University of Pittsburgh
Mascaro Center for Sustainable Innovation

2022 Undergraduate Summer Research Project Descriptions

Application link: Sustainability Summer Research Application
Applications Due: February 16th
Program Runs: May 9 – July 29, 2022

Sustainable and Reliable Energy Management
This project focuses on energy distribution system with distributed energy resources (power storage and photovoltaic) and variable loads (including electric vehicles). It involves applying artificial intelligence (AI) for autonomous energy management to improve sustainability and reliability.
Advisor: Mai Abdelhakim, Electrical and Computer Engineering

Global Projects for Developing Cultural Diversity and Global Awareness in Engineering Careers
In depth analysis of 33 global projects developed by SSOE/ChE students joining foreign partners all over the world. Proposal and development of a social-media platform to socialize the results. Structure of an expanding worldwide social network of people and institutions. Literature research and background summary for publications. Benchmark and best practices. Extensive guidelines and rubrics.
Advisor: Joaquin Rodriguez Alonso, Sustainability in Engineering Education

Outreach Projects for Promoting STEM Careers and the Social Appreciation of Engineers
In depth analysis of over 80 outreach projects developed by SSOE/ChE students. Proposal and development of a social-media platform to socialize the results. Structure of an expanding social network of people and institutions, state and nationwide. Literature research and background summary for publications. Benchmark and best practices. Extensive guidelines and rubrics.
Advisor: Joaquin Rodriguez Alonso, Sustainability in Engineering Education

Mapping Intersections in Water Inequities
Spatial patterns in water inequities will be compiled from existing and novel data to identify interactions among these inequities and the resulting impacts on people and communities. Project work will accommodate student interests, while emphasizing cross-site comparative and accumulative impact analysis frameworks.
Advisor: Dan Bain, Geology and Environmental Science

Legacy Soil Metals in Urban Systems
Soil metals are enriched in urban systems owing to long histories of industrial activities and concentrated human inputs. This project will use measurement, data synthesis, and comparative analysis to reveal important patterns in soil metals and the implications for urban systems.
Advisor: Dan Bain, Geology and Environmental Science

Solar-Powered Fabrication of Functional Graphene for Flexible Electronics
The fabrication of carbon nanomaterials such as graphene, carbon nanotubes, and other porous nanocarbons is typically achieved through energy-intensive processes such as chemical vapor deposition. This project will focus on developing solar-powered alternative toward fabricating functional graphene orders of magnitude lower carbon footprint and less emissions.
Advisor: Mostafa Bedewy, Industrial Engineering

Solar-Powered Self-Folding of Shape Memory Polymers Toward Origami-Based Green Manufacturing
Creating intricate three-dimensional structures such as mechanical metamaterials is typically either achieved by additive manufacturing or by other complex multistep fabrication processes, both of which can be slow, expensive, and energy-intensive. This project will focus on developing a solar-powered alternative toward creating directed bidirectional folds in thin sheets of prestrained polymers.
Advisor: Mostafa Bedewy, Industrial Engineering

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Pitt Regional Campus Greenhouse Gas Inventor(ies)
The University of Pittsburgh has been doing greenhouse gas (GHG) inventories for the Pittsburgh campus since 2008, but the carbon impacts of Pitt's regional campuses in Bradford, Greensburg, Johnstown, and Titusville have never been inventoried. This project will work to create the first GHG inventory for at least one and up to all four of the regional campuses, collaborating with Pitt's cross-departmental GHG inventory team and regional campus operational experts. Data collection will be completed across Scope 1, 2, and 3 emissions, which includes campus energy use, commuting, air travel, and other categories.
Advisors: Melissa Bilec, Civil and Environmental Engineering
Aurora Sharrard, Sustainability

Sustainable Forestry within the Eastern Deciduous Forest Biome: Is salvage logging compatible with healthy forest regeneration following a major windstorm?
We are rigorously evaluating if logging that occurred after a tornado blowdown in the Laurel Highlands of Pennsylvania is inimical to the regeneration of a diverse and healthy forest. During the summer of 2021, we will recensus trees and shrubs as part of a long-term field experiment evaluating forest sustainability at the Powdermill Nature Reserve, the field station of the Carnegie Museum of Natural History.
Advisors: Dr. Walter Carson, Biological Sciences
Hannah Assour, Biological Sciences

