DREXEL UNIVERSITY
College of
Engineering

DREXEL UNIVERSITY ENGINEERING

2022 CELEBRATION OF ENGINEERING DESIGN

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CAE-1 Aghayere - Center for Black Culture

Jayla Garvin, Lulu Obinwa, Abby Debebe, Daniel Ramut, Ali Mohammad
Dr. Abieyuwa Aghayere, Professor Jeffery Fama

At the start of the pandemic, there were multiple discussions with President John Fry about the black organizations and students at Drexel needing a space to study, have events, and build a community. Currently, the space provided is only a floor in the rush building. We have decided to create a multi-story building for the Drexel Center for Black Culture near or on campus. The main purpose of the Center for Black Culture is for Black Drexel Students, faculty, and staff to have a place on campus to call home where they can learn, study, grow and build up the Black community. The audience is geared towards Black students, organizations, faculty, and staff on campus but is open and welcome to all. The most important aspect is to make sure we integrate as many assets of Black culture and creativity as possible while complying with IBC 2018 and Drexel University Building System standards.

CAE-3 SEPTA-Yards Building Design

Joseph DiMarco, Brandon Hensyl, Christopher Kierce, Madeleine McCoskey, James Murray
Dr. Abieyuwa Aghayere

The SEPTA Yards Building Design project is located on an irregular-shaped parcel within Drexel and SEPTA property just north of Canaris Hall (east of 32nd Street). The goal of this project is to create a multifunction building (commercial and residential) that optimizes the given space for Drexel University Real Estate and Facilities and SEPTA employees. The proposed building will cantilever over an existing SEPTA rail yard to maximize usable space. The cantilever requires structural and geotechnical considerations to ensure minimal deformation, provide support for uplift, and ensure the axial demand of the building is safely met. This project will include structural, mechanical, and water resource engineers, along with construction management procedures throughout the duration of the project. Structural design, load analysis, and documentation will be provided for the structural aspects of the building. The geotechnical portion will investigate deep foundation design, to resist the uplift forces caused by the cantilever and to meet the axial load demand of the building. The mechanical design will consist of analyzing and selecting an energy-efficient insulation for the building envelope, along with heat gain/loss calculations for the HVAC zones. The stormwater management aspect will focus on urban water reuse, as well as design considerations for the green spaces and sustainability. Finally, building costs and timelines for the design and construction phases of the project will be determined based on typical construction management techniques.

CAE-4 Philadelphia Renewable Energy Solutions

Olivia Szabo, Galen Steven-King, Brenda Dluhy, Lux Ezell, Cole Rooney
Dr. Shannon Capps

The former Philadelphia Energy Solutions (PES) site in South Philadelphia is set to be redeveloped. This site was home to the largest oil refinery on the east coast for over one hundred years. The refinery released copious amounts of hazardous pollutants into the soil, groundwater, and air. This project plans to renovate the site into a sustainable, environmentally friendly, and community focused location. The 1,300-acre site has been divided into a commercial logistics center, an integrated road network, a recreation public park, a forested park, and a constructed wetland. The project also proposes plans for environmental remediation of the site, climate resilience and renewable energy. The group designed preliminary remedial systems, locations, and costs to make the site safe for future use. The team also conducted stormwater modelling to ensure that runoff from the site is managed without contributing to combined sewer overflow or river flooding. Renewable energy systems were modeled and designed to deliver clean power to the entire site. Additional planning went into making a park in the northern part of the site to inspire community engagement and create access to forested areas. To replace the economic engine that used to exist on this site, a layout

for a logistic center with large warehouses, mid-rise waterfront office buildings, and a road network was designed. The result was a cohesive layout for the 1,300-acre site that used each aspect of the design to complement the other elements of the development.

CAE-5 Revitalization of South Christopher Columbus Boulevard

Jeremy Bottrel, Michael Galanaugh, Evan Giordano, Kyle Mietkowski
Dr. Jonathan Cheng

Currently, Columbus Boulevard is underutilized, unsafe, and inaccessible. By increasing walkability, bike infrastructure, and public transit, Columbus Blvd will have its traffic mitigated and the value of the regional property will increase. With the additional traffic from new apartment complexes currently undergoing construction, and the proximity to businesses and waterfront trails, a means to alleviate future traffic will be necessary. Existing problems associated with intersections along Columbus Blvd are inadequate crossings, lack of signaling and road markings. There are also abandoned railroad tracks wasting valuable space in the center of Columbus Blvd that could be utilized for better transportation purposes. Designing new bicycle crossings at Washington Ave allow pedestrians and cyclists to access the river trail more easily and safely. For Dickinson St, the addition of stoplights and redesign of the pavement markings will better facilitate traffic flow. At Morris St, safety and traffic concerns are addressed through the addition of a crosswalk and adjustment of the bike path for safer traveling. At Swanson St, the development of new sidewalks prevents trucks from interfering with oncoming traffic from Columbus Blvd. The Delaware River Trail will see the development of new recreational spaces and playgrounds to Philadelphia Parks and Recreation safety standards to attract visitors and deliver an appeal to surrounding local businesses. Design plans for the railroad tracks not in service include the introduction of a trolley line, track removal in favor of an isolated bike path in the roadway median or for extra vehicular lanes.

CAE-6 Green Restorative Community Space

Varsha Ajith, Sadeel Eidda, Khadija Koita, Aarohaa Satyal
Dr. Eugenia Victoria Ellis

The Green Restorative Community Space is a restoration project that aims to create an enriching community space that will foster collaboration and innovation for non-profit organizations within West Philadelphia. Our client, the Dornsife Center for Neighborhood Partnerships, is interested in making the existing building located at 3512 Haverford Ave, Philadelphia, PA 19104, an extension of the Dornsife Center. The design services focused on for this project were site development, building envelope, structural redesign, green infrastructure and building energy efficiency. Sustainable solutions for all aspects of this retrofit were of utmost importance and influenced the design process. The new community center facilities were dictated by community needs and the goals of the Dornsife Center. Some of the new spaces include a hoop house that can support the growth of fresh produce, a full kitchen with adjacent dining facilities, accessible roof space with extensive green roofs, a central atrium space to maximize daylight gain, and modernized gym and pool spaces. Structural analysis was performed with the AISC 7 and IBC 2018 guidelines. The updated energy consumption was compared to the baseline model using EQuest and design decisions were based on HAP modeling to present the client with a budget for each application. This building which was originally a Philadelphia Public School has historical significance within the region and our goal is to create an impactful design with this building that meets equitable, economical, and environmental goals for the community.

CAE-7 CHOP/HUP Traffic and Access Evaluation

Emma Youngs, Mary Diane Boquila, Natalia Dzietczyk, Rebecca Davidoff, Valerie Melecio

Dr. Patricia Gallagher

The Children's Hospital of Philadelphia (CHOP) located at 3401 Civic Center Boulevard, Philadelphia, PA 19104, and the Hospital of the University of Pennsylvania (HUP) located at 3400 Spruce Street, Philadelphia, PA 19104 are experiencing a significant amount of traffic. The goal of this project is to alleviate the traffic congestion around the area that is caused by the limited access points and high traffic volume. Girl Boss Inc. proposes to design integrative, multifaceted traffic mitigation solutions around the CHOP and HUP areas. Evaluation of the traffic and access points in the area was performed using crash data and traffic counts to determine the appropriate solutions to the problem.

The integrative, multifaceted solutions include road widening, bike and bus lane addition, a parking garage near the CHOP area, intelligent transportation systems (ITS) solutions, and pedestrian improvements. The road widening will be done along Civic Center Boulevard and South University Avenue to accommodate more vehicles and bikers. The parking garage will be built on the existing CHOP parking lot located at 3400 Market Street to accommodate more employees, patients and visitors. The ITS integration will include digitized signs and a CHOP/Bus Flex Lane. The digitized signs will replace the existing, inconsistent signage located on Civic Center Boulevard, and the CHOP/Bus flex lane will service buses, emergency vehicles, and patients getting to the hospital. The pedestrian improvements will be located on the intersection of 33rd Street, 34th Street, South Street, and Spruce Street. These solutions will reduce traffic congestion and improve public safety.

CAE-8 Redevelopment of Philadelphia Public School Building: Science Leadership Academy at Beeber

Cynthia Phun, Joshua Perez, Anna Chen, Kelly Anne Ryan, Isabelle Coupet
Dr. Patrick Gurian

The School District of Philadelphia requested redevelopment services for the HVAC, plumbing and electrical systems, stormwater management, and electrification of the Science Leadership Academy (SLA) at Beeber building. The objective was to improve learning spaces that will benefit SLA students' productivity and wellbeing using sustainable engineering practices. A Storm Water Management Model (SWMM) was created to analyze the benefits of popular GSI methodologies. Ultimately, a bioretention basin was the best green infrastructure alternative because of its natural hydrologic process, possible use for educational purposes, and its capability to reduce total runoff in acre-feet for a ten-year storm by 11.5%. SLA Beeber also lacks a dedicated cooling and ventilation equipment which can exacerbate disease and affect students' performance and health. After generating a simulation model developed by the University of Colorado Jimenez, the best design was a ventilation rate of 8.02 ACH in tandem with mask-wearing limited the probability of infection in classrooms to 0.31% when used with the newly designed HVAC system. This system uses active chilled beam displacement induction units to heat, cool, and ventilate classrooms and offices; modeled by EnergyPlus for the purpose of estimating annual energy consumption of the newly renovated school. In addition, a borefield design and sizing determined by ASHRAE software is provided for the vertical bore geothermal ground loop heating system. Finally, the ample updates were accompanied by new electrified facility: an upgrade to a 2,000 A, 480V/277V service entrance switchboard. The total estimated construction cost for the renovation is $31,734,000.

CAE-9 Collaborative Corners: 34th and Market Street Student Hub and Campus Reinvigoration

Dan Brown, Kassandra Sloan, Amanda Grogin, Katherine Wade, Andrew Howe, Daniel Inglis, Jezreel Abelo, Carlos Gutierrez, David Wood
Dr. Abieyuwa Aghayere and Dr. Simi Hoque

Drexel University (the client), a private research university in Philadelphia, PA, is continuing to 'tear down the silos' and provide opportunities for cross-disciplinary collaboration between students, professors, and researchers.

Intersection Design (the project team) has developed a building complex titled Collaborative Corners that embodies this mission with an architecture and landscape design that provides spaces for interaction and connection. The building further advances this objective with integrated and coordinated design development level structural, mechanical, electrical, plumbing, and civil engineering systems as well as an in-depth construction timeline and budget.

Collaborative Corners is a 220,000 square foot building complex located on four lots at the intersection of 34th and Market St: 3401 Market St. (35,650 sf), Drexel University's Lot C (27,460 sf), 3440 Market St. (35,420 sf), and 3400 Market St. (26,660 sf). Aligning with the client's goals, the building complex hosts a new home for the Department of Civil, Architectural and Environmental Engineering, an expansion of the Westphal College of Media Arts and Design, a new student hub with study spaces and lounges, and a new makerspace with classroom, workshops, and research spaces. Collaborative Corners seeks to equitably serve all its visitors and occupants through the integration of design elements including extensive interior and exterior public spaces to facilitate connection, exposed engineering systems to act as teaching aides and inspiration, and LEED Gold certification to help address climate change and provide healthy spaces and amenities.

CAE-10 Highway Overpass: Vine St. Reclamation Project

Daniel Bolton, Shane Carey, Rosa-Maria Diez, Nathan Herbert, Keith Rupp
Dr. Abieyuwa Aghayere and Dr. Simi Hoque

The 142 Design team designed a multi-use building and structure that caps a section of I-676 between N. 11th and N. 12th St., a recessed highway that runs through the Callowhill neighborhood of Philadelphia. The building includes a public park on an accessible green roof, two commercial restaurant spaces, and a 22-unit residential transitional housing program for those dealing with housing security and homelessness. This provides a positive societal impact on the area's residents while also providing a positive environmental impact by improving the local microclimate, improving urban biodiversity, reducing urban stormwater runoff, and reducing noise pollution from the highway below. The engineering design includes a variable refrigerant flow HVAC system and a responsive lighting system to create an energy-efficient design and ideal indoor environment. Low-usage water fixtures and a rain collection system for greywater use reduce the amount of potable water usage. Finally, a robust structural design using sustainably sourced materials ensures the safety of the building occupants and drivers below. The result of this intensive design process is a sustainable, LEED-certified building that positively affects the environment and surrounding community.

CAE-12 Graffiti Pier Park

Nicole Davis, Jessica Drager, Julia Kovach, Anthony Lawrence, Gianna Monaco
Dr. Joseph Hughes

The Delaware River Port Authority has commissioned a 180-acre park redevelopment in the Port Richmond area of Philadelphia, Pennsylvania, named Graffiti Pier Park. This will be constructed on the presently abandoned site of the former Reading Railroad coal pier. The objective of this project was to create a recreational green space that is accessible to everyone in the community and will provide features that the location currently lacks. This redevelopment included: a visitor center, small cafe, athletic fields, hiking trails, an event venue, and recreational water activities. The team focused on the structural, transportation, and water resource aspects of the design. The visitor center was designed as a two-story structure with bathrooms, offices, event space, an information desk, gift shop, and rotating art exhibit. The cafe was designed as a simple one-story structure with a kitchen, counter space, and seating area. Access to Graffiti Pier Park is available via public transportation as well as a 300 space parking lot. The parking lot and access roads are made of pervious asphalt to allow for proper drainage. Green stormwater infrastructure was incorporated into the site to capture stormwater and assist in drainage. Because the site is located on the banks of the Delaware River, climate change effects were investigated. The rise of the river level was calculated throughout the park's life to determine the areas of the site that would flood. Our project also represents our

commitment to sustainable design by meeting net-zero energy and water goals.

CAE-13 Remediation PFCs

Timothy Schauder, Kelly McNicholas, David Evan Dixon, Rebecca Manthorpe, Gwen Yaeger
Dr. Joseph Hughes

The Willow Grove Naval Air Station (WGNAS) located in Horsham, PA, is a Superfund site that has Perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS) contaminating the site. In 2011, PFOA and PFOS were found in drinking water wells on site and in the neighborhoods surrounding the military base. The contaminated public wells were capped off site and additional remediation efforts are still required for the soil and groundwater on site. For the purposes of past remediation, the air base was broken up into 12 different sites. Site 5 is the fire training area and has the largest concentration of perfluorinated alkyl substances (PFAS) on site. The groundwater leaving Site 5 goes into the surrounding communities drinking water and private well water.

PFAS are contaminants of which there is limited data about successful remediation technologies. Due to this, a systems management approach allows for multiple treatment technologies to be employed allowing the individual strengths of the approaches to be combined. The different technology options this group has decided to incorporate into the design are carbon injection barrier, soil mixing/stabilization, permeable reactive barrier, and phytoremediation. Carbon injection barriers and permeable reactive barriers both work below ground as a form of in situ containment. Soil mixing and Stabilization provides some immediate removal of contaminants and can provide stabilization for the new development. Phytoremediation measures will account for removal of residual PFAS contamination. All of these options will work concurrently to manage the PFAS concentration levels in the groundwater flowing off of Site 5.

CAE-14 Traffic Analysis at 31st & Spring Garden St

Zoe Bennett, Abby Corrato, Lazar Lazovic, Paul Pullia
Dr. Liang Chung Lo

There is a recurring traffic backup along Spring Garden St, especially at the intersection of 31st St and Spring Garden St. Adaptive traffic lights are a way to analyze the traffic backup and adjust the light cycles to be able to reduce the amount of sitting traffic and backup at this intersection and the surrounding intersections. The types of light sensors that would be utilized to analyze the traffic are virtual loop sensors and traffic imaging sensors. The role that ALPZ plays in this project is to analyze traffic in the area, investigate the best sensor installation options and placement, and see how networked sensors and traffic lights work together to reduce traffic congestion. Our ideal system would connect the traffic lights at Intersections along Spring Garden Street to a command unit or brain that would monitor traffic movement using a variety of sensors positioned at each intersection and alter traffic signalization based on the logic parameters established. We plan to show our design at work using a simulation in Synchro.

CAE-15 Pandemic Resilience in the Restaurant Space

Grace Albert, Ahmed Alkhafaji, Joe Bitetto, Thanh Vu, Jennifer Zhang
Dr. James Lo

The client requests a redesign of a restaurant space in Old City, Philadelphia, formerly known as Mamoun's Falafel. The COVID-19 pandemic had an especially significant impact on the restaurant industry and dining experience. The client wishes to open a new restaurant with the following requirements: Fall 2022 opening day, maintaining current dining occupancy, dinner service only from 5 pm - 10 pm, and reducing risk of transmission for a mask less dining

experience. The final design and intervention strategy requires a preventative and multi-layered approach. The maximum occupancy must be reduced due to limited space. To mitigate this problem, the addition of a second floor and outdoor dining are included. Limiting the risk of transmission includes increasing restaurant operation efficiency, HVAC system zoning, addition of an elevator and dumbwaiter, and portable tabletop air purifiers. A structural and electrical analysis was made to ensure adequate support in the columns, girders, and electrical system. HVAC design separates 1st and 2nd floor dining and kitchen spaces into different zones to address their individual load and ventilation requirements properly. Furthermore, guests and staff are protected by installing a plenum for displacement air ventilation to provide "ventilation bubbles". Upgraded filtration is also necessary to include HEPA filters for tabletop air purifiers but MERV 14 for HVAC zones. The final design is expected to deliver about 3 times more air changes per hour than a conventional well-mixed scenario. The estimated cost is $320,000 with a projected construction completion date of October 2022.

CAE-16 Marsh Creek Hydroelectric Project

Denny Howell, Cameren Lewis, Dylan Ulshafer
Dr. Joseph Martin

The Marsh Creek Hydroelectric Project proposes modifications to the existing Marsh Creek Dam to allow for the generation of electricity. This system will operate a 275 kW generator and is capable of producing ~1 GWh of electricity per year, the equivalent of the yearly demand of ~100 typical American homes. This system is intended to generate the majority of its electricity during the hours of peak demand, 6AM-9AM and 4PM-8PM, when the energy output from solar is low. The schedule can be adjusted to better serve other hours of the day or smooth the power output from other renewables such as wind and traditional hydropower. This will be achieved by constructing a 400,000 CF basin at the base of the dam. This basin will be filled rapidly and generate a large percentage of the available energy for any given day during a short period of time. The basin will then release water into the East Branch of Brandywine Creek at an environmentally conscious rate. Water will be supplied to the turbine by an aboveground penstock. This penstock will use the principle of a siphon to suck the water out of the reservoir and into the turbine while requiring minimal excavation of the existing earthen embankment. The earthwork operations on this site will not require any material to be imported or exported. In addition, based on the original design plans it is not anticipated to have an affect on the stability or compromise the safety of the existing embankment.

CAE-17 Eastwick Community Landswap

Matthew Dundon, Taylor Sweeney, Ryan Bird, Noah Machek, Sterling Fitser
Dr. Franco Montalto

The Eastwick community landswap concept is a design proposal intended to relieve the Philadelphia neighborhood from reoccurring flood events dating back decades. The landswap proposal consists of the relocation of residents from 250 private homes to a proposed flood resilient development on city owned property located to the south of the existing neighborhood. This proposed development includes new townhouse style homes for the relocated residents. Also, a senior living center for Eastwick's large elderly population and a community center to retain and promote existing bonds between residents. To protect against future flood events and the estimated impacts of sea level rise on coastal areas, the development and its ingress/egress on Lindbergh Boulevard is to be graded to an elevation 4' above the FEMA 500-year flood plain. Protection for homes remaining within Eastwick is to be provided by a berm located at a 20' elevation connecting existing high points on the site and a 4' x 60' constructed dry stream channel. This channel provides an alternative routing option for excess fluvial flow from the Cobbs Creek and assists in establishing a safer flood plain away from the community. Emergency flood relief is provided by a 1.6 million SF stormwater detention basin to be constructed near the Pepper Middle School. Flood overflow is conveyed to the basin along 82nd street, which is to be converted into a cloudburst street, this enables the cross section of the street to be used as an open flow channel during major storm events.

CAE-18 9th and Spring Garden Street Railroad Revitalization

Daniel Yamba, J'Anna-Mare Lue, Myrlie Taylor, Preetham Adla, Ramon Hernandez
Dr. Nariman Mostafavi

The purpose of this project is to restore the Reading Railroad's abandoned 9th and Spring Garden Street train station while addressing some of the social and environmental needs of the community. Currently, the platform is abandoned, and the station building has been demolished. It was proposed that (1) the platform would be retained and retrofitted as a green space with biking and walking lanes and (2) an adjacent community center and garden would be built to occupy the street-level space. This space is intended to foster a sense of community and increase access to green space. Various alternatives were considered for each system and chosen based on budget, materials, sustainability, community, and time.

The building is a 1,600 square feet steel building designed to serve as an indoor space where community members can host social and educational events. The community center will also provide an accessible entrance to the platform. The platform will feature dedicated walking and biking lanes to create opportunities for greener transportation routes and to increase pedestrian and cyclist safety from car-related accidents. Both the elevated platform and the street-level green space will make up the site's green stormwater infrastructure network that harvests rainwater, as well as reduces potable water consumption and stormwater run-off.

