. With current estimates, the plant will return -$2.3 billion per year and has a DCFROR of -59,769%, indicating that this process is not economically feasible under current economic assumptions.

ABSTRACTS

CBE – 19

VGO Hydrocracking Plant

Advisor(s): John Speidel

Ian O'Donnell, Lucas Etim, Thura Soe Aung, Dong Gook Kim

This project is the Hydrocracking of Vacuum Gas Oil or VGO. In this project, a hydrocracker plant is designed to process 30,000 barrels per day of VGO in order to create smaller chain hydrocarbon products: naphtha, kerosene, diesel. The plant will also remove the VGO impurity of vacuum gas oil residuum—a range of larger, heavier hydrocarbon chains than VGO—and distribute it to other plants for profit. The total cost of the project is $1.2 billion dollars on a yearly basis over a lifetime of 20 years, with a two-year period prior to startup for construction. The projected Discounted Cash Flow Rate of Return (DCFROR) is 81.70%. This hydrocracker plant will be placed adjacent to an operational oil refinery in the United States of America. The plant consists of six major different units: the reactor unit consisting of the hydrotreater and hydrocracking reactors, the debutanizer unit, the main fractionator unit consisting of three separate distillation columns to separate naphtha, kerosene, and diesel, the vacuum tower unit, and the product tank farm. The reactor unit will take the VGO stream and remove sulfur and nitrogen impurities, then performing the hydrocracking process, creating smaller chains and molecules. The remaining VGO and the created smaller chains will be sent through a series of distillation columns, where a range of molecules are separated. The molecule ranges will be in the C1-C5 range, naphtha range, kerosene range, and diesel range. It is concluded that this project is overall feasible and capable of generating revenue after taking in account the fixed costs and variable costs. Fixed costs include equipment that were sized to accommodate the 30,000 barrel per day VGO feed, as well as the labor that will be required to keep the plant operating to specification. Variable costs include utilities: cooling water, natural gas and electricity, while also including raw materials the fresh VGO and hydrogen. The process becomes feasible due to the amount of naphtha, kerosene, and diesel can be produced and then distributed for sale.

CBE – 20

Ethically Produced Beef

Advisor(s): John Speidel

Nicholas Daniels, Kait Moran, Manuel Zimberoff, Donna Oyella

The following report outlines the production equipment, manufacturing process, biochemical nature, and economic feasibility of a pilot scale cell cultured meat plant. Factory farming has proven its harmful impacts on the environment time and time again. This has led many to investigate alternative sources of meat. The cutting edge of these investigations has inquired about the possibility of sourcing meat from an industrial tissue culture operation. This project aims to design a pilot plant that would scale up the laboratory procedure of tissue culturing for market distribution. For the production portion of the plant, a Fluidized Bed Reactor (FBR) was utilized as the main cell culture vessel due to its efficiency when it comes to cell viability. The plant was also designed to synthesize the growth factors in house to cut down costs of the raw materials and create an alternative revenue stream for the plant. The economic feasibility of the plant was determined using plant production capacity, estimated materials costs, and labor and utilities. From these values, a cash flow analysis is constructed resulting in an internal rate of return (IRR) of 0% and net present value (NPV) of $-291,104,099.29. The IRR and NPV could then be used to see if the project is a worthy investment. The NPV indicates that the project is not economically viable.

ABSTRACTS

CBE – 21

Direct Carbonylation of Adipic Acid to Diesters

Advisor(s): George Rowell

Oluwadamilola Bolarin, Savannah Schimdt, Connor Harris, Pranav Laxman

This report details a plant designed to produce dimethyl adipate from a novel "green" process using 1,3-butadiene, methanol, and carbon monoxide as the main raw materials. Dimethyl adipate is an ester used as a precursor to nylon production, a plasticizer in commercial products and an organic solvent on pilot-scale. The current industrial process to manufacture dimethyl adipate involves a combination of excess of nitric acid with cyclohexanol and cyclohexanone and requires specialized equipment because of the corrosive nature of nitric acid. This process is possible with the use of a specialized bidentate phosphine ligand named HeMaRaphos and a palladium catalyst system. The proposed plant will produce 1.5 MM lbs. of dimethyl adipate per year which is 3% of the U.S. dimethyl adipate market but has the capacity for further upscaling and market competition. Currently, the process is not feasible economically, with a discounted net present value of -$25,520,000 and an undefined discounted rate of return for the base case. The optimized case, with multiple cost reducing measures implemented improved the process marginally, resulting in a discounted net present value of -$11,710,000 and an IRR of 1.52%. The plant location, Louisiana U.S.A., was chosen for proximity to multiple raw materials which are all manufactured in Texas or on the Gulf Coast. Our recommendations to management are to analyze the process and catalyst manufacturing further on a pilot plant scale. At this time, we do not recommend constructing a plant currently based on this design.