Additive Manufacturing of Magnetocaloric Materials for High Efficiency Cooling
Ni-Mn-Ga-X alloys have shown great potential to be a solid state cooling material with much higher energy efficiency than traditional cooling systems. In this project, we will optimize the printing of magnetocaloric materials to enable the building of high surface area structures for improved heat exchange, characterize and test the materials with advanced magnetic and thermal characterization methods and scanning electron microscopy.
Advisor: Markus Chmielus, Mechanical Engineering and Materials Science

Sustainable N95 Filters via Binder Jet 3D Printing of Reusable, Self-Sterilizing Metal Filters
The Covid-19 pandemic not only has a large toll on humanity, but also creates large amounts of unrecyclable garbage from one-time-use, throw-away masks and other medical equipment. In this project, we are working on optimizing the binder jet 3D printing and sintering parameters to enable strong, easy to breath-through, N95 compliant filters, use microCT and scanning electron microscopy to characterize the printed filters, and adapt testing setups to test these filters.
Advisor: Markus Chmielus, Mechanical Engineering and Materials Science

Microswimmers in the Ocean
Organisms ranging from bacteria to protozoa and crustaceans are ubiquitous in the ocean. These organisms are universally featured with non-spherical shapes and considerable intrinsic mobility, and they are usually surrounded by complex or even turbulent fluid environments. Over the summer, you will use high-speed cameras to study the microswimmers in a mimicked ocean environment experimentally in the lab.
Advisor: Lei Fang, Civil and Environmental Engineering

Bubble Eruptions at the Air-Sea Interface
There are roughly 10^20 bubbles (100 billion billion bubbles!!) that erupt every second at the ocean surface. A huge amount of gas and liquid has been fluxed from the ocean to the atmosphere every second, so understanding the detail of bubble eruption is of great significance. This summer, you will use a high-speed camera (that can acquire images at 20,000 frames per second) to study the process of bubble eruption.
Advisor: Lei Fang, Civil and Environmental Engineering

A Building Information Modeling-Virtual Reality Interface for Disaster Management and Mitigation
In this project, we will investigate capabilities of novel tools for data manipulation between Building Information Modeling (BIM) and Virtual Reality (VR) platforms, in the specific context of disaster management, response and recovery. We will provide novel comprehensive tools for 3D visualization and manipulation of large geospatial datasets. Within this environment, we will define novel Agent Based Modeling techniques to increase the immersion and fidelity of the VR simulations.
Advisor: Alessandro Fascetti, Civil and Environmental Engineering

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Agent-Based Modeling of Root Growth in Pervious Concrete Elements
In this project, we will build agent-based modeling techniques for the numerical simulation of root growth in the large, connected pore networks typical of pervious concrete materials. These composites are, in fact, being used in environmental restoration projects (particularly in riverbeds), and a thorough description of their compatibility with different types of vegetation could help increase efficiency and sustainability of this type of applications.
Advisor: Alessandro Fascetti, Civil and Environmental Engineering

Save It, Don't Spray It: Do water saving showerheads impact the microbes we breathe in during showering?
This project will compare the drinking water aerosol particle distributions and concentration of bacteria individuals are exposed to during showering when using conventional shower heads and water saving shower heads. Specifically, aerosol dynamics and respirable bacteria from showerheads will be assessed in our full-scale shower lab to determine if water saving shower heads such as EPA's WaterSence head create unexpected negative impacts on microbial air quality.
Advisor: Sarah Haig, Civil and Environmental Engineering

Measuring Ozone Deposition to Crops
This project entails the development and testing of a rapid ozone sensor capable of quantifying the deposition of the pollutant ozone to croplands. The instrument will be built and calibrated on campus and tested at an agricultural field site.
Advisor: Reem Hannun, Geology and Environmental Science

Structural Design with Bamboo
Dr. Harries led the successful effort to develop an international standard for design with bamboo (ISO 22156). There are multiple opportunities for self-contained research studies directly related to identified research needs and the development of the next version of the standard. Projects include study of test methods for shear, bamboo connection methods, creep, and durability. Architecture students or those taking the Architecture Minor would have the opportunity to design bamboo structures.
Advisor: Kent Harries, Civil and Environmental Engineering