CAE-19 Designing Alternative Energy Systems for the Native Village of Tyonek, Alaska

Jorge Gonzalez, Margaret McCurdy, Joan Nguyen, Andrew Risser
Dr. Mira Olson

The Native Village of Tyonek, located in a remote area of Alaska, requested system planning and design services for a renewable energy system. Their goal is to lower exorbitantly high household electric bills. The system design took into consideration community needs and interests, environmental impacts, financial feasibility, and includes solar energy as the primary electricity source through a Power Purchase Agreement (PPA) with the utility, along with wind energy as a secondary supplemental source. The designed solar system consists of 1680 modules that can generate an estimated annual energy supply of 725 MWh which is almost 70% of the community's annual demand. The wind system was designed on a demand percentage-basis, allowing the community to select the number of wind turbines to install. The team consulted with local geotechnical engineering professionals to develop a geotechnical subsurface exploration plan, and a proposed solar array foundation system was designed. Transmission lines were also designed to be climate appropriate for Alaska. Stormwater and erosion control was implemented at the proposed project sites using Alaska's Best Management Practices. Overall, this project effectively combined principles of community based design, civil, environmental, mechanical, and peace engineering in addition to risk management using probability and statistics.

CAE-20 Reichenbach-Mixed Use

Maggie Higgins, Tenaya Hubbell-Wood, Spencer Schade, Pat Trombetta
Dr. Matthew Reichenbach

At the request of Drexel University, redevelopment of the existing Myers Hall site was explored. The primary goal of this redevelopment was twofold: to offer the student body modernized, first-class gathering spaces on campus including a new student center and dining hall; and to provide the university with ample undergraduate housing. An

eleven-story building, nicknamed "The HUB," has been proposed, consisting of three lower stories dedicated to various student activities and eight upper stories dedicated to student residences. The design and planning of this structure was a multidisciplinary effort, involving coordination between architecture, structure, and mechanical. Structurally, composite steel beams were the most cost effective gravity-load support option, with braced frames as the lateral-load-resisting system in accordance with the 2018 International Building Code (IBC). Open-web steel-joist systems were designed to support ancillary single-story structures independent of the main tower. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards governed the mechanical system design. The final design utilizes both roof top and air handling units, which use electrical heating coils and chilled water coils to condition the air. Sustainable best practices were implemented within each discipline to support the university wide effort for a more sustainable urban campus. Some initiatives include a building integrated photovoltaic (BIPV) facade system and reusing runoff for non-potable water applications. In addition to meeting the request of Drexel faculty, the design team strived to produce a building that improves campus life and facilities, promotes collaboration amongst the student population, and utilizes innovative engineering practices.

CAE-21 Bucky Boyle Community Center

Nathan Rees, Kyle Biro, Alex Natale, Kenji Fong, Cade McDowell
Dr. Robert Swan

The City of Allentown has enlisted engineering design services for the Bucky Boyle Community Center project located at 249 N. Front Street, Allentown, PA. Lehigh Valley Consulting Group (LVCG), composed of engineers with a combined 19 years of engineering education and 8 years professional experience, is more than capable of meeting the needs of the City of Allentown and implementing sustainable practices. In the 2012 Lehigh Riverfront Master Plan, the City of Allentown outlines the need for a community center, building upon the Eastern Pennsylvania quality of life that Allentown's residents enjoy. The community center will enhance the unique character of the city, while helping the Lehigh Riverfront reach its optimum potential as a balanced space serving both the Allentown community and visitors. The Bucky Community Center will complement the existing Bucky Boyle Park and provide flexible space for the eventual renovation of the park. The 249 N. Front Street site, located immediately adjacent to the park and currently occupied by several dilapidated manufacturing buildings, provides the ideal location for the proposed community center. The current design of the community center meets or exceeds all client and code requirements and expectations. A broad range of engineering services have been provided to ensure the completion of a comprehensive and detailed design of the structure and site. Every effort has been and will continue to be made to incorporate sustainable design and building practices where possible.

CAE-22 Redevelopment of 3151 Market Street

Adwitiya Tibrewal, Caitlyn Yergey, Fritha Elizabeth Francis, Jacob Rogers, Naomi Ramos
Dr. Michael Waring

The design team is proposing a modern research facility to address the need for an exclusive research facility for engineering students and faculty at Drexel University. A major problem that was to be addressed in this design is the lack of human-building interactions (HBI) in current campus buildings. The proposed research facility aims to integrate HBI, attain LEED Gold certification, and provide a research space to Drexel researchers.

The defined issue and proposed project created many opportunities and constraints. The chosen site location provides the opportunity to tie into Drexel's campus. With ideal proximity to Drexel facilities, it proves to be an optimal location for a research complex. There is also the unique opportunity to associate the proposed design project with the existing Schuylkill Yards Development Project. The Schuylkill Yards Development Project aims to bring the community together and create a streamline for people to use public transportation, which would allow for the proposed design project to have a larger impact on the surrounding society.

The architectural layout includes five floors of mixed use spaces including laboratory, office, and collaborative spaces. The building incorporates smart systems to enhance HBI and energy efficiency. All decisions for engineering systems are based on optimizing user experience and creating an environmentally conscious building, in line with LEED goals.

CHE- 1 Isomerization of C_5's and C_6's

Ryan Miller, Raj Patel, Tony Truong, Jared Wallace Matthew Hipkins
Dr. Joseph Petracco

Rising demand for gasoline with higher burning efficiency prompts the need to improve the octane rating of gasoline mixtures. High quality paraffins not only lengthen the combustion engine's lifespan but also reduce its carbon and greenhouse gas emissions. Among the components of low molecular weight paraffins (C4-C8), straight chain pentane and hexane (n-C5 and n-C6) have the lowest research octane number (RON). This study focuses on designing an isomerization unit to convert these components into iso-pentane and iso-hexane respectively. This project is in collaboration with Monroe Energy, a refinery in Trainer, PA, to augment their production capability and revenue by enhancing the RON of approximately 26,000 barrels of paraffin per day. The design discusses the necessary separation procedures, the use of zeolite catalyst, and the optimal operating temperature and pressure for the isomerization process. The reaction chemistry is modeled based on the thermodynamic and kinetic data that have been experimentally determined from literature. Through extensive equipment sizing and gauging the cost of implementation, operation, and maintenance, a thorough economic analysis is performed to evaluate the profitability of the isomerization unit. A sensitivity analysis is conducted to potentially further improve the RON of the product streams and minimize the utility costs of the unit. The estimated cost to build the unit is $182 million over the first year and is projected to lose $414 million over the plant lifetime with no payback period due to the unprofitability. The projected non-discounted cash flow rate of return is -11.32%, making it an unfavorable investment for the company to consider.

CHE-2 Thorium Molten Salt Breeder Reactor

Matt Gavenda, Will Gibson, Javier Lazo, Nicole Tavormina, Ed Luckiewizc
Dr. Christopher Peters

The rising threat of catastrophic climate change caused by CO_2 emissions has reinvigorated the search for clean energy generation around the world. Nuclear power has been present since the 1950's and research continued through the early 1970's in the United States until government funding was pulled due to lack of public support caused by major nuclear disasters. In the mid to late 1960's the Oak Ridge National Laboratory developed a next generation nuclear reactor using molten Lithium and Beryllium Fluoride salt (FLiBe) and Thorium bred into fissile Uranium fuel to generate energy. This design was chosen on account of its inherent safety measures and fuel efficiency and cost. Molten salt reactors are considered safe because of the impossibility of runaway reactions due to the fuel being contained within a liquid salt that can be quickly drained and the reaction stopped. A breeder reactor is also preferred since Thorium is four times as abundant as uranium, and an optimal breeder would provide a Uranium to Thorium ratio of over 1. Much of this proposed design is based on the work done by the researchers at ORNL to create a quarter scale 250 MWe nuclear power plant steppingstone to a full scale 1000 MWe power plant.

The chosen location for the plant is Winona, Minnesota because of its access to the Minnesota River, a large enough source of water to provide for the cooling tower. The nuclear reactor will require about 44.5 kg of thorium and 11.1 kg of uranium in molten FLiBe to maintain a stable critical reaction. This molten salt and fuel is then separated from the fission products and recycled to the reactor in order to decrease the amount of nuclear waste. Currently, a thorium molten salt breeder reactor is not an economically feasible project due to the high operation costs and relatively low market price of electricity.

CHE-3 1,4-Butanediol Production from Glucose Fermentation

Anna Buss, Jamie Connelly, Jonathan Schwenk, Mingwang Jiang
Dr. Michael Keane

The biologically derived production of 1,4 butanediol (BDO) occurs through E. Coli batch fermentation in the presence of oxygen. E. Coli cell culture is first grown in batch wise medium preparation with the addition of various salts, nutrients, water, and air. Following this, biological synthesis of BDO occurs by the conversion of 45,000 kg/hr glucose fed into 5 identical 922 m^3 fermenters at 37 °C and 1 atm. Purification of the resulting BDO product occurs through several continuous separation steps including centrifugation, ultrafiltration, nanofiltration, ion exchange chromatography, and distillation. This process leads to an expected BDO production of 69.2 kT/year of 99.6% purity.

Most solids of the fermenter effluent are removed continuously with centrifugation and filtration. Specialized equipment required for this process includes 2 ion-exchange chromatography columns, which are filled with appropriate cation and anion exchange resins to separate out dissociated salts. Sizing and pressure drop for filters and ion-exchange are based on hand calculations. The distillation columns produce liquid waste streams that flow at 63,300 kg/hr with 95.1% water and most of the fermentation byproducts. Other necessary separation units have been sized and configured to maximize BDO production rate and purity. Pressure and temperature conditions for all process streams have also been determined based on expected pressure drops across process units and temperatures needed to achieve adequate separations. All necessary compressors, pumps, and heat exchangers have been designed to achieve these conditions.

The plant will be in Lima, Ohio. Total annual profit associated with this process is $35.5 MM/yr, which is expected to be achieved by the fourth year after plant startup. This leads to a net present value after 20 years of plant operation of $72 MM and an IRR of 17%. As a result, this project is recommended to be pursued.

CHE-4 Re-Nyckel Neopentyl Glycol Production

Ranim Ferkh, Yena Kim, Emerald Smucker, Nickole Xenakes
Dr. John Speidel

A process to produce Neo-pentyl Glycol (NPG), a polymer used in the base of resin coatings, lubricants, and paints, was designed by the company Re-Nyckel and simulated virtually using ASPEN V-10. Two different commercialized methods for NPG production, a hydrogenation process and a Cannizzaro process, are currently used in industry and were considered by Re-Nyckel for this process design. The hydrogenation process was ultimately chosen for this design since the Cannizzaro method includes by-products with no financial value that are difficult to remove from the final product. The process begins with the reaction of Isobutyraldehyde and formaldehyde to form an intermediate product, which is hydrogenated and then purified to make the final NPG product. Raney-Nickel and Triethylamine are used throughout the process as catalysts to achieve a high production rate and purity of NPG. Mizushima, Japan was selected as the plant location due to its local resources and proximity to efficient transportation.

Following an economic feasibility study of this design using ASPEN, it is recommended that this project be considered for implementation and completion, since it is feasible and economically profitable. According to the study, beginning in the fifth year of estimated plant life, the discounted after-tax rate of return exceeds the hurdle rate of 12% at 21% and continues to increase to 38% in the year 2029. The total estimated capital cost is $1,863,000. In the fourth year of plant life, 100% production capacity is reached at 49.62 million lb/year and an estimated $169.7 million in revenue. After optimizing the process by including recycle streams for 5% of the catalyst triethylamine, the most expensive raw material price is reduced by $1.22 MMUSD per year. In addition, recycling water and octanol, assuming 2% loss, decreases the manufacturing cost from 130.7 MMUSD per year to 125.2 MMUSD per year at full plant capacity. Based on these results and recycle optimizations, Re-Nyckel's plant process is highly profitable.

CHE-5 Zero-Carbon Hydrogen Extraction Process from Depleted Oil Fields

Srinidi Badhrinathan, Daniel Chen, Kyla Gardiola, Pavel Beinarovich
Ed Andjeski

This project is an in-situ combustion process designed to recover hydrogen from underground reservoirs of heavy hydrocarbons, based on Proton Technologies' Hygienic Earth Energy process. The plant will be located a few miles outside of Kerrobert, Saskatchewan, at a depleted former oil field. The process involves pumping oxygen into a heated reservoir to drive a series of gasification reactions and produce a mixture of carbon oxides and hydrogen. A hydrogen-selective membrane is then utilized within the wells to enable recovery of the hydrogen while ensuring the carbon oxides and other syngas components remain underground, resulting in net zero-carbon operation. The 4 semi-cylindrical hydrogen separation membranes will be constructed from a palladium-copper alloy, which will cost approximately $\$1000/ft^2$, and hydrogen will diffuse through by means of a proton-electron recombination mechanism. A portion of the produced hydrogen will be used in on-site generators to power the equipment aboveground, ensuring that no carbon-intensive energy source is required. The plant is calculated to produce hydrogen at a rate of 17,000 lbs/day from an oxygen input of 400,000 lbs/day. The estimated required capital is $16 million USD; the annual cost of operating the plant was calculated to be around $6.5 million for the first two years, and $2.3 million afterwards. The discounted cash flow rate of return was calculated to be 9.99%. Finally, the selling cost of hydrogen was set at the competitive price of $2.5/lb H2 to help establish hydrogen as a commercially viable clean fuel. The feasibility analysis of this process showed that it is economically favorable due to the high demand for hydrogen, existing oil field infrastructure that can be repurposed, and the negligible cost of raw materials. Thus, it is recommended to move ahead with this project design once preliminary site surveys are conducted, and reservoir geography is determined to be suitable for this purpose.

CHE-6 CO_2 Free Production of Ethanol from Sugarcane Bagasse

Sidney Daniel, Crystal Jain, Manthan Patel, Nick Sternby
Dr. Nicolas Alvarez

The United States market for ethanol is versatile with uses ranging from fuel and gasoline additives to a primary solvent in the manufacturing of perfumes. Here, the production of fuel-grade bioethanol using a novel method that eliminates greenhouse gas byproducts is explored. A partnership will be established with Florida sugarcane mills as waste bagasse from this process will be shipped to the ethanol production plant as a raw material. Conventional bioethanol is produced from the fermentation of sugars, generating CO_2. To avoid direct CO_2 generation, our process utilizes 4 complex steps: 1) degradation of bagasse using steam explosion 2) anaerobic fermentation of sugars using a novel bacterial co-culture to produce acetic acid 3) esterification of acetic acid using reactive distillation to produce ethyl acetate, and 4) hydrogenolysis of ethyl acetate using a plug flow reactor packed with copper-zinc catalyst to yield ethanol. Product purity is specified by requirements for the commodity exchange of ethanol. The product is 99.9% ethanol by weight and the balance water and is achieved by distillation and molecular sieve separation.

The plant is expected to produce 144 MMlb/yr of ethanol by processing 447 MMlb/yr of dry bagasse. The capital cost is estimated to be $20.6 MM. Other costs include raw materials at $58.3 MM/yr and a utility cost of $25.8 MM/yr. Revenue from ethanol and byproducts totals $78 MM/yr. The net present value of the project is –$126 MM. However, the greenhouse gas emission from this process is estimated to be 0.571 kg CO_2-eq/L of ethanol, less than the 0.584 kg CO_2-eq/L of ethanol from conventional bioethanol production methods. Thus, sustainability is the main benefit of the novel process, and subsidies aimed to combat the global warming crisis by reducing greenhouse gas emissions could improve the economic viability of the project.

CHE-7 Isopropyl Alcohol from Acetone

Ariel Yeung, Yen La, Thuy Vo, Sim Shihmar
Dr. George Rowell

Isopropanol (IPA) is an isomer of propyl alcohol, volatile, colorless liquid with a sharp musty odor like rubbing alcohol, which will be produced in Mobile, Alabama utilizing the nearby acetone and hydrogen plant which will be feeding the raw materials directly into the plant. The IPA plant is projected to produce 2% of total global production, which is 108 MMlb/year of IPA with weight 99.9% purity level. IPA is effective as a disinfectant and antiseptic used in various industries, especially with the high demand for sanitizing solutions during COVID-19. With the average IPA price of $2.09/lb, the plant will generate approximately $225 million per year.

The process is built based on the US Patent by Air Products and Chemicals, Inc., as an effort to improve the production of isopropanol by the hydrogenation of acetone in the presence of Raney Cobalt catalyst. The single-pass conversion from acetone to IPA is 99.2% with catalyst loading of 2.7 MMlb/year and needs to be replaced in 12 months for catalyst purchased from Grace. The plant consists of three main units – CSTR reactor, flash drum, and distillation column – which allows the process to produce high purity products with little waste through acetone and hydrogen recycle streams. This has been optimized by changing the process from two reactors to one, and utilizing a safer catalyst, as opposed to Raney Nickel.

The capital investment cost is around 4.5 million dollars, and the fixed cost is at 13.5 million dollars. For a 20-year plant life, the internal rate of return is 21.06%, which exceeds the hurdle rate at 15%. The economics feasibility study concludes that it is profitable to invest in this IPA production plant in Mobile, Alabama.

CHE-8 Biosynthetic Palm Oil Production Facility

Goldy Cubacub, Geoffrey Du, Mei Fang Wang, Brian Yee
Dr. Michael Kain

Traditional palm oil production is an environmentally destructive process due to the resource demands associated with the crop cultivation. Palm plants require specific climate conditions to grow leading to deforestation of rainforests in tropical regions. This process explores manufacturing of a synthetic palm oil product produced through fermentation by yeast species *L. starkeyi*. Using the thin stillage waste stream from an adjacent ethanol fermentation facility as feedstock, this new plant seeks to reduce the environmental impact of palm cultivation and produces an oil product with a healthier lipid profile compared to existing consumer grade options. A new palm oil plant located in the Midwestern United States is designed with capacity to treat 484 million gallons of thin stillage per year, the waste produced by an average sized ethanol biofuel plant. This thin stillage waste stream composed primarily of water and organic compounds is purified and concentrated before being hydrolyzed by enzymes in the first reactor to convert polysaccharides into monomers for later fermentation. This hydrolyzed stillage is then fermented in the second reactor where palm oil fatty acids are produced and stored within the cell membranes of the yeast cells. The fermentation product stream undergoes sonication to rupture cells and release fatty acids into the liquid stream. Centrifugation and phase separation then isolate the palm oil compounds from the remaining material for packaging. Under 24/7 operation, this plant is expected to produce 10,734 lbs synthetic palm oil/year, an amount that would normally require 1.84 acres equivalence of deforestation for crop cultivation. Despite process optimizations, various reasons including reaction kinetics and commodity status of the product prevent the plant design from being economically feasible.

CHE-9 Production of Acrylic Acid from Glycerol

Hannah Sheibley, Noah Hecox, Zachary Hamilton, Mike Matteo
Dr. Steven Schon

In this report, the feasibility of producing acrylic acid in Banten, Indonesia is studied. The process differs from the industry standard method in that it uses an organic feedstock of glycerol and water. The final design consists of two reactions, two separation sequences, storage tank facilities, and a waste handling facility. The first section of the process consists of dehydrating glycerol to acrolein with a zeolite Socony mobil-5 (ZSM-5) catalyst. This process consists of a fluidized bed reactor, absorption column, and an air stripping column, producing acrolein. The second part of the process consists of oxidizing the acrolein feed to produce acrylic acid with a molybdenum vanadium mixed oxide catalyst ($MoVO_x$). This consists of a multitube packed bed reactor for the oxidation and an additional absorption column. The last section of the process involves refinement of the developed acrylic acid to its industry standard purity of 99.5 weight percent. This refinement uses two distillation columns and a liquid-liquid extraction column with a benzene solvent.

The annual acrylic acid production rate of the plant is 342 MM lb/yr. This is 2.5% of the 2020 global acrylic acid market share and is projected to be 1.6% of the 2024 market share. An IRR of 18% is given by a 20-year plant life with a full plant life depreciation schedule. Taken into consideration is a 25% corporate tax rate in Indonesia, as well as fixed costs, variable costs, and a 3% inflation rate. With these considerations, the project is profitable with a payback period of 4.5 years if economic factors remain stable. A drop in the current price of glycerol by 30% and rise of acrylic acid selling prices by 13.3% increase the IRR of the project to reach the hurdle rate of 25% for new technologies. The current prices fall below this hurdle rate making the project unadvisable compared to the traditional acrylic acid production process.

CHE-10 Agave Plant Advantages in Ethanol Production

Long Tran, Melanie Huot, Noor Al-Nazal, Jorge Camacho
Dr. Richard Cairncross

The production of fuel bioethanol is largely sourced from corn in the United States. In efforts to explore other feedstocks to diversify sourcing material, the production of ethanol from agave is modeled. Assuming a similar capacity to existing corn ethanol plants, a full capacity, industrial-scale plant is simulated, with a production rate of 653 million pounds of ethanol per year, requiring a yearly feedstock of 8 billion pounds of agave. Production will take place in the state of Texas, close to the US-Mexico border for the ease of agave shipment from Mexico.
Sugars in the agave juice are extracted through roll mills, and the juice stream is then sterilized using pasteurization method High Temperature Short Time, HTST, before entering the batch fermentation system, where yeast and nutrients are added to convert sugars to ethanol for a batch time of 16 hours. After separating the waste biomass from the water and ethanol exiting the fermenters through a centrifuge, the water and ethanol are sent to a distillation system. The first column removes water from ethanol to a purity of 93 wt.% ethanol, which is headed to the second column, an azeotropic column with benzene as the entrainer, to reach a final purity of 99.41 wt.% ethanol. The total cost of manufacturing, including raw material, labor, and utility costs, is projected to be $470 million. The capital cost of equipment and installation is $22.9 million. The projected discounted cash flow rate of return, DCFROR, is -154.28%, whereas the discounted cumulative cash flow is -$368 million per year. The production results in a net loss yearly. Avenues of optimization include alternative entrainers from benzene, such as heptane, and the sale of bagasse for fuel use. A sensitivity study is conducted on the price of agave per ton to explore potential to improve profitability.