CBE – 22

Plant for Extracting Gold without Using Sodium Cyanide

Advisor(s): Mike Grady

Brienna Ogilvie, Zudi Ye, Kevin Mercedes, Yuyi Liao

The Cycladex process using alpha-cyclodextrin to isolate gold is an economically and technically viable replacement for traditional sodium cyanide methods. Cyclodextrins are derivatives of starches that possess no environmental concerns and are still effective isolators of gold ions. Additionally, the Cyclodex process can increase gold yield by 5-10% according to laboratory studies from Cycladex sponsored labs. The proposed plant (named Gold Rush) utilizing this technology will be co-located with a Kinross owned gold cyanidation plant (Fort Knox) in Fairbanks, Alaska. This location was chosen because the Kinross company recently did a study on the viability of expanding their operations in the area. This co-located plant will serve as a proof of concept so the production capacity will be limited to 0.25% of the world market share for gold. This is equal to about 2.1 lb/hr of gold or an annual production of 16.8 Mlbs of gold. To produce this much gold ore must be purchased and processed at a rate of 3,700 MMlb/yr . The raw ore will be purchased directly from Fort Knox gold mine after ore grinding and flotation. The life of the Kinross mine is estimated to be 10 years at the current rate of production. The estimated cost of building the Gold Rush plant is $149 MM with direct equipment costs being $13.9 MM. The estimated cost per pound of gold is $6,500 with 60% allocated to raw material costs. Estimating a selling price of $15,000/lb of gold with a 3% inflation value as the basis, the discounted cash flow rate of return is expected to be 30% with an NPV of $308 MM by the end of the 10-year plant life

ABSTRACTS

CBE – 23

Green Production of Adipic Acid

Advisor(s): Steven Schon

Alex Scottoline, Jason Rodman, Sk Dipta, Daniel Steinberg

Adipic acid has played a significant role worldwide for the last century, most notably for its use in nylon production. Through a new environmentally friendly process, adipic acid production could potentially gain a competitive advantage over the conventional greenhouse gas intensive route. In the proposed plant, adipic acid is produced via a single-step co-oxidation of cyclohexane and cyclohexanone with molecular oxygen. The plant will be constructed in Osaka, Japan, which is strategically located near China, which occupies a large share of both the adipic acid and nylon markets. The process uses a utilizes a continuous Buss loop reactor which is well-suited to the metalloporphyrin catalyzed reaction that occurs. The reactor effluent is separated into an acid melt stream and a solvent stream using a forced circulation evaporator. The acid melt stream is fed to a batch crystallization process in order to purify each of the three acids. These three acid melts are then sent to drum flakers in order to produce a solid, flaked product. The solvent stream is sent to a separation scheme consisting of a decanter, extractor, and distillation column in order to treat wastewater and recover reactants for recycle. In total, the plant will produce 21.6 MM lb/year of adipic acid, along with 4.5 MM lb/year of succinic acid and 2.0 MM lb/year of glutaric acid. Each of these acids will be produced at a high level of purity (99.8%, 97.5%, and 99.5% by weight respectively). This is approximately 5% of the capacity of a large conventional adipic acid plant. Overall, the process is not economically feasible. With a CAPEX of $73 MM USD and manufacturing cost of $33.7 MM USD ($1.55/lb adipic acid) annually, the plant loses $25.8 MM USD over the course of its 20-year lifetime. A discount rate of -1.56 % is required for the NPV to equal 0, which fails to meet the hurdle rate of 20%.

CBE – 24

Ammonium Nitrate Fertilizer Plant

Advisor(s): George Rowell

Zachary Arvanitis, Jackie Zackowski, Tony Tang, Joseph Miller

The feasibility and hypothetical construction of a chemical plant that produces ammonium nitrate fertilizer is studied. Several aspects of the plant such as economics, production processes, and environmental safety are studied. Originally, the design was based on a chemical process where ammonium carbonate and calcium nitrate were reacted to form ammonium nitrate and calcium carbonate. Through further research, it was discovered that this process is rarely used in industry due to the complexity of and costs associated with the reactions. Therefore, the process that was chosen was to react nitric acid with ammonia gas to form ammonium nitrate fertilizer prills. Given the vast global market for ammonium nitrate fertilizer, an optimistic plant size was determined to be capable of accounting for 2% of the global market. A plant of this scale will require approximately 110,000 square feet of space. The seasonal nature of demand for fertilizer means that large amounts of product will need to be stored during the months where they cannot be shipped, namely in Fall and Winter. Given the highly explosive nature of ammonium nitrate, rigorous precautions must be taken to ensure it is handled and stored safely. The location for the plant is in the Midwestern/Rocky Mountain region of the United States because it is an area less often affected by extreme climate events such as hurricanes, earthquakes, and tornados. The population density is also relatively low, but a high concentration of agricultural operations take place there. It was determined that it would take us at least 5 years of the 20 year plant-life to begin earning a profit.