Statistical Models for U.S. Electricity Grid Renewable Production
A long term project in my group is to develop optimization models to help grid operators make decisions. This project will build statistical models of US renewable energy production which will be used within these optimization models. Key skills for the project: coding, and data analysis.
Advisor: Oliver Hinder, Industrial Engineering

Reducing Energy Consumption through the Optimization of Low-Friction Coatings
Because roughly 8% of all energy used in the US is wasted overcoming friction and wear; this project helps to remedy this by understanding and improving low-friction, wear-resistant coatings. Specifically, the student(s) will use cutting-edge experimental tools to investigate how the adhesion and friction of a coating depend on its surface roughness.
Advisor: Tevis Jacobs, Mechanical Engineering and Materials Science

Alchemical Screening for Hetero-Bimetallic Catalysts
This project will use our group's developments in computational alchemy methods to study chemical catalysis reaction mechanisms involving earth abundant metals. An innovative aspect of this project is the understanding of how and why combinations of two earth abundant metals can bring similar catalytic properties as a single precious metal. This computational project will be done in collaboration with experimentalists at the University of Illinois, Chicago.
Advisor: John Keith, Chemical and Petroleum Engineering

Distributed Energy Resource Control
Distributed energy resources (DER) such as solar, battery storage, and even reconfigurable loading have made an impact on meeting the UN Sustainable Development goal of providing clean and affordable energy to all. With the recent passing of the Federal Energy Regulatory Commission Order 2222, the playing field has been leveled so that owners of DER, can compete in energy markets run by grid operators. In this undergraduate research project, the student will work on maximizing the use of green energy, and its economic and sustainable benefits, through the control of energy storage. The project will be conducted in the Benedum Hall Picogrid lab which couples 5 kW of rooftop solar with a 10-kWh battery storage system and a 240-V residential loading circuit. The student will focus on data collection, equipment interfacing, algorithm development, and system analysis. It is preferable, but not necessary, that the student have a familiarity with energy, electric circuit analysis, computer programming, and version control.
Advisor: Bob Kerestes, Electrical and Computer Engineering

Using Machine Learning Models to Identify Wildlife Species in Field Recordings
Our lab uses small, inexpensive acoustic recorders to record soundscapes at field sites across the United States. We are interested in hosting a summer fellow who will work with us on this research. The main tasks will be developing and testing machine learning models to identify species of birds, bats, frogs, and/or insects within long field recordings, but tasks may also include deploying recorders in the field, managing incoming data, and testing new hardware designs. Several of our previous summer fellows have been co-authors on manuscripts describing their work.
Advisor: Justin Kitzes, Biological Sciences

CyberWater
CyberWater is an open and sustainable modeling framework software system under development that enables easy and incremental integration of diverse environmental data sources and models for knowledge discovery and interdisciplinary team-work. The student will learn how to develop part of the CyberWater system, test and evaluate different features of the CyberWater system, develop use cases, and identify limitations of the system. Skill requirements: Proficient coding skills in Python and/or C. Students in applied mathematics, applied physics, or statistics, civil and environmental engineering, computer science, software engineering, computer engineering, or data science.
Advisor: Xu Lange, Civil and Environmental Engineering

Developing a Miniature Acceleration-Logging System for Small Animals
Monitoring movement of animals enables us to understand their behavioral characteristics. Existing devices can successfully log acceleration of relatively large animals, but they are too large or heavy for small animals (e.g., insects). In this research project, a student will develop a wireless acceleration logger in 1 centimeter or smaller by studying low-power custom chips, designing printed circuit boards, designing the full system, and evaluating the manufactured system.
Advisor: In Hee Lee, Electrical and Computer Engineering