CHE-11 Production of Ethylene Carbonate by Carbon Dioxide Sequestration

Ryan Light, Jesse Efymow, Gabe Canzanese, Conlan McHugh
Mr. David Kolesar

This novel process reacts captured sequestered stack gas carbon dioxide with ethylene oxide to produce ethylene carbonate. Ethylene carbonate is primarily used in lubricants and lithium-ion battery electrolyte solutions. The plant designed is projected to have a lifespan of 20 years and yield $379 million of product in net profit by the end of its lifespan. The entire project is predicted to require $14,324,330 in capital costs, $4,973,040 in yearly operation costs, and produce $65,550,000 per year of product. The location of the plant is Texas attached to or near an ethylene oxide

plant, which helps streamline the acquisition process for both ethylene oxide and flue gas from which carbon dioxide is captured from.

CHE-12 LDPE via a High-Pressure Tubular Reactor

Joey Martini, Phillip Choi, Nicholas Yaidoo, Peter Hahm
Dr. Michael Grady

This report is a financial assessment of the viability of a capital project aimed at producing 1,200 MM pounds of low-density polyethylene per annum. This volume represents 2.6% of the global annual production of this important commodity polymer. A process flowsheet with complete mass and energy balance based on an Aspen Polymer Plus flowsheet is presented. The process utilizes 4 plug flow reactors operating at 2000 bar with an ethylene recycle stream to generate product. The major pieces of equipment in the flowsheet are designed and sized including the reactors and the multi-stage compressors to bring ethylene to reactor pressure. Capital estimates of the major equipment are used in a factored project estimate as input to a full cash flow analysis. The total project capital was estimated at $1.3 Billion, total operating cost at $0.80/kg of product produced leading to a minimum selling price for the product at $4.90/kg to realize a 20% return on investment.

CHE-14 Substitute Natural Gas from Coal

Duy Bui, Thanh Pham, Kevin Radadia, Cameron Flanagan
Ed Andjeski

The goal of this project is to create a method for producing substitute natural gas (SNG) from coal implementing one step methanation located in West Virginia. The lack of oxygen throughout all our plant reactors is the main difference between our theoretical process and the current design of coal gasification processes running today. Typically, after an oxygen rich gasification process occurs the reactor product needs to go through a water gas shift to prime the gasses for methanation. With the removal of oxygen, the water gas shift is not required. This strategy provides a long-term supply of domestic energy since SNG is ultra-clean burning, suitable for future technological uses, and a massive pipeline distribution system already exists in the United States. Since coal is a plentiful natural resource in the United States, it provides a long-term supply of abundant energy.

All flows rates are on a basis of 10,000 lb/hr of coal input. Methyl Diethanolamine is our desulfurization catalyst while MCX-2R and PK-7R are our methanation catalysts. The product SNG after separations from carbon dioxide is expected to have 90.0% purity. The desulfurization catalyst will need to be replaced in full every 2 years and the methanation catalysts will need to be replaced every 5 years. The expected output of SNG is 76 million pounds per year. The upfront capital investment cost for equipment is $15,050,00 million and the installation costs are $5,310,100 million, bringing the total to $20,360,000 million. Assuming the plant operates for 20 years before stricter environmental restrictions and newer technology, the calculated rate of return is -15%. The SNG plant has a poor profitability index of 0.6, indicating that the plant should not be built.

CHE-15 Process Manufacture: Production of Magnesium Carbonate from Wastewater Brine

Alec Fagaly, Shreya Singh, Harshan Sivaraju
Dr. Aaron Fafarman

There is a strong global push to both reduce carbon dioxide emissions and efficiently utilize concentrated wastewater

produced by desalination plants. In this report, a plant is designed near the Mediterranean Sea, close to the Hedera desalination plant. Hedera incorporates wastewater brine from reverse osmosis plants and captures carbon dioxide from chemical plants to produce a monetizable product, magnesium carbonate. However, this plant produces a large amount of carbon dioxide during its operation, preventing the overall plant design from being carbon neutral.

The plant consists of an evaporative concentrator, 4 crystallizers, 2 screw bed reactors, and a scrubber producing gypsum, Glauber's salt, and sodium chloride, as by-products and magnesium carbonate. The aqueous hydrogen chloride produced in the plant is purified in a scrubber, recycled, and inputted into the evaporative concentrator.

This plant produces 59,000 kg of magnesium carbonate annually and uses 35,000,000 kg of seawater and 85,000 kg of carbon dioxide. It also has an annual production of the following by-products: 22,600 kg of gypsum, 557,000 kg of sodium chloride and 25,500 kg of Glauber's salt. The plant produces 1,275,000 kg of carbon dioxide annually, preventing the overall plant design from being carbon neutral.

This plant produces its major revenue by using wastewater brine ($18.9 million per year) and selling sodium chloride ($6 million per year). The plant is projected to reach 100% operation in the fifth year of plant life and has a capital cost of $55.3 million and an annual cost of $18.4 million. The Net Present Value (NPV) is $ 8.1 million with a discounted cash flow rate of return (DCFROR) of 7.28%. Even though the NPV indicates a profit, as this DCFROR is not above the standard hurdle rate of 25% for the plant, this project at its current conditions is not considered economically feasible and hence, not a safe investment. However, considering the significant environmental benefits that this project yields, this project can still be pursued. If either the total capital cost decreases to about $10 million, the plant capacity of magnesium carbonate production increases to about 40 kg/hour, or the price per kilogram for one of the revenue-generating compounds changes, such as the selling price of magnesium carbonate increasing to $80 per kilogram, then this project can be feasible.

CHE-16 Production of Caprolactam from Benzene

Jianqiao Song, Pagnaa Attah Nantogmah, Jassa Sengha, Colin Brady
Dr. Steven Schon

The goal of this project is to conceptualize a process plant in Jakarta, Indonesia with the aim of producing 50,000 US tons per year of the monomer to Nylon, ε-caprolactam. The motivation behind this project was to capture the emerging market for caprolactam in Asia and more specifically, Indonesia. The production begins from benzene and undergoes five reactions and one neutralization to achieve the final product.

Numerous production pathways were considered. It was decided to use benzene as the feed material as opposed to intermediates such cyclohexane and cyclohexanone, due to benzene being readily available from refineries. The chosen process scheme involves the hydrogenation of benzene into cyclohexane, followed by the air oxidation of cyclohexane into cyclohexyl hydroperoxide (CHHP), the caustic decomposition of CHHP into cyclohexanone, the ammoximation of cyclohexanone into cyclohexanone oxime, and the acid-induced Beckmann rearrangement of the oxime into the neutralization to ε-caprolactam. A significant potential for improvement lies in finding a more efficient oxidation method, which currently requires four reactors and multiple separations.

The project has an estimated total capital cost of $51,075,300, with yearly operating, raw material and utilities costs of $237,026,000, $182,934,000 and $32,827,200, respectively. With an estimated products sales of $201,593,000 per year, the Net Present Value (NPV) is $41.29MM and the DCFROR 250% after 20 years with a payback period of 8 years. It is not recommended to proceed with this project in its current state, as investment costs far exceed the NPV of the plant. However, the project has potential to be lucrative with further research and optimization.

CHE-17 Solar Desalination and Power Production Using a Power Tower

Chance Szabo, Ian Leap, Josh Shoulder, Duaa Saleh

Dr. Jason Baxter

Green power and purified water will be produced at a power tower station located in Ecuador. Power tower stations are the greenest method of producing electricity and could prove to promise a brighter future for the world. Seawater will be pumped from approximately 9.94 mi away to the power tower set up nearby San Antonio, Ecuador. Power towers use concentrated solar energy to heat a molten salt that flows around the tower, acting as a heat transfer fluid. The concentrated solar energy is harnessed using a large field (around 1.2 million m^2) of mirrors to reflect the sun's rays up to a main receiver that the molten salt runs through. The molten salt runs through heat exchangers which allow it to pass by a stream with seawater. The seawater is heated and turned to steam. The steam is then superheated and sent to spin a turbine, allowing for electricity to be made. The steam is recondensed and treated for drinking. The leftover brine from the seawater is sent away for use by another plant. Ecuador has a demand for clean drinking water, as the country's current tap water system is unsafe for consumption. Ecuador also has a reliable amount of sunlight that can be used by the power tower station that will be set up. This process is set to generate a gross amount of power 466,439,340 kWh, 267,109,920 lbs of salt, and 5,900,000,000 lbs of water per year. The main sources of revenue – in order from most revenue to least revenue – from this plant will be drinkable water, electricity, and sea salt. The respective revenue from each product over a ten-year period is as follows: drinkable water, $508,097,986, electricity, $50,427,499, sea salt, $7,024,991. The operating cost of the plant has a fixed cost per year of $15,509,188 and a variable cost per year of $71,700. The electricity and drinking water could greatly impact the people who live in Ecuador, given their hardships when it comes to water and electricity.

CHE-18 Landfill Gas Clean-Up and Conversion to Dimethyl Ether

Quader Moore-Robinson, Sam Shar, Kevin Huang, Inesse Hanna
Dr. George Rowell

Dimethyl Ether (DME) is a sustainable fuel that can be produced using landfill gas (LFG). DME is considered an alternative to current fuel options, such as gasoline and diesel fuel, because it emits little to no greenhouse gases when burned. This chemical process aims to use the methane from the landfill emissions and convert it into fuel grade DME. The overall goal of this project will be a sustainability effort to reduce greenhouse emissions while creating an alternative energy source.

The chosen plant site is Modern Landfill in York, PA. From the wellheads at this landfill, the LFG is pumped through a methane purification system to remove sulfides, nitrogen, and carbon dioxide. This technology is outsourced to GAS RNG, a third-party company that specializes in LFG purification. The capital cost from design to installation is estimated at $55 million.

The next step is to convert the methane into synthesis gas (syngas) using a fluid bed reactor with an $FeTiO_3$ catalyst that also carries the oxygen needed for the reaction. This prevents any hazards associated with oxygen mixing. The effluent is separated using a cyclone where the spent catalyst can be sent to a regeneration unit so it can be used again.

The syngas is then fed into a packed tubular reactor under high pressures to create methanol. This process uses a Cu/ZnO/Al catalyst. The effluent is separated using a tank separator and a flash column. Methanol is finally fed into the packed bed DME reactor. The effluent is purified for 98.5% of DME using two distillation columns. The optimized process uses a singular divided wall column with the effluent already separated.

Using the methods described in the report, this plant can produce 6,485 lbs/hr of DME with an LFG flow rate of 7.219 mmscfd. With the current price for DME being $0.61 per kg, the process generates $15,216,369 per year.

The total capital cost of this process is $88 million. The annual utility cost is approximately $3 million and operation cost is $4 million. With this in consideration, it is not economically feasible to create DME from LFG although it is a more sustainable process than allowing LFG to become greenhouse emission. This project would require substantial government subsidies to proceed.

CHE-19 Production of Lithium from Lepidolite

Josh Demboski, Alex Turano, Connor Kulczytzky, William Aniagoh
Dr. Maureen Tang

The purpose of this process is to extract lithium from the ore lepidolite as an alternative to spodumene. As such, the process for extracting lithium from lepidolite draws from knowledge obtained and used in the processing of spodumene. Lithium is extracted from spodumene through what is known as the "traditional process," where spodumene is roasted with sulfuric acid to extract it from the ore then converted into lithium carbonate as the final product. Initial lepidolite processes explored included sulfuric acid roasting in combination with vanadium pentoxide for flue gas recovery as well as roasting with the additives iron sulfide (FeS) and calcium oxide (CaO) to liberate sulfur trioxide and prevent the production of hazardous hydrogen fluoride as a byproduct respectively. The chosen process employs the use of CaO and FeS additives in roasting, a water leaching system, and the addition of an evaporator and carbonation step before precipitation to convert the initial lithium products (LiKSO4 and Li2SO4) into the more desirable and economical product lithium carbonate (LiCO3).

The plant is grass roots and located in Sonora, Mexico due to proximity rail transportation and the largest known lithium project in the world. The plant aims to produce 1% of the world's total production of lithium or 1.12 MMlbs/yr. This is achieved by converting a feed of 87.41 MMlbs/yr lepidolite into 6.32 MMlbs/yr of lithium carbonate. The estimated cost of manufacturing with depreciation is $122 million. The raw material profit runs at a deficit of $33.4 million per year and the discounted NPV after 15 years of plant life is negative $528.62 million dollars. With the hurdle rate set at 12% and the rate of return at –99.43% the confident recommendation is that money is better spent elsewhere and that this plant should not be put into production until vast economic optimization occurs.

CMGT-1 Affordable Housing Project in West Philadelphia

Jacob Hornung, Jon Kaufman, Keanu Brewster, Juan Hillinger, Anaelle Charlot
Dr. Christine Fiori

West Philadelphia is a diverse area of the city with local families and college students living side by side. However, as the college campuses continue to gentrify the area, many families are forced out into the surrounding neighborhoods by the rising property values. The city poverty rate is 26.5% whereas, in West Philadelphia, the poverty rate is 50.8% showing the drastic need for affordable housing in the area. The goal of the project is to create affordable housing for this community with a focus on providing housing to families and individuals making $30,000 or less a year. The project seeks to fund the housing through the utilization of different government organizations and private investors to ensure affordability. The project also aims to break the traditional affordable housing complex stereotype. Generally, affordable housing complexes only allocate a percentage of the units as affordable, however, this project aims to have all the units be classified as affordable housing units. As West Philadelphia continues to gentrify, much of the existing affordable housing is being replaced by student housing. This project seeks to provide much-needed affordable housing to Belmont and Mantua.

CMGT-2 Innovative Technological Facility

Joe Rooney, Robert Hogrefe, Dean Peck, Sam Mediavilla
Dr. Christine Fiori

The construction industry is one of the largest industries yet, it fails to implement the newest technology. The industry continues to stick to its known methods despite new tech improving construction activities massively. Our solution is

to partner with Drexel to design the building and business plan for the Innovative Technological Facility. Led by Drexel's Construction Management program and in partnership with local contractors, we plan to research, train and expand on construction technology. The space will consist of computer laboratories for software training, lecture areas for scheduled courses, a sandbox space for hands-on field training and our "What's New Workshop". Currently, Drexel has no permanent area for its CMGT students. We feel this facility will be a perfect headquarters for the growing major at Drexel and connecting them with industry professionals, as well as improve construction in the region. Not only will Drexel students be able to utilize the space, but classes will also be offered for safety certifications and licenses required in the field and industry people can come to learn as well. Companies will also have the opportunity to showcase their new products and hold hands on seminars for direct advertising and marketing benefits. Successful completion of this facility will provide Drexel students, the administration and construction professionals alike a place to share ideas and maintain solid connections. Teaching people how to utilize technology effectively, efficiently and safely will help this industry progress into the future.

CMGT-3 Renovation to Net-Zero

John Card, Joseph Lapinson, Tara Marrongelli, and Christopher Vokes
Dr. Christine M. Fiori

There is more and more waste being produced and energy being consumed than ever before. Construction is typically stereotyped and generalized as ground up construction. Renovations and salvaging existing building structures is not the first solution that comes to mind. However, by renovating an existing home, one is able to salvage the substructure and superstructure of the building which would reduce the carbon footprint of construction by nearly 70%. Our focus is to create an innovative guide, blueprint, to convert existing structures to net-zero energy consumption. A house in Cherry Hill, NJ, representative of the typical suburban single-family house in the area, will be utilized to form the basis of our research and testing. A net-zero home is a balance between energy needed for the building and renewable energy sources that are producing energy onsite. A home energy audit will provide you with the crucial information that is necessary to quantify energy usages. This audit established the home baseline to compare renovation options. Since affordability plays a large aspect of the final decision when it comes to upgrades, payback periods were calculated. While the idea at large sounds like the environmentally, financially, and morally thing to do, most system payback periods are longer than the time period that the average United States citizen owns a home for. Strictly from the financial standpoint, lighting is the only system upgrade that would save the homeowner money while conserving energy consumption within a reasonable time frame.

CMGT-4 Construction Technology Laboratory

Ankit Avichal, Jason Calabria, Alex Criswell, Nick Fredericks, & Ernest Sciulli
Dr. Christine Fiori

In recent years, the Drexel Construction Management Program has been moving from facility to facility on campus due to the needs of Drexel University. Currently, the program is in the University Crossings building on a single floor and its director, Dr. Christine Fiori, is on an entirely different floor due to the space constraints in the space given by the university. While the rest of the program's faculty are connected well to the classroom's, there is still not enough space and resources to conduct all the classes on the floor. To address this, Summit Construction has proposed a building design, budget/estimate, schedule, and location to accommodate the needs of the Construction Management Program. The needs and desires of the current faculty, student body, and the surrounding West Philadelphia community have been taken into consideration. Many features and amenities ranging from a large demonstration space to an in-house recreation center have been included in the design. It is with this building that the Drexel Construction Management Program shall finally gain stability and a new home. While gaining the space it needs to expand its outreach to new students exploring the possibility of a career in the construction industry.

CMGT-5 Spring Garden Street Bridge Replacement Project

Abdelrahman Ali, Jacob Birgen, Daniel Dolliver, Andy Houston, Steven Volpe Jr
Dr. Christine Fiori

The Spring Garden Street Bridge replacement is a construction project that poses many challenges to both designers and constructors. The Spring Garden Street Bridge is a bridge that connects one of Philadelphia's major highways (I-76) to West Philadelphia and Center City as well as providing a path of travel between West Philadelphia and Center City for the nearby communities. This bridge is in dire need of repair to ensure safe travel for all and no longer structurally deficient. The challenges that this project poses are completing work through the obstructions of working over the Schuylkill River, working over I-76, and working over several railway lines. To face these challenges, the project was segmented into several phases with comprehensive traffic control plans to go along with each phase. Detailed schedules, safety plans, demolition plans, construction plans, and more for this project were also developed throughout the time working on it. It is vital that coordination with all agencies that would be involved in the project is established well before the project begins so that this project can be delivered in a safe, efficient, and economical manner.

ECE-01 Medical IoT – AIRwAI

Rohan Patel, Sima Noorani, Christina Strobel, Reilly Shaffer
Dr. Kapil Dandekar and Malvin Nkomo

Currently, ventilators are an essential part of treatment for patients who are unable to breathe on their own. Ventilators are often interfaced to the patient via a mask or an intubated tube that is inserted into the trachea. The ventilator's breathing cycle is initiated by detecting breath, known as triggering. When adult patients initiate a breath, modern ventilators detect changes in air flow or air pressure through sensors located in the intubated tube to trigger ventilation. However, in neonatal, or newborn, patients inserting an endotracheal tube is associated with higher risks of developing chronic lung disease. The standard methods of detection such as air flow or pressure sensing are ineffective in non-invasive ventilation such as nasal intermittent positive pressure ventilation (NIPPV). Noninvasive triggering methods do already exist, such as the Graseby Capsule used on the InfantStar 950 ventilator, but they rely on a cumbersome number of tubes and electrical sensors. This paper will discuss a novel, wireless, and non-invasive method of triggering to improve neonatal patient-ventilator synchronicity. An open-source emergency ventilator was constructed, and a custom microprocessor-based controller was developed to drive the ventilator. We will be utilizing the Drexel University developed IoT (Internet of Things) platform, VarIoT, and a fabric-based RFID (Radio Frequency Identification) antenna to track respiratory behavior and transmit information to a predictive algorithm. The final ventilator system can send as well as receive information through the IoT.

ECE-02 Raspberry Pi Nuclear Reactor Simulator

Joey Arnold, Tristan Marshall, Matthew Czerwinski, Casey Adams
Dr. Christopher Peters

Nuclear power generation will play a key role in inhibiting the steady growth of carbon emissions in the upcoming years. With the recent advancements made in the nuclear industry such as the development of Small Modulator Reactors (SMRs) nuclear power is starting to receive more attention world-wide. With this resurgence of interest in nuclear power, it is essential to be able to educate students and non-nuclear reactor operator employees on the functionality of a nuclear reactor. This will ensure that those involved with the topic have a thorough understanding. Currently, educators use software to show the effects of a nuclear reactor, and the primary hardware models are costly,

complex, and reserved for training personnel directly involved with nuclear reactor operations. While this software-based approach does manage to help educate, the lack of physical systems can inhibit certain concepts from being understood completely. The proposed method enables a more immersive and accessible learning atmosphere by incorporating a combined hardware and software model to create a nuclear reactor simulation program. The software models a homogenous cylindrical Pressure Water Reactor (PWR). This system is set up to be used remotely or locally with a Raspberry Pi and an Arduino, allowing the user to log-in to the simulation program hosted on a web browser GUI called Node-RED and control the software and hardware functionalities of the reactor.