Powering Miniature Embedded Systems using a Supercapacitor
Lifetime of a miniature system using a small rechargeable battery and an energy harvester is limited to a few years due to battery capacity reduction over time, and the small battery internal resistance becomes higher considerably at lower temperature. In this research project, a student will develop a miniature system using a supercapacitor, as an alternative to overcome the disadvantages of a small battery. The student will study characteristics of supercapacitors, find how large supercapacitor is required to power an advanced miniature system, develop a supercapacitor-powered system using low-power custom chips and a printed circuit board, and evaluate the manufactured system.
Advisor: In Hee Lee, Electrical and Computer Engineering

Osmocapillary Effect in Hydrogel Friction
Hydrogel is known for its extremely low coefficient of friction (<0.01). The low friction behavior of hydrogel is crucial for biological tissues such as articular cartilage in your knees. We are performing controlled experiments on synthetic hydrogels to understand the physics underlying the unique friction behavior of hydrogels.
Advisor: Qihan Liu, Mechanical Engineering and Materials Science

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Low Voltage Electrospinning of Nanofibers
Electrospinning is the leading manufacturing platform to produce submicron fibers, which are useful for filtration (e.g. N95 mask) and tissue engineering (to support cell growth). One major drawback of conventional electrospinning is the high operational voltage (>10kV). We are testing a special design to lower the operational voltage of electrospinning to <100V, thus making this technology more accessible.
Advisor: Qihan Liu, Mechanical Engineering and Materials Science

Electrify Everything: Reimagining the future of chemical manufacturing
We are looking for an undergraduate student to contribute to our growing research program on sustainable chemical manufacturing. We can tailor a project to fit your interests—opportunities range from studying the basic physics and chemistry of next-generation catalyst materials, to building chemical reactors that use electricity and water to turn pollution back into useful chemicals, to systems-level analysis of which types of chemical manufacturing technologies will have the greatest positive impact on energy and environmental sustainability in the long run.
Advisor: James McKone, Chemical and Petroleum Engineering

Teeny Tiny Testers for Big Bad Batteries
Our lab has conceptualized a new type of testing device that will revolutionize the way we design and build really big batteries (as in big enough to power a small city), and we need your help to build the first working prototype! Experience and/or interest in CAD design, machine shop, 3d printing, and/or electrical circuits is especially encouraged.
Advisor: James McKone, Chemical and Petroleum Engineering

Testing Biobased Sorbents for Contaminant Removal
Per and polyfluoroalkyl substances (PFAS) are highly persistent global pollutants. This project will develop and test novel protein-based sorbents to remove PFAS from drinking water using a combination of molecular modeling and laboratory experiments.
Advisor: Carla Ng, Civil and Environmental Engineering

Of Mice and Humans: Finding the right model for testing human toxicity of chemicals
This project will evaluate strategies to relate toxicity data collected in model systems (fish, mice, rats, and cell-based in vitro assays) to expected effects in human populations. Identifying appropriate models and conducting effective extrapolation to humans is essential to developing health-protective guidelines for chemicals in the environment, drinking water, food, and consumer products. This project will use a combination of literature data mining, molecular and whole-organism modeling, and will collaborate with students and postdocs producing experimental data.
Advisor: Carla Ng, Civil and Environmental Engineering

Electromagnetic Field Processing of Soft Magnetic Alloys for Electric Vehicle Applications
Soft magnetic materials play an important role in vehicle electrification, including inductors, transformers, and electric motors. The proposed project will explore the application of electromagnetic fields to process soft magnetic alloys for achieving improved magnetic properties which can reduce size and weight of an electric vehicle. More specifically, radio frequency induction and laser processing will be used for crystallization of amorphous alloys to produce new nanocrystalline soft magnets.
Advisor: Paul Ohodnicki, Mechanical Engineering and Materials Science

Machine Vision Process Control of Single Crystal Optical Fiber Growth
Single crystal optical fibers can be used in a number of important energy applications which include harsh environment sensing in nuclear power plants for reliable, safe, and efficient power generation. The manufacturing of single crystal optical fibers is challenging and involves careful control of the solidification process, often using a technique referred to as laser heated pedestal growth in which a laser is used to locally melt a feedstock material so that a seed crystal can be used to grow long single crystals. Machine vision methods will be developed and applied to monitor and control the laser heated pedestal growth process in real-time enabling optimal single crystal fiber growth.
Advisor: Paul Ohodnicki, Mechanical Engineering and Materials Science

Social Network and Media Contexts of Substance Use
The purpose of this project is to understand social network and media contexts of substance use. Using large-scale agent-based modeling and empirical data analysis, the undergraduate researcher will get to experiment and compare the effect of various interventions that can be non-pharmaceutical (e.g., law-enforcement and education), or pharmaceutical (e.g., naloxone) on public health outcomes such as overdose prevalence. Special attention will be paid to sociodemographic and psychometric drivers of these outcomes.
Advisor: Amin Rahimian, Industrial Engineering

Human-Machine Teaming
This project explores various strategies for human-machine teaming to improve coordination, cooperation, and performance with specific attention to mission requirements and task features. The undergraduate researcher will be exposed to a variety of tools from agent-based model building, optimization, and reinforcement learning, and use them to analyze teaming performance in mission-critical contexts.
Advisor: Amin Rahimian, Industrial Engineering

Smarter Riversheds—Real Time Sensor Networks
Combined sewer overflows result in over 9 billion gallons of sewer/storm water flowing into Pittsburgh's rivers each year. Identifying water-quality trends in real-time is essential to solving this problem, projected to cost over $3 billion for Pittsburgh. With many cities across the U.S. facing this challenge, this project focuses on triangulating historical, historical, and grab sample water quality data to understand water quality dynamics in real-time and to evaluate Green infrastructure. Student will gain experience in environmental sampling, analytical chemistry techniques and data science.
Advisor: David Sanchez, Civil and Environmental Engineering

Using Microbial Fuel Cells to Degrade Contaminants of Emerging Concern
There is a growing portfolio of emerging contaminants in the environment that are unregulated but pose risks to human and environmental health. The goal of this project is to evaluate the potential for biofilms and micro-electrodes to degrade these contaminants. The project will focus on designing micro-electrodes for biofilms, and selectively adapting electrodes to degrade these contaminants. Additional aims will focus on identifying governing parameters (material morphology, electrochemical activation) to optimize degradation kinetics. All disciplines are welcomed to apply.
Advisor: David Sanchez, Civil and Environmental Engineering

Best Practices in Climate Change Leadership
Confronting climate change and advancing a sustainable future requires leadership across the public, private, and nonprofit sectors, yet leaders in each of these sectors often fall short. This project will research best practices in leadership across sectors - how do leaders advance sustainable policies and practices that will ensure our secure future? How do they most effectively work together? And what can we learn from them to advance these practices in our own work? Student research on this project will inform new leadership development programs offered by the Johnson Institute and may be published in our Journal, Leader to Leader.
Advisor: Julia Santucci, GSPIA – Johnson Institute for Responsible Leadership

Environmental Sampling using Adaptive Passive Flyers
The project will explore flight dynamics of passive flyers that are inspired by the flight patterns of wind-dispersed maple seeds. Utilizing stimuli responsive polymers and their 3D printing, the project will explore flight dynamics that can be tuned using light, mid flight. This will present a system for environmental sensing using microflier swarms.
Advisor: M. Ravi Shankar, Industrial Engineering

Building Food Access, Community, and Sustainability
Building a digital and interactive unit for a class on the Politics of Food, Land and Sustainability using a case study in Homewood. Requires interest in digital media and technology, creativity, and imagination. Incorporates community outreach, historical narrative, biotechnology, agrotechnology, and the politics of food.
Advisor: Kay Shimizu, Political Science

Validation of Google Eco-Friendly Routing Method
This project will give students an opportunity to validate Google's, recently introduced, Eco-friendly method where drivers are given the best route not in terms of shortest time to their destination but in terms of the lowest impact on the environment (by suggesting a route which leads to lowest fuel/energy consumption). Students will compare Google's results, for a selected number of routes, to data from a set of highly calibrated and validated microsimulation models to test validity of the proposed routing method. The study and results are intended to be submitted for presentation at the 2023 Transportation Research Board conference and the associated journal.
Advisor: Aleksandar Stevanovic, Civil and Environmental Engineering