ECE-03 Classifying Patents and Automated Routing

Jonathan Yu, Jordan Franklin, Catherine Nguyen, William Stewart, Connor Strohecker,
Dr. John Walsh

Every patent application arriving at the United States Patent and Trademark Office (USPTO) must be classified into a subject category within the Cooperative Patent Classification (CPC) system. Patents are assigned to a maximum of 13 classifications selected from more than 250,000 possible classifications. Presently, classification assignment is a multi-step process where USPTO subcontractors make an initial recommendation that gets either changed or confirmed by USPTO examiners. This subject classification assignment ensures that the patent is routed to an examiner with extensive experience in that specific subject. However, this process is labor intensive. It is not only expensive, but also has poor scalability, which degrades results as patent applications increase. The USPTO could improve its patent examination quality and speed if the classification process was improved to become more economical and scalable. Our patent classification software aims to improve classification speed and reduce cost through automation. Our system leverages state-of-the-art Natural Language Processing, text recognition machine learning models, and other techniques to match classifications to patents and route patents to examiners. Our approach addresses issues such as a patent having more than one classification and is flexible enough to update with the changing CPC schema. With the help of an extensive database, these predicted classifications can then be leveraged to recommend the best examiners based on user-configurable criteria. Authenticated users can use both algorithms delivered through the web; each interaction is logged for performance tracking.

ECE-04 Plagiarism Detection and Deterrence System

Simon Cohen, Abhishek Kumar, Michael Martin, Chance Shipley
Dr. Andrew Cohen

Plagiarism in introductory programming courses is one of the biggest problems facing universities. Existing tools can identify cases of high confidence plagiarism through a variety of sophisticated machine learning processes. By identifying such cases, course instructors are alleviated of the pressure to manually seek out students who may be plagiarizing. However, currently available tools are inadequate for addressing the full scope of the issue. The similarity detection between student submissions typically produces arbitrary scores, which make the results difficult to interpret. Additionally, the results fail to consider the social nature of the problem; students tend to plagiarize within the same cohort repeatedly. Finally, existing tools fail to proactively deter plagiarism and instead serve as a reactive solution for punishing students. These shortcomings warrant the development of a preventative model that can detect low-confidence plagiarism and intervene earlier than previously possible. This study demonstrates a plagiarism detection and deterrence system to monitor student-cohort behavior and actively discourage the act of cheating in introductory programming courses. The model uses pairwise, compression-based similarity detection to capture relationships more accurately. An automated deterrence system is used to warn students that their behavior is being closely monitored. High confidence instances are displayed on a secure, online dashboard for instructor review. An unbiased scoring system aids students and the instructor in understanding true independence of effort. Preliminary results indicate that the system can provide meaningful measurements of independence from week one, improving the efficacy of technical

education.

ECE-05 Campus-Scale Internet of Things

Har Patel, Matt Rantz, Kyle Russo, Saem Jeon
Dr. Kapil Dandekar, Dr. William Mongan (Ursinus College), and Dr. Malvin M. Nkomo

The Internet of Things (IoT) describes networks of sensors and software designed to share data amongst each other, applicable across several domains including health, environmental studies, and even home life. Within these networks, gateways serve as access points for sensors to connect to a larger network and send information to a centralized location. There are various gateways available in the market today. However, many of these tend to be centered around protocol- or application-specific use cases without flexibility to expand the infrastructure. To use a new gateway for each use-case is costly and introduces technical hurdles many of those interested in IoT may not be well-equipped to overcome. The motivation for Campus-Scale IoT is to develop a multimodal infrastructure that is easily accessible across campus regardless of technical background. Many off-the-shelf commercial sensors will be able to connect to this gateway across a diverse set of protocols. The hardware component of the solution is a printed circuit board gateway, while the software primarily consists of an open-source IoT platform, ThingsBoard, and a Flask website. The Flask website helps users easily connect their devices via a form. Once a device is connected, users will be able to visualize the device data on ThingsBoard. Currently, data from multiple BLE, WiFi, LoRa, and ZigBee devices communicate via a gateway with ThingsBoard where data is successfully visualized in real-time. Data can be retrieved and manipulated via APIs and rule chains, and other groups have begun successfully integrating their projects with this one.

ECE-06 Autonomous Multi-Seasonal Landscaping Robot

Brandon Hall, Isaac Hong, Stephen Johnson, Cody Liu, Michael Livornese
Dr. David Han

By eliminating the need for both a snowblower and lawnmower, customers will save money and storage space. It will also improve the lives of our stakeholders by reducing the amount of time they need to spend caring for their driveway and lawn. The robot will be able to successfully mow a lawn autonomously and have the capability to swap to a snowblowing system that can successfully clear a driveway on its own. There are two main challenges our team will face. The first challenge is developing a swappable system for the robot that allows it to change from one mode of operation to another. The second challenge is getting the robot to autonomously recognize its workspace and stay within defined boundaries. Our solution to the first problem involves developing mower blades that can be swapped out of the machine for snowblower auger blades and turbine setup. For the second challenge, the team intends to modify the code of an already existing system, like Roomba, or other open-source libraries in order to stay within the workspace and avoid obstacles. Our design shows and reflects a missing and potential industry for a low-cost autonomous multi-seasonal landscaping robot.

ECE-08 Medical Delivery Drone

Brendan Higgins, Tri Pham, Jordan Lanzoni, Manh Cuong Phi, Binh Tran
Dr. Adam Fontecchio

Recent advances in robotics have made it possible to deliver packages with small autonomous drones. Over the past 5 years, companies like Amazon have been rushing to develop such drones that can deliver packages ordered online

in a timely manner without any human interaction required. Most of these companies are still in the development phase, while a few have an initial product released. Due to advancements in drone technology being so recent, there are still many possible applications in other fields that have been overlooked. One such field with little drone implementation is the domain of medicine. The idea is to overcome the delays and inefficiency of traditional ground delivery by using the sky as a medium for transport. Our team has outfitted a drone with automatic navigation and onboard flight sensors to send it to its destination via GPS signals while avoiding obstacles while in transit. It is also equipped with a carrying compartment to store and deliver life-saving medicines quickly and efficiently. While existing medical programs like Telehealth allow for wireless diagnoses and medical aid through a computer screen, remote patients not having physical access to emergency medical supplies or sample collection for further diagnoses is still a major constraint. With the development of our delivery drone, life-saving medications and treatments can be delivered fast and directly to the sick without the limitations of ground transportation infrastructure.

ECE-09 ROVRR: Remotely Operated Virtual Reality Robot

Bernard Morelos, Ryan Bergauer, Akshat Pokharna, Violeta DeSantis
Dr. John Walsh

Since the beginning of the 20th century, the world has gotten smaller and smaller with the help of technology. However, despite this closeness, the pandemic has made people more isolated than ever before as traveling and attending large gatherings are still high-risk situations. Many people ultimately desire to congregate at social gatherings and events without worrying about the risk of contracting illnesses. ROVRR aims to satisfy this desire by allowing people to remotely attend events and gatherings through the utilization of VR. Users will be fully immersed in a photogrammetry rendering of the event with multiple sources of live data streaming to them from a physical robot attending the event. So far, we've successfully created photogrammetry renderings of relevant areas within the school and of the area we expect to present the prototype. We've also successfully integrated a virtual rendering of the robot that is controllable by the VR user. We've streamed live video into VR and established a Mumble voice communications server. Our next steps are linking the virtual robot to the physical robot for accurate movement representation, and mounting an iPhone to the robot which will stream live LIDAR data. The rapid expansion of the VR market indicates that this realm will continue to grow into other sectors such as business and entertainment. This project will aid in this expansion by collecting live real-world data from gatherings and streaming it back to the safety of a VR environment for users to interact with and enjoy.

ECE-10 Using HTCondor to Scavenge CPU Cycles from Lab Resources

Sameh Abedin, Fiona Sarno, Joseph Stewart
Mr. Andrew Marx and Dr. Gail Rosen

Modern research is highly dependent on computing power whether it be to record data, run simulations, or analyze data automatically. Many research groups outsource this computation to third-party resources where the servers and architecture are maintained for them such as with Amazon Web Services (AWS). For underfunded or unfunded research projects, this outsourcing is not a realistic option. A better option for Drexel's researchers would be to utilize the unused computing power already available on the campus machines. Currently, Drexel's ECE and MEM departments have over 100 machines available to faculty, staff, and students at any given time. These machines spend the majority of their time powered on without actively being used. Instead, these machines sit idle wasting CPU cycles. Our project seeks to use these cycles for High Throughput Computing (HTC). Our project strives to accomplish two goals. First, to provide a resource for Drexel students and faculty to solve any kind embarrassingly parallel problem they might encounter through HTC. Second, to utilize the wasted CPU cycles of the idle machines in the College of Engineering computer labs at minimal extra cost. To accomplish these goals, we have elected to use HTCondor, a job scheduler that specializes in scavenging CPU cycles from idle machines for HTC. As of now, we have successfully implemented HTCondor on a small pool of computers. Further, we have shown results in applications such as: Basic

Local Alignment Search Tool (BLAST), python, and MATLAB. As this project continues beyond our tenure, we expect a focus on the security and usability of this new resource.

ECE-11 THRIVE

Katayoun Hazaveh, Neil Patel, Richard Scott, Tobenna Oduah
Dr. Gail Rosen

Plant-growth chambers are designed to produce environmental conditions that maximize plant growth. Such technology has inspired urban farmers to increase self-reliance to grow accessible and sustainable food. Unfortunately, despite the initial attempts of individual urbanites to develop their horticultural methods, there seems to be a complete lack of community and resources for urban agriculture.

Previous prototypes of urban growth chambers lag behind the current technology and fail to utilize community-driven analytics. This problem could be improved by developing a better performing controlled environment system that utilizes state-of-the-art plant characterization and introduces data networking.

THRIVE's objective is to use unified open-source, IoT, AI, and 3E (Emulated Earth Environment) based solutions to provide a unique framework that allows for crowd-sourced data to help control individual plant growth environments. THRIVE will bridge the divide between laggard technology and lack of resources in urban farming by presenting an integrated solution and network architecture that allows an ecosystem for multiple controlled-environment instances to collaborate and share phenotypic data.

The project features a microcontroller and climate sensors that are readily available. The software includes contemporary machine learning approaches as a recommendation system to provide context of the plant's health, which enables the user to adjust the control parameters of the 3E. A cloud-based multitenant transfer and storage serves as the backend of the network infrastructure which goes along with the state-of-the-art user interface component created to make the interactive process between the user and the assembled 3E easier.

The system will serve to foster community-driven analytics for urban food production and will serve as inspiration for better plant growth chamber design.

ECE-12 Optimizing Power Distribution System Reliability with Inverter-Connected Distributed Energy Resources (DER)

Devin Thurber, Jake Ward, Renat Ramazanov, Forrest Leffer
Dr. Karen Miu

The power distribution grid traditionally supplies power radially from a centralized power source to customer locations demanding power. Currently, there is an increase in Distributed Energy Resources (DERs) penetrating the power distribution grid in the form of grid tied solar, wind, diesel, and battery sources. One area of research being studied is what occurs during power loss due to a fault in the grid, like downed power lines. Usually there is a loss of power until the connection is restored. DERs presently installed can potentially supply power when connections to the centralized source is unavailable.

Generation between residential and commercial establishments can network to power more than just themselves. Providing power to these establishments that normally would have been out of power decreases the customer average interruption duration index (CAIDI) - an important reliability metric. This scenario is referred to as an Island - a live circuit that is disconnected from central generation. IEEE Standard 1547-2018 has strict requirements involving Islands and whether they can be formed.

This project seeks to present possibilities of using DERs to supply multiple loads in an islanded circuit. The project will produce repeatable Drexel power laboratory experiments using controllable sources/loads and software to further this research. Techniques of inverter controls and switch placement are explored to balance the demands with the generation of the island.

The team has been researching various equipment used in the experiment including Yokogawa Power Analyzer, Chroma AC Loads, and Chroma AC Sources to accurately emulate real power island scenarios.

ECE-13 LBPAlert - Wearable for Low Back Pain Risk

Bunmi Oluwatudimu, David Ajibade, Ekenedilichukwu Illoh, Kathrina Waugh, Kweku Aboagye
Dr. John Walsh

Low Back Pain (LBP) is one of the most prevalent musculoskeletal disorders. Four out of five people will experience some variation of LBP in their lives which can have a profound impact on their quality of life due to its associated physical and economic burdens. Although there has been a plethora of research efforts towards pain and its association with fatigue as well as health-care resources devoted towards diagnosing LBP, these efforts are hindered by their lack of accuracy and convenience due to their invasiveness. LBPAlert combines novel non-intrusive sensors, an advanced cloud-based machine learning framework, and a cross-platform software application to sense, predict and alert an individual of their risk to low back pain in a highly accurate and convenient manner. LBPAlert presents itself as an early predictive solution in the form of a wearable with the potential to reduce the steady growing population of LBP patients.

Non-invasive sensors such as Surface Electromyography (sEMG) sensors record muscle activity based on biopotentials, and Inertial (IMU) sensors - Accelerometer, Gyroscope and Magnetometer - record the body's relative position and track motion. The sensor data is streamlined to a cloud-based machine learning model which makes a real-time numeric prediction within the 11 point Numeric Pain Rating Scale where 0 represents no pain and 10 represents extreme pain. The numeric prediction along with consolidated low back muscle data is communicated to an iOS or Android based application - giving users their health data in the palm of their hands.

ECE-14 Frame-Mounted Bike Safety System for Vehicle and Road Hazard Detection

Pankil Chauhan, Isaac Deerwester, Cory Spiner
Dr. David Han

Cycling is a popular form of transportation and leisure, but the inherent dangers of sharing the road with much larger and faster vehicles pose a threat to riders' safety. Even with significantly decreased vehicle traffic due to the COVID-19 pandemic, 675 cyclists were killed in accidents in 2020 compared to 712 fatal vehicle crashes in 2019. A cyclist's rear blind spot is a gap that raises concern, especially for hearing-impaired cyclists and the growing popularity of quieter electric vehicles. Devices on the market today that seek to address this issue often struggle to perform well in busier cities due to difficulty distinguishing real incoming hazards from false positives such as parked cars. They also require the rider to divert their attention from the road. We propose a rear-view, frame-mounted device that will communicate with a helmet-mounted heads-up display to relay hazards detected by a camera module. Together, the two devices will augment and enhance riders' awareness by indicating when there is a vehicle approaching from their blind spot on either side without the need to take their eyes off the road. The camera-based approach, utilizing machine learning, will create a more reliable system capable of far greater awareness than the radar-based systems in use today. To test and demonstrate the system, physical prototypes of the system components, along with functional software, are created, mounted, and tested. The performance is measured by quantifying and evaluating the number, reliability, and quality of hazard detections along with the warnings subsequently triggered by them.

ECE-15 Off-Grid Electrically Heated Suit

Madeline Harmes, Ben Siti, Michael Bonacquisti
Dr. Kevin Scoles

Enjoying outdoor winter activities in much of the United States is difficult or unrealistic due to the freezing temperatures. Winter sports such as skiing or snowboarding thrive in the cold weather. However, other activities like hunting and hiking become uncomfortable on the body and potentially dangerous if exposed to freezing weather for too long. A variety of battery-heated clothes have been created to combat freezing weather, such as: vests, gloves, and boots. All these products fall short for two reasons: the garments do not heat the entire body and there is no option to recharge the battery from a remote location. Staying warm and safe is especially important in a freezing, remote location. There is one battery-heated product that encompasses the entire body; however, it is more similar to a sleeping bag and does not allow for mobility. To solve this issue, a full-body electrically heated suit has been designed. The heat suit can be charged by a wall outlet or by an included solar panel. A full-body electrically heated suit with a remote charging option solves all the problems listed above. This product will allow people to safely enjoy their favorite outdoor activities even in freezing conditions. Suit temperature can be adjusted with the control belt on the suit. The battery can be recharged whenever the user is stationary and wherever there is sun.

ECE-16 Reducing the Latency of Millimeter Wave in 5G Cellular Communication

Davis Ranney, Emil Snyman, Jamie Wu, Kevin Yu, Md Abu Saleh Tajin, Kyei Anim
Dr. Kapil Dandekar

Millimeter Wave (mmWave) is becoming the new standard for high-speed 5G cellular communications. It can deliver gigabit speeds and low latency streaming and handle massive deployments of receivers. One of the inherent drawbacks for mmWave is that antennas need to radiate the wireless signal directly at the receiver, and these beams are very narrow to overcome path loss and signal attenuation. Antennas must search through many beam-states to identify the receiver's direction which drastically affects the latency of mmWave communications. Several solutions have been proposed, such as applying deep learning, to reduce the search time or space. For increased reliability, sub-6 GHz antennas are often deployed in conjunction with mmWave antennas. With a sub-6 GHz antenna capable of beamforming, it can inform a mmWave antenna of an approximate direction of a receiver. The approximation can be estimated more quickly because sub-6 GHz beams are wider than mmWave beams and thus have fewer states to search through. Together, sub-6 GHz and mmWave antennas can swiftly identify optimal beams and reduce the latency of 5G communication. Previous research has validated that this concept works by manually steering the mmWave antenna. We have designed a solution to automate steering of the mmWave antenna and implemented an intelligent algorithm to control the antennas by predicting the Angle of Arrival (AoA) based on Received Signal Strength Indicators (RSSI). We can compare this system with other search algorithms and quantify the reduction in latency that commercial systems should experience if they deploy a similar strategy.

ECE-17 Hyperspectral Imaging Drone System

Francis Franco, Mansoor Khan, Fredy Sanchez, Jeffrey Tharakan, Alan Zhou
Dr. Adam Fontecchio

Crop production experiences numerous drawbacks, each requiring improvements in technology to increase efficiency.

Hyperspectral imaging, a newer technology involving the measurement of light from pictures taken at narrow spectral bands in a contiguous spectral range, is used to characterize large spectrums of biological, chemical crop traits, and soil by analyzing the reflective properties over its spectral band's range. Through this technology, several parameters such as soil classification and weather can be done quite easily, making it functionally better than spectral imaging. Hyperspectral imaging has been successfully employed in a variety of remote sensing applications that requires the calculation of physical parameters of many complex surfaces. It also identifies visually similar materials with fine spectral fingerprints due to these characteristics. Plant diseases, soil erosion, weeds, crop identification, are factors that have derailed crop production. These processes can help in improving the efficiency of production to meet ever-rising agricultural demands. Drones in use can be improved, incorporating hyperspectral imaging technology to enhance crop production efficiency. Multispectral and thermal sensors can be used to sample and calculate the chlorophyll, pesticides absorption, water deficiency, and diseases based on reflectance. The design & construction of the drones will require precision and will be costly, but the results will prove worth the cost. This paper focuses on explaining the current crop production problem in this field and the creation of a low-cost optic lens-based hyperspectral imaging system for around $800.

ECE-18 Astrocelium

Rhea Dutta, Celine Khoo, Bethany Pittman, Daniel Rodriguez
Daniel Belquer, and Andrew Wiggins

For decades, technology has been used to enhance and optimize the music and entertainment industry. Today, this is more prevalent than ever with the new capabilities of wireless technology and real time data transmission. After achievability, the next concern of technology's integration with music is accessibility. How do we leverage this technology to allow everyone to enjoy the art that it elevates? The simplest examples of this are seen in services like streaming platforms for music and TV, or live streams of performances and concerts to make entertainment more accessible to all. However, technology can take the accessibility initiative to heights never previously imagined in the music industry. For example, Daniel Belquer has dedicated much of his professional career developing technologies that provide unconventional musical experiences for impaired individuals. Most notably, he developed a vibrotactile to create a better live music experience for the deaf. The goal of Astrocelium is to continue and build on this idea of accessible and inclusive entertainment by implementing available technologies into an integrated musical experience through senses other than hearing. The project aims to integrate multiple available musical applications, electronic devices, sensors, and microcontrollers into a large plant-like structure that will be controlled by live musical pieces to create visual, auditory, and sensory displays.

ECE-19 Hindsight's Personal Safety Backpack

Spencer Fan, Steven Lee, Kevin Ly, Christina Phan, Jacob Wong
Dr. Steven Webber

According to a RealTime research survey, "50% (of people) feel unsafe walking alone at night". This concern not only affects students but parents and loved ones who want to keep them safe. The current solutions consist of defense weapons like pepper spray and tasers, or alert devices like whistles or phone apps. These are all reactive solutions that attempt to treat the issue after it's already happened. We are the first to explore a preemptive personal safety device. We aim to provide a solution where people can avoid confrontation entirely without staking their lives on how calm and rational they are in a high-stress situation, how well they can use a defense device, how fast others would come to their aid from an alert device, or how dangerous the attacker is. People walking alone at night are already on high alert and conscious of the severity of the situation. No matter how aware a person believes they are, they need to constantly shift their focus to cover 360 degrees. We are proposing a device that will mitigate these physical and mental vulnerabilities. This will take the form of a backpack with lidar sensing to provide
real-time haptic alerts with information on a pursuer's distance and direction. The backpack will contain vibrational

motors on the straps, with a gimbal stabilizing the lidar sensor. After validation testing, the system was able to accurately detect pursuers and ultimately increase the user's spatial awareness making their nightly walks safer and less stressful.

ECE-20 CHEF: Robotic Kitchen Assistant

Julie Le, Gavin Fox, Phil Jones, Abhigyan Khullar and Samantha Efman
Dr. Christopher Peters and Dr. Tom Chmielewski

61 million Americans live with a disability in the United States. These disabilities can include fine motor, mobility, vision, and cognition impairments, among other variations. These, unfortunately, have far reaching implications that disrupt the lives of millions of people on a daily basis. Amongst this population, fine motor disabilities end up leaving 7% of disabled American adults struggling with self care, and independent living, consequently. Specifically, it can be difficult to perform the tasks that are necessary in order to prepare a home cooked meal. This can result in over-dependence on assistance from others, unhealthier diets, and a myriad of non-ideal circumstances for those affected. CHEF will alleviate this pain point for those who struggle with this particular challenge, allowing them to achieve more independently in their own home. It will result in more independence for the disabled individual, improve the quality of their diet and provide an extra level of safety when performing tasks that may have otherwise put them at risk. The CHEF robot provides an alternative to existing expensive, "nice-to-have" kitchen gadgets that are not targeted for this demographic. CHEF is a tabletop gantry system that will perform all appropriate food-safe actions using various stations to prepare, cook and plate a full, nutritious meal for the user. CHEF will provide end-to-end assistance for someone who would have otherwise been unable to perform those actions safely. Ultimately, the user will provide very little input to the system, which will autonomously recognize and prepare the meal.

ECE-21 Mini-Golf Modernization

Declan Beaudoin, Joshua Boniuk, Finn Clements,
Dr. Christopher Peters

Mini-golf is an industry which currently uses old-fashioned methods of score keeping. The current method uses a significant amount of paper and mini-pencils and requires a lot of user intervention. An example of an industry that struggled with outdated score keeping methods, and saw a surge in popularity when modernizing its methods is bowling, which is now almost exclusively automated. Evidence suggests that, as seen with bowling, automating the score keeping process enhances gameplay by removing the tedious tasks required by the current system, allowing players to focus on the game experience itself. Additionally, the added flares of having a computerized scoring system appeals to a wide variety of mini-golf players. The promising nature of the popularity increase that bowling saw leads us to believe that this too can apply to mini-golf. The purpose of this project is to extrapolate from the success seen with bowling and apply that knowledge towards improving the mini-golf experience. The effectiveness of the project is being confirmed through market research surveying of mini-golf beta test players. Initial survey results have shown that most players enjoy our alterations to mini-golf and the majority would choose automated mini-golf over standard mini-golf.

ECE-22 U-Grow: Autonomous Herb Garden

Bryce Trimble, Frank Tuminello, Tobias Green, Zoe Sucato
Dr. Bruce Eisenstein

Growing plants can be a daunting task. Factors for creating an optimal environment include temperature, humidity, sunlight, water, pH balance, and nutrients. If one of these factors is incorrect or neglected, a plant's growth success rate can significantly decrease. The goal of U-grow is to automate the climate conditions of a miniature greenhouse for optimal growth of specific plant selection. Current solutions on the market are lacking in multiple places. Most merely have lights and a water supply on a timer. For people that don't want to give raising plants a second thought, this won't do. This project's objective is to bridge the gap between overly-professional and overly-simplistic indoor greenhouses. U-Grow was designed to keep environmental conditions stable while being sleek and suitable for an amateur gardener. U-Grow autonomously monitors and controls conditions, while posting real-time data to an app. A prototype is under development that will demonstrate cultivation of a variety of herbs and maintenance of environmental control. So far the electrical subsystems have been successfully tested and controlled, the communications scheme has been developed and is in testing, and the mechanical body of the system has been designed and assembled. After elaborating on the need for this product, this poster will outline the subsystems of the design, including mechanical construction, hardware requirements, control scheme, and application communication design, and detail U-Grow's economic impact and marketing plans.

ECE-23 Control System Design for a Climate Controlled Enclosure

Amanda E Hipple-Bornhorn, George Guo, Michael Yu
Dr. Bruce Eisenstein

Reptiles are getting more popular as pets during the past several years in the United States. Social study shows that the number of households owning reptiles had doubled from 2007 to 2020. Demographic change had an influence on the rising popularity of reptiles. The college tuition has raised far more dramatically than minimum wage and average salaries. Which made more young people live with parents and stuck in smaller apartments. So they won't have room to have a dog. The changing perception of reptiles also let more people consider reptiles as a potential pet. Media and popular culture created more positive images instead of evil and scary reptiles.

Unfortunately, most reptile and amphibian enclosures provide improper husbandry causing them to experience illnesses and sometimes death. These enclosures could be improved by maintaining proper temperature, humidity gradients, and light cycling.

This paper presents and evaluates a new solution which properly automates the environmental conditions of an enclosure for a herptile reduces the burden of husbandry on a keeper. Instead of constantly checking and altering the conditions in the enclosure manually with devices by the keeper, a remotely control system can be implemented to check and maintain conditions. The widespread adoption of such a remotely control system can lead to significantly fewer premature deaths of reptiles through the reduced change of improper environmental conditions, particularly among inexperienced keepers.

ECE-24 Smart Refrigerator

Yelnur Abilakim, Oluwasijibomi Akinkugbe, Wyatt Brisbane, Keidi Xhagolli
Dr. Jaudelice de Oliveira

Smart Devices have been making huge strides in the world today. From Amazon's Alexa devices to Apple's Home Dot and even Google's Lifx Mini Smart Bulb, smart devices are making the lives of individuals and businesses easier and more convenient. Smart Refrigerators are the next generation of smart devices.

There are smart refrigerators on the market, however their smart features usually provide help with cooking or maintenance. Almost none of them target the issue of food waste directly. Implementing features that can notify the owner of expired or close to expiring food can help fill a niche that no fridge manufacturer has yet filled.

We have developed a smart refrigerator device that can help combat food waste by allowing the user to always have a correct idea of the contents and its respective state in their refrigerator and make choices that will help reduce the amount of wasted food. Our solution includes an (a) application, (b) touchscreen, and (c) barcode reader. The touchscreen is mounted on the refrigerator to allow the user to manually input and view refrigerator contents without opening it. The barcode reader will be used to automatically add food items to the smart refrigerator database to accurately predict the expiration date. The application will be used to send notifications about the approaching end date of and will additionally display the refrigerator's contents to the user.

ECE-25 Retrofit Vehicle Camera System

Jack McVeigh, Clayton Sheffield, Shawn McHugh
Dr. Prawat Nagvajara

In 2018, a law went into effect that requires all new vehicles to have backup cameras and video displays. Less than half of cars out on the road today are equipped with these capabilities, and it is not projected to be a majority for years to come. Many aftermarket rearview camera modifications can cost hundreds of dollars, and require the consumer to pay for a monitor as well as professional installation. Apart from do-it-yourself projects, there are no cheap products that solve this problem. This product will not only act as a backup camera when reversing but also as a dashcam. The Retrofit Vehicle Camera System (RVCS) is also capable of recording and storing video feeds using Bluetooth or Wi-Fi capabilities. RVCS will set the standard by combining an affordable camera system with a smartphone, eliminating the need for a separate monitor.

ECE-26 Improved Projectile Accuracy with Drone Assistance

Kanstantsin Paulau, Philip Vee, Kevin Vo
Dr. Prawat Nagvajara

The United States has one of, if not, the largest military budgets in the world. Criticisms of the high spending has led to the Department of Defense (DoD) cutting costs. Some of the strategies in reducing costs are downsizing personnel and modernizing older equipment with newer technology. This modernization agenda includes unmanned aerial systems. Drones would fall under this category and have seen increasing usage with both the military and civilian population in the past decade. What is a way in which the DoD can modernize equipment and use fewer personnel to be more efficient? Our team has identified the mortar system as equipment that the DoD has been trying to improve on for a significant period. In particular, the accuracy of mortars has been seen as unsatisfactory as GPS-guided rounds were one of the proposed solutions by the military. Our team has been making a system that integrates a projectile launcher and a commercial drone to make the firing process more accurate. The use of a drone is to reduce costs over the long term as guided rounds are expensive and have limited use. Microcontrollers have been attached to the projectile launcher so the drone can go to where the predicted landing will be. The drone provides visual confirmation and maps out a line of its flight path. After the first shot, we want to calculate the error and figure out the best adjustments to make for the subsequent projectiles.

ECE-27 Smart, Efficient and Light Solar Microgrid Inverter (S.E.L.S.M.I)

Omar Gomaa, Cody Tran, Modibo Fomba, Henry Nguyen, Fatimata Dia
Dr. Fei Lu

In the past 40 years, solar energy has grown and expanded from just powering satellites in space to a technology that

powers homes and businesses. Inverters are an essential part of the installation with their main function being converting the DC electricity from the solar panel to AC electricity that can both feed the load, and/or be integrated again in the grid and supplied to the utility. Before the 1960s, solar systems were only 6% efficient and cost $300/Watt. With the advancement in both PV technology and more economical solar inverters, the average solar system performs at an efficiency that ranges from 14 to 18 percent efficiency and could cost as low as $3/Watt. As more PV solar systems get integrated into the electric grid, energy efficiency and installation costs became a concern to residents and businesses. The objective of Smart, Efficient, and Light Solar Microgrid Inverter (SELSMI) is to provide grid support functions, such as frequency support, voltage regulation, and ride-through capabilities. The design aims to reduce heat sink losses, weight, and system's size, hence reducing the overall installation cost for the customer. This is done by optimizing the capacitor and inductor values for the LCL filter, the most convenient Full-bridge for the DC-DC converter, an STM32 based controller, and isolators.

ECE-28 Smart Wheelchair: Brain-Actuated and Semi-Autonomous Assistive Device Interface

Mario De Lorenzo, Kaustav Bora, Mohor Bhowmick, Ashley Siddiqui
Dr. Hasan Ayaz

According to the WHO, 65 million people depend on a wheelchair for mobility to complete day to day tasks. An estimated 40% of the disabled community finds power wheelchairs difficult, and in some cases, impossible to operate. This includes patients suffering from Tetraplegia, Spinal Cord Injuries, Parkinson's, or cognitive deficits. Conventional motorized wheelchairs' interfaces use joysticks, head/chin control, tongue control, and face/gaze control, all of which still requires continuous movement or posture control that patients or users have difficulties keeping up. The recent emergence of Brain-Computer Interface (BCI) technology presents an opportunity to capture input user intention for relaying them to computer and machines in diverse communication and control scenarios. In this project, we propose a new motor-imagery (MI) based mobile EEG-BCI to control navigation of a motorized wheelchair. This is also enhanced by collision avoidance IR proximity sensors as an additional layer of safety and semi-autonomous control. All together with these capabilities, we aim to build a Smart Wheelchair. To capture brain dynamics continuously during wheelchair driving, an 8-channel Unicorn mobile EEG system with OpenVibe software stack will be used. The Smart Wheelchair will be enabled to have a recording session to train inter-subject models for 4 classes (opening and closing left, right, both hands and both feet). As an embedded computational platform, Raspberry Pi 4 will be used to perform real-time BCI operations that include visual stimuli display, signal pre-processing, and classifiers. This Smart Wheelchair aims to provide greater accessibility and ease of use for severely disabled patients.

ECE-29 Autonomous Shopping Cart

Andrew Judge, Tony Mao, Francis Silvestri, Sudarshan Krishna Bhatia
Dr. James Shackleford and Dr. Tom Chimelewski

Transporting goods through a grocery store is necessary for customer satisfaction and store success. Pushable shopping carts offer a solution to this problem, but prove difficult to use for customers with disabilities. Electric riding carts have allowed disabled customers to get around this hurdle by offering the choice to steer through the store and reach for groceries. These solutions however, strip customers of a sense of autonomy, sometimes carry stigma that customers would rather avoid, and can make it hard for customers who have trouble, or would not like to push a cart, but can otherwise walk, to reach certain items.

We have designed an automated cart that has the capability to follow a user around a store. The base has been constructed out of HDPE plastic Omnidirectional wheels are used for improved turning. The navigation of the cart will be accomplished using IR transceivers with overlapping conical detection regions. Object avoidance will be

accomplished using ultrasonic sensors. Progress has been made to construct the base of the cart, with wheels and motors, to build and test a motor control circuit consisting of an Arduino, a battery and four motor drivers and to build an IR sensor circuit consisting of an Arduino and four IR sensors. The Motors have been tested to turn when the IR receiver falls in the transmitter's detection region.

ECE-30 Self-Balancing Bicycle

Jason Ellstrom, Phil Huddy, Zach Miller, Peter Nguyen, Theo Strahan, Kenny Tea
Dr. Thomas Chmielewski and Dr. Paul Kalata

The self-balancing bicycle is an autonomous transport system that can transport a load from one destination to another; the system's control is based on the inverted pendulum model. The inverted pendulum model works by applying counter forces to keep a system stable enough to remain upright in otherwise impossible conditions. This project is a continuation of a previous senior design group that researched and began the implementation of the pendulum model using state-space control systems. In this field, there have been very few previous attempts at a self- balancing bicycle. Unlike Google Netherland's CGI version, this project is aimed at creating a real self-balancing vehicle in the future. Although the groundwork has been laid, there is still much more work to be done. For example, a few existing parts of the bike need to be fixed, and the construction of the bike must be completed. Additionally, all the software for the bike needs to be written. Finally, once the bike is working, the model will need to be iteratively tested to maximize stability. The creation of this self-balancing bicycle will be groundbreaking because it takes advantage of the inverted pendulum problem to create a linear model of a complex issue. Doing this would be a huge accomplishment for control theory. Due to unanticipated complications in getting components and subsystems working the scope of this senior design project has been modified to reach a functional state for all subsystems as the final deliverable. These completed subsystems will then be available for use as a steppingstone towards a fully autonomous self-driving bicycle.

ECE-31 CAMEL LiDAR Drone

Evan Byrnes, Christopher Lijoi, Andrew Ragni, Laxmi Sanigepalli, Maggie Wang
Dr. Adam Fontecchio, Nicholl Glasco (Collins Aerospace)

Emergency scenarios in urban environments risk the safety of both civilians and first responders, so gathering information on the situation is critical for efficient response time. Current research on three-dimensional live mapping primarily focuses on the locations of first responders within the building itself. However, having knowledge of the surrounding site can be just as critical in an emergency scenario. By examining the building as well as the area surrounding it, we can direct bystanders away from dangerous areas and identify key areas for the deployment of rescue vehicles. This team is implementing the use of a drone with attached LiDAR sensor to be deployed in fleets in the event of emergencies so as to generate a three-dimensional map of an emergency site and potentially decrease response time. The drone in use is an EXO X7 Ranger paired with a SICK TIM 571 LiDAR sensor. This sensor has a horizontal aperture angle of 270º with a scanning frequency of 15 Hz, allowing for a scan every 20-30 ms. This team has been testing the gathering of these scans to generate a point cloud for 3-d imaging of an area with implementation of a ROS to the raspberry pi. When enough images are spliced for a mapping, a filter is applied to smooth out the data and eliminate any possible outliers. Mounting brackets have also been designed for the hardware attachment of the drone and testing for weight distribution will begin shortly when the elements are added to the drone.

ET-1 DSP Smart Guitar System

Paulina Bejar, Neftali Barreto, Chinedu Onukwuru, Shevin Joseph
Mr. Eric Carr, Dr. Fanaei Mohammad

If you have ever used standard guitar effects pedals, you know how time-consuming, disorganized, and expensive it can be to set them up. Over 16 million Americans aged 13 to 64 have started learning to play guitar in the last two years, according to a study conducted by Fender Musical Instruments Corporation. Consider what might happen if these aspiring guitarists were given an effects system that could save them time, effort, and, most crucially, money. With the DSP (Digital Signal Processing) based guitar effects system and associated software, more people may learn to play guitar by reducing the amount of equipment required and substantially lowering the cost, all without sacrificing sound quality. By eliminating large chains of physical effects pedals, our DSP smart guitar integrated system dramatically simplifies the entire process. You may easily unplug a pair of instrument cables using a DSP setup. A diverse array of our stakeholders, such as concert artists, might save a lot of time and money with the DSP smart guitar system. Without the trouble of connecting different standard pedals, music therapists might spend their time more productively. Music therapy may be highly customized, making it appropriate for people of all ages, even very young toddlers. Our DSP-based guitar effect system has a system capable of delivering four of the most popular effects: distortion, overdrive, delay, and reverb. It reduces the need for excess equipment, reduces expenses for guitar players, and reduces the amount of external equipment usually required in the traditional guitar setups.

ET-2 D.I.Y. Eurorack Physical Modelling Sound Source Module

Benjamin Cowell, Robert Bruhns, Gianluca Natale
Dr. Finley Shapiro, James Mackenzie

The A-100 Ecosystem, more commonly referred to as a Eurorack system, is a standardized modular sound synthesizer format first created in the 90s by Dieter Doepfer. Over the years, the power standards and size requirements outlined by the Eurorack format have gained rapid popularity and are now the most widely adopted modular synthesizer format to date. These racks typically consist of sound sources, amplifiers, filters, mixers, sequencers, and utility modules where the signal path is patched together using 1/8” audio cables which control the voltage of various parameters of the modules within a system.

Many Eurorack synthesizer modules are offered as either open-source projects or DIY kits; however, the current chip shortage has led to problems manufacturing the modules and/or supplying the components necessary to allow the end user to be able to build it themselves. In addition, there are no sound source modules that utilize physical modelling techniques in order to generate sound. This project will outline the component selections, design choices, testing procedures, and manufacturing processes that will lead to the production of a quality Eurorack physical modelling sound source module D.I.Y. kit that is unaffected by the global chip shortage.

ET-4 Portable Hydrogen-Powered RT-LAMP Medical Test

Edward Fusco, Bryan O'Toole, Nicholas Wall
Dr. Michael G. Mauk

RT-LAMP (Reverse Transcription Loop-mediated Isothermal Amplification) Testing is a saliva-based medical test method that can be used to detect several types of viruses (SARS-Cov-2/COVID-19, AIDS, chicken pox, and others). This serves as an alternative to polymerase chain reaction (PCR) medical tests, which are the standard for testing a patient for COVID-19 and other viruses in high-income countries. There are also at-home tests, but they have a significantly lower accuracy rate than that of PCR testing. In developing nations where PCR testing is not an option and electrical infrastructure is scarce, it can be difficult to obtain accurate information about the spread of a virus within a given population. To solve this problem, we have designed an enclosure and diagnostic collection method for an experimental COVID-19 detection system based on a test devised at the University of Pennsylvania. The experiment uses Magnesium-Iron (MgFe) powder to generate heat and a wax powder phase change material (PureTemp 68) to regulate temperature and prevent the saliva sample from boiling. Our current portable prototype can

harness the hydrogen gas emission from this chemical reaction and generate electricity through a hydrogen fuel cell. This is used to run a microcontroller coded to diagnose the sample, power LEDs to display a test result, and even connect with a smartphone without needing the use of batteries or traditional electrical power. Our system is currently the size of a reusable water bottle but could eventually be reduced to a palm-sized device with further research and development.

ET-5 Project Condor

Rick Temple, Abdullah Iqbal, Chris Meyers, Nikolay Kozitskiy
Dr. Yalcin Ertekin, Dr. Irena Ciobanescu

Currently, there are no easily accessible and affordable fixed-wing aircraft. The majority of affordable consumer/ business level drones on the market are quadcopters. Quadcopters are inefficient and do not have the ability to fly long distances without paying an astronomical price tag. The team worked to develop, manufacture and generate a detailed report on the building process. With the finalized report, anyone with access to a 3-D printer and a budget of $200 can build a drone. The body of the aircraft is completely printable utilizing pla-lite filament and the electronic components can all be purchased from Amazon. The aircraft is modular allowing for a myriad of uses from small deliveries to fire prevention. The aircraft is also designed to ensure that it will break at specific points to ensure damage is mitigated. This will also allow users to quickly replace specific parts as opposed to the entire aircraft in case of crashes. The overall purpose of our project is to create a step-by-step manual that will enable anyone to create their own customizable 3-d printed aircraft.

ET-6 Biomass to Methane Power Generation

Joseph Maltinsky, Tristan Neugebauer, Kaushil Patel, David Popiak
Dr. Mohammad Fanaei

Everyday worldwide, food waste of some kind is being sent to rot in landfills. The current market solutions for anaerobic digestion do not provide a seamless, efficient experience for the user, and do not produce methane of a quality for use in power generation. For this project, our main goals were to build a smart anaerobic digester that would be able to decrease fermentation times while increasing biogas production. The methane that it produces will be filtered in order to be burned safely, and the user will be able to monitor the status of the digester remotely. After considering several design alternatives and embarking on a lengthy design and building process, we have begun the testing stage of our project. The completed build is located in a safe outdoor location, where the production of methane will be monitored and recorded by an array of sensors connected to an Arduino. Based on our research, we expect the rate of methane production to be exceptionally high for a digester of its size, and for the methane to be filtered to a higher quality than the market competition.

ET-7 Digital Camera Motion Control System

Mareo Headley, Edward Jankins, Kenil Patel, Robby Onwundinjo, Tianna Williams
Dr. Irina Ciobanescu Husanu, Mr. Nicholas Jushychyshyn

Digital camera motion control is becoming more ubiquitous as visual-effects heavy productions and creative digital media have become more popular. There is a current market need to fill the gap between expensive, high precision state-of-the-art control systems and hobby-level camera motion control systems in an accessible price range. Consequently, the team drafted several prospective designs and performed detailed theoretical calculations based on

specifications from Drexel's Westphal College of Media and Design, which informed a final design. This motion control system prototype is a 2-meter-long by 3-meter-high motion control rig with two-axis stepper motor speed and distance control. The system allows for horizontal motion with a 2-rail setup using a DanaDolly and mounted stepper motor. The vertical tower is mounted on the DanaDolly and the camera is supported by a custom 3D printed mount with an additional 2 motors to control pan and tilt. This system will provide repeatable programmable motion with movement precision accurate enough to capture overlaying pictures that match within 0.5 pixels. The prototype will be tested by shooting a film and assessing its performance. This digital camera motion control system will benefit Westphal by providing an automated camera rig capable of smooth, repeatable motion for use in films.