Practical Optimization of Traffic Signals to Reduce Fuel Consumption and Vehicular Emissions
This project will give students an opportunity to investigate impact of various stop penalties (e.g. how many seconds of delay is each vehicular stop worth, from the perspective of consumed fuel) on optimization of traffic signals. Students will use one of the contemporary practical signal optimization tools to test how various stop penalties affect the quality of signal timing plans, which will be measured through associated fuel consumption based on outputs of highly calibrated and validated microsimulation model. The study and results are intended to be submitted for presentation at the 2023 Transportation Research Board conference and the associated journal.
Advisor: Aleksandar Stevanovic, Civil and Environmental Engineering

Towards Circular Use of Polyurethanes
Polymeric waste is one of the great challenges of our time. In this project, we are developing a strategy to deconstruct TPU (thermoplastic polyurethane) waste into its constituent components for circular reuse (i.e. chemical recycling), in close collaboration with an industrial partner.
Advisor: Goetz Veser, Chemical and Petroleum Engineering

Catalysis in a Witches Brew…
Catalysis is a foundational reaction technology in the chemical industry. Most catalysts in industrial practice are composed of solid metal nanoparticles supported on a ceramic support. In this project, we are exploring liquid metals as an unexplored, novel class of catalysts that promises to open entirely new pathways to chemical processing.
Advisor: Goetz Veser, Chemical and Petroleum Engineering

Carbon Dioxide Capture through Carbonic Anhydrase-Catalyzed Carbon Mineralization in Saline Water
Capturing the greenhouse gas carbon dioxide is crucial to mitigate global warming. This project aims to investigate the feasibility of biocatalysis for the capture of carbon dioxide in saline water (e.g., seawater) as carbonate minerals.
Advisor: Meng Wang, Civil and Environmental Engineering

Copper-Embedded Silica Materials for Enhancing the Catalytic Efficiency of Laccase Enzymes
Laccases are oxidoreductases that catalyze the oxidation of substrates by molecular oxygen and have been used in food processing, bioremediation, and textile finishing. The industrial application of enzymes generally benefits from immobilization by improved stability and ease of separation and reuse. The objective of this project is to develop a green immobilization approach that not only stabilizes laccases but also enhances their catalytic efficiency.
Advisor: Meng Wang, Civil and Environmental Engineering

Ultra-High Strength Materials Design for Sustainable Additive Manufacturing
This project aims to apply integrated computational materials modeling to guide the advanced materials design for additive manufacturing. The powder-based 3D printing technique will be used to perform high-throughput experiments based on the computational design. This will lead to the development of new materials with enhanced mechanical properties for sustainability.
Advisor: Wei Xiong, Mechanical Engineering and Materials Science

Additive Manufacturing Design for High-Entropy Alloys for Energy Components with Enhanced Efficiency
High-entropy alloys are nonconcentrated materials that are different from traditional steel and superalloys. In this project, the mixture of conventional alloys powder will be designed for additive manufacturing and thus result in alloy components with high entropy, which will introduce stabilized microstructure with enhanced mechanical performance. The improvement of the mechanical strength for high-entropy alloy components will be quantified to evaluate the efficiency enhancement in energy applications.
Advisor: Wei Xiong, Mechanical Engineering and Materials Science

Developing Electrical Interfaces for Phototonic A.I. Hardware
The goal of this project is to develop an experimental framework for controlling and measuring all-optical matrix-matrix multiply units which can achieve very high bandwidth and ultra-low energy computations. This project will involve the design, construction, and testing of a multi-channel PCB which interfaces with and controls electro-optic photonic components with high precision via a PC interface.
Advisor: Nathan Youngblood, Electrical and Computer Engineering

Sustainable Photopolymer 3D Printing
Despite the current and potential applications of photopolymer 3D printing, there is a lack of research on eco-/bio-friendly photo resins and a limited understanding about their printability and potential applications. The objective of this project is to develop bio-based photo resins derived from renewable resources (e.g., vegetable oils and starch) and demonstrate versatile applications of these sustainable materials such as sensors and microfluidic bio-chips. The developed 3D printable photo resins will serve as green alternatives for the fossil-based acrylates and epoxides used in current photopolymer 3D printing.
Advisor: Xiayun (Sharon) Zhao, Mechanical Engineering and Materials Science