ET-8 Pulse Oximeter Sensor for Application with Pre-term Infants

Malena Farber, Bartosz Jaskulski, Julia Knipe
Dr. Michael Mauk, Eric Carr, Dr. Marcus Davey, Matthew Slipenchuck, James Tarmin, Stephen Krufka

This project consists of a reflectance-based pulse oximeter for preterm infants. Most pulse oximeters are only accurate in the range of 70-100% which is fine for healthy adults. However, fetal blood typically ranges in oxygenation from 40-75% thus requiring a unique device. This project entailed designing a prototype that accurately measured oxygen saturation of the blood over a range of 30-100% saturation for application within the extracorporeal circuit of a system. The pulse oximeter was housed on both sides of an oxygenator with transparent plastic windows. An 11-channel spectral sensor with a broad light spectrum measurement and built-in white LED was selected. The outputs of the sensors are corrected for ambient light, converted to assorted color spaces, and then converted to oxygen saturation using a trained linear model on a microcontroller. The microcontroller then communicates with a single-board computer which logs the data and provides a visual representation on an LCD screen monitor. The developed GUI also provides a calibration mechanism. Empirical data was collected to train this linear model to convert from the color spaces to oxygen saturation. The corrected data from the sensors, the color space data, and the oxygen saturation were all data logged on the single-board computer with time stamps for both arterial and venous oxygen saturation. Verification testing was conducted with animal blood, in which the oxygen saturation levels were increased and decreased over a set amount of time.

MEM-01 Braille Training Device

Daniella Jose, David Hanna, Lauren Lugones, Stephen Abbate, Rostam Kojouri, Angelo Meissler
Dr. Euisun Kim

Across the United States today, there is a braille literacy crisis threatening the blind community. The National Federation for the Blind (NFB) reports that only 10% of the population in the blind community is braille literate. This issue is driven by deficiencies in braille education and a decrease in the engineering and creation of accessible and affordable braille technologies. The process of learning braille requires secondary personnel to assist learners in building connections between letters and their braille representation. This reliance on braille educators prevents students from practicing their reading skills independently. This project introduces the development of an interactive braille training device which uses voice commands to actuate braille characters on a single cell display. The solution utilizes a pen latch mechanism triggered using stationary solenoids. An array of six individual braille dots and solenoids are controlled though a pre-defined braille character library where the entire alphabet and single number values have been created. Using an open-source voice recognition engine, the team has allowed for single letter or numeric inputs to the device to be output across the six braille dots. Through a key partnership with VisionLink, a Philadelphia based organization for the blind, this innovative approach to braille learning will allow students to easily learn fundamental braille characters.

MEM-02 Integrated Shim™ Assembler

Xin Yue Jocelyn Liu, Maxwell Ralston, Eli Dellston, Luc Maloney
Dr. Andrei Jablokow

Cancer patients often undergo radiotherapy, which often incorporates a certain thermoplastic face mold. At QFix, the Encompass™ SRS System is a patented patient positioning system, which incorporates the Integrated Shim™ pin assemblies, a crucial assembly component for thermoplastic face molds. This groundbreaking product has grown quickly and labor costs have grown with it. Qfix has been investigating ways to reduce the labor costs of manufacturing the pins. The current procedure at QFix involves assembling the Integrated Shim™ pins completely by hand. With high demand for these pins, the operation of assembly must be automated. The objective of the Integrated Shim™ Assembler is to make the mass production of Integrated Shim™ pins faster. The assembler will utilize both mechanical and Arduino components to semi-automate the production of fully assembled pins. Using two subsystems, the lever-driven push assembly and the rotational system, the assembler will be able to utilize custom-designed seatings for the Integrated Shim™ parts. It will also utilize arduino-controlled components to ensure repeatable construction patterns. The lever mechanism will be based on a slotted couple, integrated into a core shaft for the whole device. The lever subassembly utilizes an internal lever-spring contraption, in order to mechanically connect all Integrated Shim™ parts. The rotational subassembly uses an arduino-driven motor to screw the ferrule component into the number-boss component in the correct orientation for good alignment of all parts. The rotational subsystem operates in a 2-step process: it fully screws the ferrule in, then utilizes a backwards rotation to ensure proper alignment. Through experimentation, the required backwards rotation was found to be roughly 185 counts of the motor's rotary encoder. After the rotational subassembly finishes aligning the ferrule, the lever-driven push subassembly pushes the pin through the other components to complete the assembly of the Integrated Shim™ pin.

MEM-03 Escalating Wheelchair Device

James R. Cox, Andy Wang, Meghan Wickersham, Ryan Won
Dr. Lutfi Agartan and Dr. Jonathan Awerbuch

Wheelchair users are faced with several challenges every day. One of their biggest challenges is to climb up and down flights of stairs. The market has developed several solutions to this problem by retailing expensive wheelchairs, installing permanent lifts in the home, or creating products that require assistance to operate. These users need a product that is universal, easy to use, and provides a sense of independence. Unfortunately, there is no such product or device that exists on the market. The common issues for available products include the barrier for entry from high product cost and the need for an additional person for assistance in operating the device. However, the main problem for existing products is the large physical footprint of the and weight device in comparison to the size of the wheelchair. The proposed Escalating Wheelchair Device (EWD)'s objective is to expand the market by developing a device which is independent of the need for assistance, home improvements, and which is easy to operate. The EWD will be located under the user's wheelchair and move the wheelchair up and down stairs using a tread system while keeping the user level to the ground. This product will be easy to assemble after being purchased off the shelf at a fraction of existing product prices. The main difference between the market today and the Escalating Wheelchair Device, is that the market tries to integrate the wheelchair into a device, whereas we aim to integrate the device into a wheelchair.

MEM-04 Project Title: E-Motorcycle

Khalil Alibhai, Connor Caizza, Peter Murzin, Jacob Segletes
Prof. Peter Clelland

Electric Vehicles (EVs) are more sustainable than internal combustion engines (ICEs) because they produce no

emissions while powered. Should the EV be charged using renewable energy sources, it would have almost no use phase emissions whatsoever. Similar to how a gas tank stores gas, an EV would have a higher capacity battery to retain electrical charge for a potentially longer drive range. The market for EV cars, trucks and motorcycles has exploded globally in recent years due to technological advances and changes in consumer preferences. Although ICEs have been dominant within the motorcycle community, an EV could offer enhanced performance and other abilities. This is considering the higher torque of electric motors compared to ICEs. Despite the advancement of the market and their potential, EV options remain relatively expensive. The widespread adoption of EVs could be quickened by more economical options and simply with more options available. It is more environmentally friendly to convert existing ICE powered vehicles to EVs. This would reduce the emissions of the gasoline engine, as well as eliminate the need to manufacture another vehicle for a motor, since this is even more pollutant. There are a variety of EV conversion kits or individual components available for sale online for similar prices to purchasing a new engine and associated accessories. For this project, a prototype will be assembled using an electric scooter motor, throttle potentiometer, and DC motor controller.

MEM-05 Rocket-Glider Radiation Detection System

Imran Ahmadzai, Austin Ogle, Anthony Truscello, Thomas Visconto, and Michael Woo
Dr. Divya Bhargava

Even though power plants have been implementing strict protocols to minimize potential safety hazards, the growing need for nuclear energy poses a risk to safety. In case of a mishap, it is imperative to keep the first responders safe by informing them when it is safe to investigate the site. As a result, the need for aerial radiation detection has become increasingly important. Currently, the only way to remotely measure radiation levels at the site of a nuclear accident is to rely on incoming data from within the facility or deploy ground-based radiation rovers. These solutions involve expensive control systems and can take a long time to arrive at their target destination. The rocket glider radiation detection system seeks to address these issues by providing an inexpensive, easy-to-deploy device that can be quickly launched into the air whereupon reaching the desired height will glide down towards the irradiated area.

Currently, the design team is finishing up the construction of the prototype and getting ready to launch the aircraft to perform test analysis. The physical prototype will be equipped with two wings, three stabilizers, two arm motors (control wing deployment & propulsion system ejection), Arduino boards, and a radiation sensor. To determine the success of the prototype, the goal is to perform several launches to observe the overall aerodynamic performance of the aircraft as well as how quickly the radiation data is uploaded to the central hub. The aircraft is designed to reach the desired altitude (400 ft) in under 15 seconds with a glider flight duration of over 2 minutes and a flight range of 3 kilometers. The rocket glider will be outfitted with a Geiger counter, allowing the aircraft to begin detecting radiation once at the desired location. Our mission is to improve the detection of radiation levels so that first responders, in the case of a nuclear accident, can quickly and safely investigate the accident.

MEM-06 Automated Adhesive Dispensing System Project

Edward Jung, Benjamin Le, Dylan Romig
Dr. Andrei Jablokow

In manufacturing, performing intricate tasks require time and strain on the operator. However, such tasks can become automated since the basic mechanism at work is advancing computer technology, which automates repetitive tasks. Automation can push people to learn, develop, and refine the uniquely human skills to move up the ladder. But, the replacement of all humans, in the pursuit of increasing productivity remains a dilemma that can result in extensive problems.

Based on experience and observations, the manual operation of a glue syringe creates waste through overfilling, time,

taking away from the productivity of a manufacturing cell. The continuation of this process in this current state will continue to cause the loss of value and time to Eaton.

The needs and wants of Eaton are to increase the productivity of the human operator coupled with increasing the efficiency of the gluing process. To accomplish this, the gripper/dispenser head was changed to require only a small block of aluminum, as opposed to a larger bulkier aluminum plate. Furthermore, an additional approach involved incorporating a laser sensor to monitor the adhesive dispensing accurately. The syringe was attached to the aluminum block via a 3D-Printed clamping fixture and tested using the vacuum pump. Lastly, the final phase was to program the cobot while using its interface to integrate a collaborative aspect of automation.

Working side by side, the process will see major improvements in output and productivity, while reducing the strain on the human operator.

MEM-07 Pin-Tract Infection Device

Matthew Acates, Brendan Holtzman, Muhammad Meajun, Briana Heintzelman, David Armbruster
Dr. Atchison

Orthopedic implants have made it possible to rectify bone fractures and treat joint degenerative inflammatory problems in millions of patients. Pin-tract infections are a common complication associated with orthopedic temporary and definitive fixation implants. Bacterial infections in external orthopedic implants cause a myriad of issues for patients such as periostitis and osteomyelitis. Due to the difficulty of treating bacterial biofilm forming around the metal surface of the orthopedic fixture, medical professionals are often left overprescribing medication to treat the infection with little success. The Depuy research project aims to solve this issue by utilizing cathodic voltage-controlled electrical stimulations through an external electronic device using a controlled ultra-low DC voltage current to kill existing bacteria found around pin-tract skin tissue. This project will demonstrate the device's capability of pushing electrons, produced by the circuity, into the pin tract site while also varying the current accordingly to account for changes in resistive impedance of the skin caused by bacterial infection. The implant component of the design will use stainless steel pins acting as the cathode for current delivery into the surrounding tissue. Electrons provided by the electronic device will inhibit bacterial infections by creating holes in the cell's membrane allowing molecules to leave the cell killing off any bacteria found on or around the pin-tract site. The design of the electronic device serves as a good steppingstone using renewable circuit elements and little expenditure in energy use, which will help keep costs low in the healthcare field and reduce morbidity of patients.

MEM-08 Beverage Evaluation, Extraction, and Retrieval Robot (BEERbot)

Joseph Aach, Brandon Kintish, Harvey Mei, Evan Thai
Dr. Jennifer Atchison and Dr. Matthew Maltese

Consumer household robotics is a rapidly expanding market that is predicted to be valued at $8.5 billion by 2025. As this market continues to evolve, the demand for robots that can perform household activities with autonomy is exponentially increasing. Because of this growing market, more accessible robotics technology makes the development of robots for use in household tasks and delivery achievable while also reducing these robots' price points.

Primarily, non-industrial robotics have been implemented in commercial sectors, such as restaurants and warehouses, where it represents an avenue for efficiency. However, many areas in the household robotics market, such as beverage service and delivery, have only a few expensive technologies which present a strong market potential based on stakeholder surveys conducted. The BEERbot is a ground-up development of a robot consisting of a differential drive base and a four-joint arm manipulator with a gripper, controlled by microprocessors and microcontrollers. Servomotors move the arm with four degrees of freedom and actuate a gripper, which is used for beverage retrieval.

Encoded DC motors are utilized to power and control the differential drive system in two degrees of freedom. This robot will use object detection and recognition software paired with a 360-degree LiDAR sensor for beverage detection, navigation, and mapping. The use of powerful, open-source software, such as Robot Operating System (ROS), TensorRT, and PyTorch, minimize consumer cost and situates the device as a domestic robot. BEERbot will serve as another steppingstone for the future of affordable and highly usable domestic robotics.

MEM-09 Foldable and Expandable (F&E) Truck Camper

Aaron Fitch, Althea Masuda, Hafsa Mohammed, Sung Pae
Dr. Dimitrios Fafalis

More than 40 million people partake in camping activities each year, in the United States. As the popularity of recreational activity continues to grow, the diversity of camping types increases. RV and van camping allows both non-experienced and experienced campers to customize their trip to the fullest extent, along with increasing the capacity of items to take along on any duration of a trip. Truck campers currently on the market are bulky, reducing the user's gas mileage and limiting the overall maneuverability of the vehicle. Designing a foldable and expandable camper for compact pickup trucks can rival modern truck campers in terms of price and accessibility, while simultaneously improving gas mileage and increasing adherence to standard vehicle height restrictions.

The F&E truck camper will be designed to comfortably sleep two adults when fully expanded and easily fit in a standard garage-sized spot. The full-scale virtual model allows for structural stress analyses for the independent mechanisms. Aerodynamic analysis will also be conducted through the use of computational fluid dynamics by comparing flow simulation with and without the camper present. A scaled physical prototype models the three mechanisms used for the truck camper which includes a nested inner shell which expands backwards, an upper portion that lifts with two supports, and a pop up tent on the roof of the camper. The scaled prototype build is near completion with current project efforts focusing on the full-scale model testing.

MEM-10 Sanitary Pad Manufacturing Machine

Dawn Kroptavich, Jordan Irgang, Sandeep Sharma, Sanjog Karki
Dr. Jennifer Atchison and Dr. Mahabir Pun (National Innovation Center)

Menstruation is a taboo subject in Nepal, and many women face ostracization during their periods. The majority of the sanitary pads used in Nepal are imported and undergo heavy taxation, while those that are domestically produced have limited availability due to the absence of automated manufacturing processes. These factors limit the availability of sanitary pads for women in remote areas of Nepal. Consequently, women resort to improvising with cloth pads and rags. Without reliable access to soap and clean water, this method dramatically increases the risk of skin irritation and life-threatening infections. The EasyPad team has designed and is prototyping a semi-automatic modular manufacturing machine with capacity to produce ten pads a minute. The knowledge and the technology are to be shared with the National Innovation Center in Nepal through a 'Technology Transfer' document to allow the Nepali team to re-create and mass produce the pad making machine for distribution across Nepal. The *Easy Pad* team has completed the procurement of about 85% of the materials required for the project and has completed about 40% of prototyping which includes building the frame and assembling electronic components.

MEM-11 Hybrid Fluid Turbine Motor Network

Michael Foster, Anthony Lombardo, Nicholas Dewey, Zachary Sinclair Riley McCarthy

Dr. Young Cho

Energy production using turbine connected electrical generators has been the main driver of industrialization since the late 1800s, but also drives the largest sector of heat and pollution emissions driving climate change. Throughout this development, machines in use have seen various improvement in construction, impeller methodology, and maintenance of magnetic and electrical fields but overall have maintained the same typical methods for energy extraction reliant on maximizing the pressure loss at low velocity to minimize stress on impacting blades. In our designs we have used a method of impelling first developed by Nikola Tesla that fell into obscurity following the bankruptcy of his plans for a power radio station at Wharncliffe that allows for a low pressure loss instead getting its energy from velocity reduction due to viscous drag and combined the system with newly developed axial flux motor technology to attempt energy harvesting at high frequency which has routinely been shown to require less torque than low frequency machines for the same load current. With this method, it is our hope to implement these designs in locations which already maintain a pressure head for the driving of fluid motion to extract energy that would otherwise go unused in vehicles and other areas. The proof of functionality of the turbine-motor network through analytical work as well as can help us determine the tensile strength and percent elongation of the materials used. These calculations can help to determine the turbine's interfacing capabilities with that of coils found in the motor network.

MEM-12 Re-Live Shoes

Sezgi Kocagoz, Morgan Peterson, Wayne Rodgers, Reilly Finegan, Huyen Nguyen
Dr. Dimitrios Fafalis

CDC (Centers for Disease Control) statistics state approximately 36 million 65 and older adults fall each year and 67% of the falls are due to elderly tripping. This statistic leads to 32,000 deaths, and one in five will suffer from injuries such as broken bones and head trauma. Most footwear manufacturers mass-produce and deliver products to the public without comprehension of individual needs and deformities. Additionally, manufacturers most often limit customization to only one aspect of the shoe design. Re-Live Shoe's intent is to introduce customizable sizing features through capturing a 3-D Foot scan to determine the precise measurements and distinctions of the client's feet anatomy to construct a well-fitted pair to decrease the rate of injuries. The Re-Live shoe material will integrate a 3-D printed TPU (thermoplastic polyurethane) design that is assembled to support motion, impact, and promote sustainability. To ensure the customer's safety and comfort, the 3-D shoe assembly will undergo FEA (Finite Element Analysis) to analyze prime specifications. Once the FEA guarantees an adequate safety factor then the 3-D model assembly will be 3-D printed and tested further. By this, the Re-Live shoe will differ from the market today by providing older adults a customizable safe design to reduce the risk of injuries and maximize comfort.

MEM-13 Artificial Sunlight Window

Khalil Wise, Nicholas Nyarko, Alex Tyagi, Michael Breeding, Ryan Schrier
Dr. Jennifer Atchison

Circadian lighting systems are designed to mimic the behavior of the sun by changing the color temperature, intensity, and position of the light throughout the day. These systems involve a combination of natural light and controllable light fixtures hooked up to a building automation system. Research has proven that a healthy circadian rhythm improves mental and physical health, energy, and mood throughout the day. Unfortunately, most commercial buildings are equipped with white lights that work against your body's naturally occurring circadian rhythm. Common office lights do not output the wavelengths needed for your eyes to send the signal to your brain that the time of day is changing. The Artificial Sunlight Window Project's objective is to create a light fixture capable of outputting circadian lighting in spaces with no access to natural sunlight. The team's solution takes inspiration from previous incarnations of sunlight windows but offers creative solutions such as color correction gel to change the temperature of the sun and color changing light strips to simulate the blue sky. To mimic the sun, a primary light will shine through the color

correction gel towards the diffuser and out into the room. Testing showed that different thicknesses of color correction gel allowed for the lighting color temperature to be controlled to mimic the sun's changing color temperature. The design will be scalable so that larger fixtures can be made once the prototype has been successfully built.

MEM-14 Project: Virtual Reality Module of a Wind Tunnel Experiment

Mitchell Eckrote, Enrique Feliciano, Julian Foley, James Nicholson, Malcolm Ximines
Dr. Lutfi Agartan

Working in a lab, collecting data, and applying theory are crucial parts of STEM education in the 21st century. This in-person experience helps students better understand concepts taught in the classroom. Outside resources state that the incorporation of hands-on learning is essential to the learning experience. Drexel University's College of Engineering currently offers in-person laboratories but has not yet replicated an experience within a virtual environment. During the Covid-19 pandemic, lab access has become nearly impossible due to various university restrictions. As a result, the lack of hands-on experience has stifled some students' passion and understanding of fundamental engineering concepts. This created an opportunity to develop virtual labs to offer a hands-on experience to be integrated into Drexel's engineering curriculum. This paper introduces the Unreal Engine-based virtual reality model of the MEM 311 wind tunnel experiment. Unreal Engine enables the user to interact with the virtual model, complete the lab procedure, and collect data as if they are in the physical lab environment. Using a large data set collected from this experiment under a wide range of conditions, mathematical models and neural networks are embedded within the Unreal Engine simulation to replicate in-person results. Two mathematical models utilize regression methods that emulate the system's behaviors based on previously collected data. Another method utilizes neural networks to find complex relationships between the inputs and output. This virtual laboratory environment will serve as means to not only replicate hands-on lab experiences, but also refresh students' enthusiasm for learning in a virtual space.

MEM-15 Modular Hydroponics System

Brett Flory, Jason Applegate, Joe Dimen, Wookun Jeon
Dr. Young Cho

Hydroponics is a rapidly growing form of agriculture due to its highly efficient usage of water and space. Hydroponic systems also allow for the control of environmental factors which increase crop growth, and they can be utilized in areas where traditional agriculture is impossible. The most common issues that are holding back hydroponics from replacing traditional agricultural methods is power usage, maintenance issues, and plant health. Hydroponic systems are often prone to system failures, bacteria growth, and plant disease that lead to crop death. To prevent this frequent and rigorous inspections are needed. Our senior design project addresses these issues with a modular system that can easily be monitored remotely and taken apart for maintenance without disrupting the plants' nutrient cycles. The design consists of a main housing unit, a nutrient reservoir, and interchangeable planter boxes. The planter boxes can be quickly swapped out to replace defective parts or to offer different forms of hydroponics. Sensors are utilized to collect metrics such as feed pressures, light levels, and water pH to remotely detect errors and control the plants' environment.

The modular design also allows for the system to be scaled based on the needs of the customer. This could vary from a small unit used for residential use, to large units used for mass food production or research purposes. Our modular hydroponics design could be the answer to food production issues by allowing individuals to grow food more efficiently in confined spaces.

MEM-16 Remote Weather Balloon

Benjamin Conroy, Jessica Huber, Olaf Nelson, Jonathan Rios
Dr. Divya Bhargava

Alaskan bush pilots, who operate in remote areas and harsh environments, are often forced to use incomplete or unreliable weather data to decide whether it is safe to take off. According to the CDC, aircraft crashes due to severe weather were the second leading cause of occupational death in the state. In 2010, the Alaskan aviation community came together and identified access to weather information as one of six vital safety concerns requiring improvement. Given the data collected by the CDC, and feedback from the aviation community, we were highly motivated to address this issue.

This project aims to allay the community's concerns with a weather balloon device for pilots to deploy into the sky and gather key weather data. This weather balloon will ascend to 5,000 feet of elevation and record atmospheric weather data such as pressure, temperature, humidity, and wind speed to inform pilots' take off decisions. Lightweight and highly portable, our system will improve the safety of flight for Alaskan pilots.

We plan to perform field tests with our remote weather balloon system in the coming days. Our team is currently in the process of assembling our ordered components, and we have prepared our tank with the helium needed to fill our balloon. We hope to decide upon and finalize the ideal test location this week, and begin trail runs to record our performance data.

MEM-17 Design & Manufacturing of a Precision-Agricultural Drone

Anthony Schrayer, Austin Squillace, Blake Cleland, Brian McKitish
Dr. Antonios Kontsos

The purpose of MEM17's project is to create the layout and design of a precision- agricultural drone. Similar drones in the market aim to satisfy larger corporate sized farms and do not provide the option for customizable design to meet a range of agricultural needs. Overall, the precision-agriculture drone industry is rapidly expanding as part of the developing trend of automating and digitalizing this important market sector. While precision drones provide a cheaper alternative, for example to overhead crop dusters, there are related design needs that could drive further developments. Our market analysis has shown a need to support small farming which is typically dedicated to targeted crops of higher economic output. To meet this goal, the project aims to design and manufacture a prototype of a scalable and customizable precision- agriculture drone which can address some of the current market needs. The features that will differentiate us from other competitors include customizable spraying capabilities, and design suited for optimized use in small farms. The manufactured prototype will be tested for its effectiveness while a product life management plan will provide the roadmap to achieve scalability and customizability. The product is currently being manufactured with on-the-market components as well as 3D printed parts for structural support, and results are expected to be reported after construction concludes.

MEM-18 Sensorized Football Helmet

Anthony Casterioto, Laurynn Boissonniere, Ethan Mawhinney, Douglas Yim, Xiaokai Zhong and Dr.
Dr. Bor-Chin Chang

Football helmets are one of the most essential pieces of equipment when playing football since they reduce the risk of a player experiencing a brain injury. Although physical injuries can still be serious, brain injuries are significantly more dangerous considering they can jeopardize an athlete's long-term health. As the years progress, helmet companies are continually improving the quality of their helmets and football leagues are implementing new rules to

minimize the chances of a player experiencing a head injury. Despite this, the actual diagnosis of a concussion on a player is unreliable, especially considering the severity of the injury. Other than the player self-reporting their symptoms, the only other method to spot a concussion is through those observing on the sidelines, which is very questionable and can be overlooked at times. The Sensorized Football Helmet's goal is to provide an extra layer of protection to the player by monitoring the magnitude of the g-forces exerted on the helmet. This will be done by utilizing several Flexiforce A401 FSR sensors and LilyPad Arduinos. Additionally, the helmet will provide the ability to pinpoint which area of the head was impacted along with the direction of the force. Depending on the location, when the magnitude of the g-force reaches a threshold for a concussion, the player will be flagged to be taken out of the game and will be given a concussion test. These Sensorized Football Helmets will be the next step in improving player safety.

MEM-19 Single Point Rifle Sling Mount

Michael Bonto, Samuel Cressman, Brandon Ronquillo
Dr. Dimitrios Fafalis

Rifle slings are an important piece of gear when it comes to improving combat functionality and user comfort for soldiers in the Army. Slings are attached to a standard military rifle via a sling mount and allow the user to conveniently carry the rifle hands free. A single point sling is attached to one mount on the rifle. The typical single point sling mount requires the disassembly of the buffer tube, which is held in place via a castle nut. Unfortunately, the Army specifications for the standard military rifle – the M4 carbine, require the castle nut to be staked. Due to this restriction, the castle nut cannot be removed. Therefore, it also prevents the attachment of a standard single point sling mount. This project focuses on working around the military restriction of a staked castle nut. The sling mount is designed to be attached and detached while the castle nut is still staked. This feature will allow it to be compatible with the military M4 rifle platform as well as the civilian AR15 rifle platform. The single point sling mount design was 3D modeled through SOLIDWORKS. Following this, Ansys was used to test the limits of the design. It was used for finite element analysis, thermal stress testing, and material selection. The final prototype was then machined out of 6061 Aluminum.

MEM-20 Collapsible Rescue Operations Chassis (C.R.O.C.)

Thomas Austin, Emily Morlock, Eric Radloff, Ryan Schmidt
Prof. Peter Clelland

Storage of small aquatic vessels on land has necessitated the design of devices that allow these vessels to be transported over land. The most common existing solutions to this problem are trailers and vessels with built-in drivetrains (amphibious boats). While effective, both solutions have limitations that prevent them from working in all applications. Trailers must be towed by a truck, meaning that the land being traversed must be easily accessible, and amphibious boats are an entire system, making them cost prohibitively expensive for anyone who already owns a boat. One such owner of an aquatic vessel is the Montgomery Township Volunteer Fire Company (MTVFC). As part of their responsibilities, MTVFC performs water rescues that require them to be able to traverse sections of land surrounded by flood waters. The MTVFC needs a rapidly deployable system to help transport the boat over land with minimal equipment and assistance. The objective of the CROC project is to build a lightweight, collapsible frame used to transport their rescue boat over land in a rescue situation. The system design is now complete and is in the early stages of the build process. The device will be able to support the weight of the boat, motor, equipment, and one person. To ensure a prompt rescue, the CROC will be capable of being assembled in under two minutes and collapsed down to fit within the boat. A hollow aluminum frame is being used to keep weight as low as possible, as excess weight will prove more laborious for personnel. A successful build will reduce response time, cause little to no effect on the boat, and ease rescue personnel's responsibilities.

MEM-21 Can Extractor for Ball Metalpack

Inal Aslanukov, Ali Elzahri, Rhys Kawaguchi, Pavlo Mrdjenovic, Tenzin Wangdak
Dr. Andrei Jablokow and Johnathan Bejuki (Ball Metalpack)

Ball Metalpack one of the leading suppliers of sustainable metal packaging for food and household products and the largest aerosol manufacturer in North America. Quality assurance checks are essential for can production, one of which occurs after attaching the base and head to the body of the can. Currently, cans are extracted from the production line manually which requires interruption of the high-speed process. Unfortunately, production numbers are partly limited by the current quality assurance check method as the production line speed must be significant reduced or even halted in order to manually extract the cans for quality assurance. Can productivity could be improved if the process of diverting the cans for inspection was able to be performed without halting the line. The Can Extractor Project's objective is to increase the can production numbers by reducing downtime while the production line is at a standstill. This project will allow Ball Metalpack's can manufacturing plant to maximize their production numbers and consequently increase company revenue by developing an electromagnetic device to divert cans seamlessly from the production line. The practicality of an electromagnetic can diversion process from the high-speed production line has been verified in practice since a similar device is used in a different stage of the manufacturing process. The electromagnetic can diverter will improve production, increase revenue, and decrease labor costs.

MEM-22 Drexel's FSAE EV 21' Car Suspension Design, Manufacturing, and Testing

Jason Abraham, Dominic Bosco, Joshua Foland, Tracy Liu, Aidan Rovinsky
Dr. Antonios Kontsos

Drexel's Formula Society of Automotive Engineers (SAE) electric team competes in a yearly competition where collegiate student teams design, manufacture, and race a single-seater formula-style race car. A major component of the car is the suspension system. The suspension system controls the movement of the four tires in such a way that the lateral and longitudinal grip of those tires is maximized. This system was determined to be insufficiently developed due to COVID-19 related campus shut downs as compared to the corresponding system used in the 2019 competition. Consequently, the team has no validated design on which to base current and future needs. To create such a design, the objective of our senior project is to design, manufacture, and test the suspension system for the 2021 car. We will accomplish this by learning the fundamentals of suspension design, designing our solution according to challenge requirements, manufacturing our suspension system, and then testing it on the 2021 car. Our group will use digital design software for designing the suspension components while also modeling the suspension system dynamics with a comprehensive and a simplified control model. The DREV 21 car suspension system and its documentation will allow future teams to iterate and improve on its design to maximize the grip of the car.

MEM-23 Drexel Robotic Optical Positioning System (DROPS)

Jared Bunch, James Heinzman, Liam Heisler, Connor Silvia, Ryan Zegarski
Dr. Ajmal Yousuff, Zakiya Tomlinson (NExIS), Justin Cassidy (NExIS)

NASA's Exploration and In-Space Services (NExIS) located at the Goddard Spaceflight Center in Maryland specializes in the development of various in-orbit platforms that support in-space assembly and maintenance of equipment. NExIS has a need to develop a visual alignment aid for their On-Orbit, Assembly and Manufacturing - 1 (OSAM-1) mission servicer with the objective of assembling a solar panel array in low earth orbit (LEO). The current

system in place utilizes a human robot operator who orients the servicer using visual inspection of surroundings and makes adjustments manually as pieces are assembled. A system that has not yet been utilized in the series of OSAM missions is automatic position and orientation measuring. The ability to obtain the location of the robotic arm during the mission would greatly reduce the overall mission time thus elevating system efficiency, by yielding coordinates that may be used to complete the assembly process. The Drexel Robotic Optical Positioning System (DROPS) team addressed this issue by constructing a multi-faced deployable object coupled with a visual recognition algorithm capable of taking field of view from the camera as inputs and computing spatial and angular orientation with respect to the center panel, which was treated as the origin. The vision alignment problem was addressed via two side-by-side approaches: analytical (utilizing homography theory in computations) and physical test. Design validation for this project is on the basis that these two solution avenues agree and each successfully compute positional and angular relations of the servicer's robot arm.

MEM-24 PV Plus Storage for Increased Resilience - Department of Energy - Solar District Cup

August Pendergast, Kieran Van Sant, Cassandra Pezza, Salvatore Anderson
Prof. Peter Clelland

Pacific Northwest National Laboratory (PNNL) is globally recognized as a leading research center for chemistry, data analytics and earth sciences. Research of this caliber often requires continuous experimental procedures. However, the vital data collected by these experiments require intensive equipment which can be disrupted by utility outages. The campus has a goal of reaching more resilient, energy-independence from the grid as part of its sustainability plan. Providing a source of power outside of the grid will provide continuous energy during outages. PNNL can also use data collection from this system as a research asset, measuring progress towards emission reduction and energy resilience for the Department of Energy Fortunately, this issue can be solved with the implementation of a stable photovoltaic (PV) system with battery storage to help sustain PNNL's vital research operations during critical moments without power. Storing zero-emission solar energy by battery charging provides the laboratory continuous energy overnight and through grid outages. The battery systems were designed to meet 25% of the peak threshold for the ride-through duration requirements for each building. PNNL can maintain vital operations by installing PV systems in two key areas of their campus. In the north section of campus, two buildings will connect to a battery system with at least 900 usable kWh capacity. In the south section, three buildings will be connected to a battery system with 3,200 usable kWh capacity. These sized systems will ensure that the critical loads are powered for ride through durations of up to six hours.

MEM-25 Oil Detection Device

Isabel Bonilla, Nelli Khalatyan
Dr. Andrei Jablokow

Water pollution due to contaminants is an underlying issue within the United States. Oil is composed of benzene rings, the simplest form of aromatic compounds. They are carcinogens with strict controls and regulations on them due to their toxicity to humans and the surrounding ecosystem.

Fluorescent technology is one effective form of detecting oil. Fluorescence is a type of luminescence caused by photons exciting a molecule, raising its electrons to an excited state.

Currently, there are many different applications of fluorescent technology such as polarized imaging and biosensors. Many individuals are not exposed to such technology until having to use it in the field. This creates a disconnect between understanding the technology, and how it works, and simply following instructions to collect data.

The purpose of this project is to allow for the individuals to be exposed to this information before field work. The team will create a class that introduces fluorescent technology, specifically Fluorescence Spectroscopy, in both theoretical and mathematical explanations. The class will be focused on how and why Fluorescent Spectroscopy can detect oil while also introducing students to existing technology currently in the field.

MEM-26 Sustainable Lunar Surveillance Rover (S.L.S.R)

Eunsung Han, Jimmy Huang, Ian Lawton, Nicholas Lombardo, Andy Wang
Dr. Ajmal Yousuff

Transporting materials from Earth to the Moon is expensive, takes a lot of time, and burns tons of fuel. Inhabitants of the Moon will instead have to implement methods for collecting, processing, and storing local materials. This process is referred to as in-situ resource utilization (ISRU). The lunar regolith is abundant with metals that can be processed and later used to manufacture products.

The collection of local materials has been studied extensively, but information on processing and then manufacturing has only gone as far as creating habitats on the Moon. Excavation and surveillance of the lunar surface will require rovers sent from Earth. What if people could build rovers out of materials on the lunar surface?

The SLSR project's objective is to design a 3D-printed surveillance rover manufactured using local lunar materials. The structural components of the rover will be comprised of aluminum extracted from regolith through the process of powder metallurgy and manufactured using direct metal laser sintering 3D printers. The SLSR will be the steppingstone to the creation of a workshop that can create rovers with different purposes out of local resources. The physical prototype of the SLSR will be 86% 3D printable by mass. MEM26 is currently programming and assembling parts to begin testing the capabilities of the rover. The team plans to simulate situations that the SLSR will be disposed to on the Moon over this last term. The simulation will involve testing traversal and surveillance capabilities, as well as obstruction avoidance/perseverance.

MEM-27 Hydrothermal Vent Metal Collector

Connor Carvin, Andrew Li, Abhi Patel, Ivan Yu, Vicki Zhuo
Dr. Antonios Kontsos

Hydrothermal Vents (HVs) are openings in the ocean floor at depths of 2000 meters or greater that output heated mineral-rich fluids which often contain rare-earth metals (REMs). REMs are critical components in most electronic devices and renewable energy applications and therefore they are currently a high demand commodity, as also demonstrated by the recent rise of demand during the COVID pandemic. Currently, some common methods of mining REMS include open- pit and seabed mining. Unfortunately, these methods of mining disrupt and destroy natural habitats and ecosystems. In this context, HVs could be leveraged to supplement or even completely replace current destructive mining techniques, allowing to tap into mostly underutilized resources. The main objective of our Senior Design project is to design and manufacture a scaled-down prototype of a HV collector. The proposed prototype will be designed with a filtration system capable of collecting particles larger than 0.5 μm while being designed to sustain the harsh environment near actual ocean floors. Collected particles will be filtered into an appropriate container. This collected mass will then be needed to be transferred via a slurry pump to another carrier, similar to marine vessels on the ocean's surface in the envisioned real-life implementation of our prototype. Feasibility of the prototype development has been partially tested through submarines and related instruments, however a system like the one proposed has not been reported yet. The team has proceeded with fabrication of the prototype. Preliminary tests of the filter and water-tight seals proves design concepts.

MEM-28 Bio-Inspired Lunar Rover

Helena Carlos, Sihah Joonhigh, Kristopher Lopez, Kaley Nhu, Darius Olega
Dr. Ajmal Yousuff

Rovers play an essential role in space exploration by providing valuable information to scientists on the environments of celestial bodies. These teleoperated vehicles grant researchers the opportunity to explore the unknown without enduring its harsh environments. However, traditional wheeled rovers have limited capabilities in navigating complex terrain on the moon, including slopes greater than 30 degrees, icy and rocky areas, and smaller confined spaces.

Other forms of locomotion, such as articulated leg movement and compliant end-effectors, can provide capability to traverse extreme environments. The Bio-Inspired Lunar Rover is an omnidirectional six-legged robot with three degrees of freedom on each leg to test the functionality and effectiveness of three types of end-effector designs to counter extreme lunar terrains; the hexapod leg arrangement increases maneuverability navigating slopes. The alternative locomotive mechanisms demonstrate compliant characteristics from animals known for being excellent climbers, including arthropods and mammals. The first end-effector features a 3D-printed umbrella mechanism that deploys a canopy to increase the footprint and provide greater weight distribution and traction. Another incorporates non-slip paw-like structure, using neoprene to brace the rocky lunar environment through shape adaptation by increasing grasp surface area while ensuring stability by dampening impact forces. The final mechanism mimics mountain-goat hooves by transforming vertical forces into horizontal using a system of springs as the body climbs steep slopes and icy terrains. Further testing will be conducted to verify whether end-effectors that provide greater surface area will demonstrate a more stable walking gait as well as higher slip resistance throughout harsh environments.

MEM-29 Floating System Concept for Flooded Cars

An Nguyen, Yuanzhe Zhu, William Zhang, Khoi Hoang
Dr. Ahmad Najafi

Car safety has been one of the most important fields in automobile designs, from simple innovations like seatbelts to more complex designs like crumple zones. One of the less common, yet recognizable threats to any car owners is car flooding, either due to natural (heavy storms) or human causes (drunk driving, poor bridges, etc.). With the growth of self-driving cars and climate change, a solution may be more needed than ever. Unfortunately, there have not been effective solutions with the most common being escaping techniques from a sinking car instead of a safety mechanism. There have been researches into assisting escape attempts that still relies much on the passengers or preventing the vehicle from sinking which complicates automation mechanisms. Our goal is to combine the detection system of the former and the airbags-raft system of the latter and evaluate the feasibility of the merged system with the idea of complementing the issues of both. The design generally includes electronic sensors and a pneumatic airbags system. A water sensor ensures the flooding condition is met, while a gyroscope ensures the vehicle is correctly oriented for the passenger's safety. A 5-panel section airbags system is used to provide buoyancy. Using a small-scale prototype, it shows that the system works in theory with a high success rate, provided the everything behaves within expectation. However, there are still many problems that could appear when applying to real-life including vehicle behaviors, balance shifts, material costs, etc. that would hinder the practicality of the design.

MEM-30 Adjustable Barbell

Evan Lineman, Daniel Khademi, Jack Ehrich, Marcelo Ozuna
Dr. Jennifer Atchison

Barbells are common exercise equipment utilized in gym environments. A barbell consists of an elongated shaft that supports weight plates on both ends. Exercises focus on working multiple muscle groups on both sides of the body. Barbells require the use of loading and unloading heavy plates so users can exercise with the appropriate resistance. Currently, there is no design approach to reduce the amount of unnecessary stress and strain caused by loading weight onto a barbell prior to a workout. A barbell's ease of use could be improved by introducing an adjustable system for loading and unloading weight plates to the shaft. Similar mechanisms are already utilized in smaller exercise equipment such as dumbbells. The Adjustable Barbell's objective is to increase the user-friendliness of the barbell by implementing an adjustable weight system that reduces loading time and unnecessary stress and strain that could result in injury. The project will focus on the design and build of a prototype barbell system that when implemented with adjustable components, will allow users to easily load and unload weight onto the barbell shaft, as compared to a barbell utilizing fixed weights loaded onto the ends of the barbell shaft. The Adjustable Barbell will use a slotted weight and key design to secure weights on the shaft. This project is committed to enhancing the exercise experience so that all gym-goers of varying skill levels will be comfortable utilizing the design to improve their health.

MEM-31 Autonomous Mecanum Wheel Open-Source Robot (A.M.W.O.S.R.)

Daniel Belote, Tom Huang, Thomas Juhas, Chad Ross
Dr. Bor-Chin Chang

Autonomous robots have allowed companies to run more efficient operations by automating repetitive tasks, such as moving products within warehouses. After purchasing an autonomous robot, the buyer can use it for any number of purposes, such as in cleaning and logistics environments. The autonomous robot senses the environment using cameras and other sensors and then performs tasks through programs like Arduino and Python. However, current autonomous robots are limited by high costs and limited maneuverability. These two drawbacks can be addressed by making the robot open source and by using a different steering system. The robot's objective is to expand upon the ability to maneuver in tight spaces while being able to map out an environment that will roam around efficiently. This project will demonstrate the ability of Mecanum wheels to improve the maneuverability of the robot in tight spaces. The robot itself features time of flight sensors to avoid obstacles and measure distance while the robot drives around. The robot's autonomous nature will allow for efficient scalability as it can avoid other variants of itself throughout a region.

MEM-32 Electric Motor Attachment for Manual Wheelchairs

Frank Tiesi, Alex Zingani, Bryant Le, Anthony Sordini
Dr. Lutfi Agartan

A wheelchair is an essential piece of equipment for those with disabilities, as it supplies mobility and ensures a better quality of life. It is also essential for healthcare workers who use them to move immobilized patients in the hospital. Wheelchairs often come in two forms – manual and electric. Both options supply value, but there has been a rise in demand for electric wheelchairs in recent years, as manual wheelchairs can be physically taxing on the user. Unfortunately, electric wheelchairs present their own problems as well. Given their bulky size and weight, transporting an electric wheelchair is an arduous process, and maneuvering in tight spaces is exceedingly difficult. They also come with a hefty price tag. The lives of those with disabilities can be improved if there was a way to reap the benefits of an electric wheelchair without the negative consequences. This project aims to create an electric motor attachment for manual wheelchairs, which would allow people to easily convert any manual wheelchair into an electric powered wheelchair at a low cost. The design will feature a substructure that includes a battery pack, two brushed DC motors, and two wheels to move the wheelchair. This substructure is attached beneath the wheelchair within the original dimensions of the chair, adding no extra bulk. The user will be able to control the speed and direction of the wheelchair via a joystick. With this design, users will be able to reap the benefits of an electric wheelchair on their own manual wheelchair.

MEM-33 Automated Pharmaceutical Prescription Systems (A.P.P.S.)

Gwyn Godin, Adam Nork, Jonah Roberts, Michael Webster
Dr. Bor-Chin Chang

Medication prescriptions are essential to continuing treatment of an ailment outside the supervision of medical professionals. Pharmacists currently fulfill these prescriptions by hand, with a total of 4.69 billion prescriptions filled in the last year, which is projected to increase every year. Unfortunately, since prescriptions are all fulfilled by hand, human-caused errors in the fulfillment process may occur, leading to approximately 15% of patients receiving the incorrect dosage. This can be deadly as stronger and more potent medications are prescribed. Large, corporate run pharmacies fulfill up to 93% of all prescriptions with a limit on the time pharmacists have to fulfill the order, leading to fatigue and more human errors. The APPS project aims to merge this basic fulfillment process with automation to minimize the potential for human related errors. This project shows proof of concept of automation within the pharmacy setting with scalable technology by expanding on similar technology currently focused on individual, at-home medication dispensing systems. Within the housing of the APPS, three Solid System Designs (SSD) custom made pill gears work to dispense a precise amount of medication. Originally, the APPS project intended to incorporate a three-geared Liquid System Designs (LSD), but decided to forgo this option and focus on the solid system design. Arduino-based controllers work as the central brain for the APPS, operating the motors for their respective systems allowing for independent operation of each. An integrated mobile device app works as a user-friendly interface to allow for prescription fulfillment from anywhere in the pharmacy.

MEM-34 Electric Mini-Truck

Ethan Selvaggio, Michael Pirylis, William Rosen, Ian Beach
Dr. Dimitrios Fafalis

Nowadays, the working class all around the world, most commonly in Asia, use gasoline powered Kei trucks and cars to transport materials, supplies, and people around major cities and farmlands. First introduced after World War II, these vehicles quickly became abundantly used for their affordability, versatility, and practicality, and have been sold and used by many companies.

However, these vehicles produce significant noise pollution and emissions in areas that are already hindered by such issues. These combustion vehicles burden the owner with significant operation costs and the surrounding population with poor air quality. Due to their affordability and manufacturability, they are easily replaced, leaving older models in junkyards, and producing general material waste.

To address these issues, an easily installed and relatively affordable electric drivetrain kit was designed to retrofit existing vehicles, allowing for quiet, emission-free operation. This is achieved by integrating a simple electric motor, a fully custom recycled battery system, and aftermarket controller in conjunction with a reinforced vehicle chassis and novel mounting system. This kit is more affordable than the purchase of a new combustion vehicle, with the elimination of vehicle waste. The design of this EV kit involves simple user interfaces and packs higher performance metrics with torque and horsepower, all while retaining the vehicle's original functionality, such as storage and drivability. The significantly higher torque output greatly benefits vehicles used to transport goods, resulting in faster delivery of more products. Electric drivetrains are already being implemented across many major automotive manufacturers for consumer and commercial use.

MEM-35 Limb Difference Heating Sleeve

Andrew Hamilton, Cole Barone, David Mathai, Thomas Evers
Dr. Moses Noh

Amputees, as well as people will circulation issues often suffer from poor thermal comfort with regards to their affected limb. This results in an uncomfortable and painful cold sensation, which worsens depending on the ambient temperature and humidity. Current items on the market do not deal with this problem as they are not geared for amputees, nor do they have the required power supply for prolonged use. Additionally, current items are also unable to assist people with circulation issues as they do not target specific areas. Limb Difference Heating Sleeve aims to provide a cheap solution to these problems by creating a heated silicone sleeve that can maintain a desired temperature for an extended period. The Limb Difference Heating Sleeve will use thermally efficient materials to maximize performance and maintain a long-lasting battery life.

The sleeve will use silicone for even heat distribution as well as comfort, and Kanthal 20-gauge wire as a malleable, yet energy efficient heating element. The Limb Difference Heating Sleeve will be able to operate at a wide range of temperatures in order to accommodate different environments. In addition to heating and energy efficiency, the Heating Sleeve will be both simple to operate and maintain. Because of its energy efficiency, common batteries can be used for a power supply, thus allowing the user to simply change the batteries when required. The Limb Difference Heating Sleeve will serve as a steppingstone for providing affordable comfort to those in need of it.

MEM-36 Multi-band Ultraviolet Post-Processing Curing Oven (MBUVPPCV) for Liquid-based 3D Printing

Brandon Burg, Jacob Hall, Alex Mount, Christopher Reed, Robert Vanleer
Dr. Antonios Kontsos

Stereolithography (SLA) is a 3D printing process in which photopolymers are selectively cured by an ultraviolet (UV) laser. SLA printers are known for their ability to create concept models, prototypes, and complex parts with intricate geometries while producing reputable surface finishes through high resolution. Once a part has been printed on an SLA printer, it must be post-processed through a heating chamber and UV curing apparatus known as a post-cure oven. This process allows parts to achieve their optimal mechanical properties and maintain part integrity. Unfortunately, available options for current resin curing methods in the industry are very limited. Most SLA 3D printer manufacturers supply a proprietary curing oven as a complimentary resource to their own 3D printer; this forces corporations and small business owners to purchase multiple post-cure ovens to meet all their manufacturing needs. By introducing the proposed solution, consumers will not be limited to the proprietary post-cure apparatuses and instead have more flexibility over accessibility to temperature regulation, wavelength and frequency concentration, and intensity properties. The proposed solution is to create a versatile curing oven that is compatible with many types of resins available that require specific property combinations. The design will consist of a controller, rotating turntable, multiple wavelength ultraviolet light emitters, and a heating element. The controller will allow users to create custom recipes with various wavelengths, temperature, and time combinations. These recipes will allow consumers to properly cure parts printed using any SLA resin under the sun.

MEM-37 Project Kinetik

Daniel Gerus, Will Messick, Erica Palandro, Anton Turpault, Tyler Wolf
Mr. Joshua Geating and Dr. Li-Hsin Han

Hands-free, close-distance transportation is commonly seen in skateboards, scooters, and bicycles, each of which can be strenuous to manually operate. Motorized options include booster boards, hoverboards, etcetera. These options,

however, have large turning radii, making them difficult to maneuver in urban areas where higher agility and sharper turns are necessary. Altering movement abilities will allow for more possibilities in this sector, permitting more use in urban environments, sports, and other hobbyist activities. Project Kinetic is the modification of an existing transportation robot. The intent of this project is to alter the mode of operation from a remote control. This will be the first robot developed for hands-free human transportation with more degrees of freedom than other options on the market, which will close the gap of mobility currently lacking in personal transporters. Design goals are hardware delivery and implementation, output signal generation, and components that support and transport human body weight. Developers are currently sourcing COTS parts and stock material, as well as communicating with the Drexel machine shop to manufacture custom parts. One component is being outsourced since it is outside the scope of the group and Drexel machinist. Once all parts are completed and assembled, the encoders will be programmed, and electrical and mechanical testing of the robot will begin.

MEM-38 Sparrow Single-Seat Golf Cart

Ryan Boyd, Lewis D'Ippolito, Thai Hua, Daniel Johnson
Dr. David Miller

The game of golf has been around for centuries and has grown a lot over that time, but over the last two decades there has been a steady decline in the number of people that golf. The main reason for this is that a full round takes about 5 hours to complete, which is too long for most people. Research has been done looking into ways to speed up the game and discovered that transportation is the main issue for the pace of play. Standard two-seat golf carts have been around since the late 1950's and are used nearly everywhere, but their use accounts for most of the wasted time in a round of golf. Many courses only allow groups of four to play. This causes delays because there are 4 people shooting 4 balls but only 2 carts, so group members must wait until their partner shoots before looking for their own ball. This nearly doubles the pace-of-play. So, despite the widespread use of two-seat carts, evidence suggests that a change in transportation would be economically and logistically beneficial to the game. We believe that the best way to speed up the game is to allow each golfer to have their own cart. Research has shown that when using single-seat carts the pace-of-play dramatically increases. Our design allows for easy integration into existing infrastructure and boosts course revenue as well. After assembling the electronics, wheels, and steering assembly, it is clear that this design will meet all our expectations and perform well on a golf course. The remainder of this paper will be dedicated to backing up these statements and proving the benefits of this cart.

MEM-39 Autonomous Line Climbing Datalogger (ALCK)

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Dr. Richard Cairncross

The planetary boundary layer is Earth's lowest atmospheric layer. It contains most of the weather and the largest exchange of the Earth's energy budget occurs. Data such as air density, temperature changes, and humidity can be used to help predict such phenomena. Current alternative aerial dataloggers include drones, crewed aircraft, and weather balloons. However, all the listed options are much more expensive to manufacture, much more expensive to operate, and cannot be flown in hostile conditions without the risk of damaging the equipment. Kites provide the ability to collect data t different altitudes for extended periods in turbulent conditions. The objective is to create an autonomous line climbing kite (ALCK) datalogger to record data using several sensors at varying altitudes in the planetary boundary layer. The sensors include a humidity sensor, temperature sensor, barometric pressure sensor, among additional sensors that will record the data. The sensors are attached to the ALCK system which is capable of autonomously climbing and descending the line of a pre-existing kite using solely aerodynamic forces for up to 12 hours at a time. Numerical analysis has assisted in understanding line climber movement and will be used for the creation of PIO loops for the control system. The prototype will be tested up to 500ft above sea level and in the future be used as a guide for newer iterations to reach higher ranges of the planetary boundary layer and beyond.

MEM-40 Electric Aeromedical Plane Design

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Dr. Divya Bhargava

Many locations both in America and abroad have remote areas or are not within driving distance of higher-level trauma centers. Air medical services such as air ambulances have been crucial in transporting injured and sick people for more complex care. These services have also been advantageous in emergency situations where an air ambulance can transport patients faster than ground ambulances due to terrain issues. Many aeromedical companies that fly these patients currently have helicopters and fixed wing aircraft in their fleet. These current vehicles are mechanically complex and incur significant costs to the company and patients. The Electric Aeromedical Plane's goal is to minimize these costs and design an electric motor-powered plane that will transport these patients safely to the care they need at considerably less cost. By using batteries and an electric motor, the plane will be significantly less mechanically complex than its competitors, making its maintenance costs a fraction of what helicopters incur. Additionally, electricity costing much less than jet fuel and providing a sustainable source of propulsion, provides an even bigger incentive to the industry to use an electric plane. A small body size fitted with a NACA 4412 airfoil and a bush plane landing gear will significantly reduce the takeoff and landing distances. Thus, making the plane competitive with helicopters, and enabling the plane to save patients in most terrain. With developments in battery technology only increasing their capabilities, the viability of an electric aeromedical transport plane becomes more and more feasible every day.

MEM-41 Solar Dragons

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Dr. Kevin Scoles

There is no path to protecting the climate without dramatically changing how we produce and use electricity: nearly 40% of US CO2 pollution comes from power plants burning fossil fuels. But we can turn things around. Renewable energy minimizes carbon pollution and has a much lower impact on our environment. In 2015, Ohio State University promulgated a set of Sustainability Goals, which include carbon neutrality and other targets to demonstrate environmental and energy leadership in the United States and abroad. By Ohio State University, we are tasked to produce a complete conceptual design and techno-economic analysis of a proposed interconnected solar PV plus battery electric storage system. This system will maximize energy offset and savings over the system's contracted or useful lifetime for the Ohio State Medical Campus and nearby agricultural plot of land, and to decrease the pollution contribution to the area. The key feature of the desired solution is a project proposal that encapsulates and summarizes:

The conceptual system design that describes the layout and specifications for the PV system including the battery electric storage system

The distribution system impact analysis and how the PV system will interact with the already existing distribution network

The financial model that demonstrates the savings of the customer as a result of the PV system installation and whether it would be a positive return of investment (ROI)

The developmental plan that shows the construction and installation process of the design considering how this is going to fit within the overall developing plan of the Ohio University.

MEM-42 Design and Testing of an Artificial Sunlight Window

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Dr. Jennifer Atchison

Exposure to sunlight is an important part of a healthy lifestyle for humans. Sunlight helps stimulate the production of vitamin D and maintain the Circadian rhythm, the natural process that helps the human body adjust to the passage of time and ensure we know when we need to sleep. It also helps produce serotonin, a hormone that boosts a person's mood and helps them feel calm and focused. Unfortunately, at this moment in time the average American spends more than 90% of their time indoors, according to the EPA. This is particularly prevalent in office workers, many of whom do not have access to window space in their workplace. This leads to Seasonal Affective Disorder (SAD), a form of depression characterized by insomnia, fatigue, and a lack of motivation. A lack of sunlight helps contribute to a stressful workplace and hampers productivity. With our project, we intend to give every worker a chance to experience a substitute for sunlight that can help fulfill their needs. This project will focus on the building and testing of an artificial sunlight window, which will be capable of following the sun's path across the sky over the course of the day and ensuring the light is as close as possible to real sunlight via Rayleigh scattering. If utilized in an office setting, workers will be able to reap the benefits of the sun without having to sacrifice office space. This will be a major contribution to many American workplaces on a budget.

MSE-1 Scaling Up A Topochemical Fluorination Reactor

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Dr. Steven May

Topochemical fluorination is a burgeoning process in research wherein fluorine is substituted for oxygen within an epitaxial metal oxide thin film without changing the parent crystal structure. The novelty of this process lies in the resulting changes in the electronic, ferroic, and optical properties of the resulting films. Leveraging engineering design criteria from the chemical vapor deposition (CVD) industry, an enclosed reactor was designed and constructed to scale up the fluorination process for epitaxial thin films to support ongoing NSF-funded research (NSF Award #1562223). Topochemical fluorination had previously been performed using a one-inch glass tube furnace. This method was limited by small sample size and slow production rate due to geometrical constraints. The new reactor design addressed the geometrical constraint that limited the previous method, being designed to accept up to four 2-inch single crystal wafers located on a resistively heated substrate holder. Silicon wafers were successfully fluorinated from a heated PVDF source and characterized using x-ray photoelectron spectroscopy (XPS) and ellipsometry to verify that fluorine was being deposited onto the sample surfaces. Results confirmed that the new reactor design was capable of topochemical fluorination. A strontium ferrite ($SrFeO_{2.5}$) sample has also been trialed to investigate the scaled-up reactor's capability relative to the glass tube furnace process.

MSE-2 Quantum Materials Properties Characterization Using Computational Models

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Quantum materials are a class of materials whose properties and phenomena fundamentally rely on the quantum nature of the electronic structure. Material properties originate from the interactions between atoms and electrons on a quantum scale. Density Functional Theory (DFT) is a reliable and accurate first-principles computational method to predict electronic structures and can be used as an approach to understand the electronic properties and behaviors of materials. In *Topological Insulators versus Topological Dirac Semimetals in Honeycomb Compounds*, Zhang et al.

identified 22 Dirac semimetals with ABC honeycomb structures that have the potential to be thermodynamically stable. In this work, the actual feasibility of these compounds was investigated using DFT calculations, aimed at determining formation energies and structural distortions. In particular, the presence of structural distortions away from perfect symmetry, caused by buckling within the honeycomb layers of the ABC structure, was considered. The buckling of the stable compounds was determined by performing DFT relaxation calculations to optimize ionic positions. After discarding the unstable compounds from further testing, electronic properties of the remainder were determined by evaluating the band-gap energies of the compounds obtained through DFT calculations. These electronic properties indicated which of the 22 ABC structures recommended by *Zhang et al.* would be worth exploring in a physical laboratory.

MSE-3 Synthesis of MXenes from Novel MAX Phases

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Dr. Yury Gogotsi

MAX phases, $M_{n+1}AX_n$, are bulk ternary transition metal carbides and nitrides where M is an early transition metal, A an A-group element from Groups 13 and 14, X a carbon (C) or nitrogen (N), and n generally a number between 1 and 4 that defines the stoichiometric ratios. At Drexel University, MAX phases are well known as the precursor materials for the synthesis of MXenes, a family of multilayered two-dimensional materials created by selectively chemically etching MAX phases to remove the A layer atoms. Non-Al MAX phases were explored, focusing primarily on Sn- or Si-based MAX phases as they are the basis for potentially forming new MXenes that were not previously accessible from established Al-based MAX phases. Non-HF etching chemistries have also been explored to selectively remove either the Sn or Si from these phases to produce MXenes without the use of HF. A standard set of synthesis conditions (n values of 1, 2, and 3, in addition to these same ratios with increased amounts of the A element, using a high and low synthesis temperature), were studied to explore novel non-Al MAX phases. X-ray diffraction (XRD) was used characterize the materials produced and determine the resulting structures and compositions. The XRD results, in combination with simulated MAX phase diffraction patterns of the material systems explored, showed indications of the presence of MAX phases, but not as the majority product. Common industry-etching chemistries have also been used on known MAX phases for indications of the presence of MXenes.

MSE-4 Designing Sustainable Plastics

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Dr. Christopher Li

Plastic production and disposal are increasingly creating waste products and pollution in the environment, with plastic waste taking exceptionally long times to degrade while creating harmful waste. One sustainable solution for current plastic production is the use of polylactic acid (PLA) as a material. Specifically, the “shish-kebab” nanofiber morphology (NFSK) has shown promise in improving the properties of crystalline PLA, which are currently not suitable for use as a large-scale plastic due to its poor plasticity and degradation resistance. Processing of the NFSK materials is challenging due to their relatively low melting temperature, resulting in degradation of the PLA during processing. To combat these challenges, samples of PLA nanofibers were annealed before incubation to allow for widespread and complete formation of the NFSK structure. PLA samples were produced using various ratios of PLLA to PDLA, which are both chiral monomers of PLA. Incubated samples were characterized using scanning electron microscopy (SEM) and differential scanning calorimetry (DSC) to determine their thermodynamic properties. Mechanical analysis was performed on incubated samples to compare the resulting properties among the various PLA ratios with those of other traditional plastic materials.

MSE-5 Near-Infrared Photodetector for Future Use in an Imaging Wand

Anjiao Wetherhold, Maxene Kohler, Frankie Lau
Dr. Wei-Heng Shih

Current methods of *in vivo* cancerous tumor imaging have low specificity. Recent research using quantum dot (QD)-based immunofluorescence (IF) showed higher specificity. While promising, its use within a surgical setting is limited by the bulky set-up used to detect IF-stained tissue. An alternative design of a handheld imaging wand using a near infrared (NIR) semiconductor photodetector on a transparent conducting substrate with a narrow gap has been proposed. Multiple imaging wand concepts have been explored: ambient-stable cubic $MAPbI_3$ rods placed across the gap to absorb in the NIR directly, and conducting poly(3,4-ethylenedioxythiophene):polystyrene sulfonate (PEDOT:PSS) with embedded $MAPbI_3$ and lead sulfide (PbS), acting as an NIR harvesting material. The semiconductors were assembled on an indium tin oxide (ITO) substrate with a scribed gap. Wires were attached to the semiconductors using conductive glue to measure I-V characteristics. $MAPbI_3$ rods were dropped onto ITO glass with a gap and allowed to evaporate and microscopy used to verify $MAPbI_3$ rods spanning the gap. PEDOT:PSS with PbS was drop-cast onto ITO glass to embed $MAPbI_3$ or PbS in the polymer matrix. Data was collected under dark conditions with no light and with an NIR lightbulb to compare the characteristic I-V curves. In the case of PEDOT:PSS with $MAPbI_3$ or PbS, the current increased more than for pure $MAPbI_3$ microrods, with embedded $MAPbI_3$ showing a larger response than PbS. Results showed that NIR photodetectors made using a simple design could be made into hand-held devices to detect fluorescence images in immunofluorescence staining of cancer cells.

MSE-6 Continuously Aligned Track-Spun Polymer Fiber Collection Device

Joseph Michalowicz
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Generating 2D and 3D nanofiber structures with a layer-by-layer, aligned, or crisscrossed pattern for current tissue engineering research requires complex and expensive tooling that is often bottlenecked by polymer precursor type and fiber generation technique. An automated polymer fiber collection device, in conjunction with a novel mechanical fiber drawing technique known as track-spinning, has been designed, built and tested to control the end-to-end fiber placement and porosity in arranged structures, and to determine which process parameters had the largest influence on the spatial resolution, orientation, and degree of crystallinity of polymer nanofibers produced. The challenges with the devices included accurate control of the collection platform translation speed, and establishing the track-spinning control parameters required to reliably produce nanofibers with consistent average diameter and length from polyacrylonitrile (PAN) and dimethylformamide (DMF) precursor solutions. The prototype collection device design and associated programming moves and rotates the collection platform through multiple axes at the required speeds using programmable commercially available hardware. The accuracy and precision of nanofiber deposition and design effectiveness was determined *via* a series of trials. This collection device, in conjunction with the novel track-spinning technique, could greatly enhance the development of tissue engineering technology and other nanofiber applications currently limited by materials and costly equipment.

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