PURDUE UNIVERSITY | Mechanical Engineering

Summer 2020
Team Research Projects

Project Name:	Design and Optimization of a Packaged Propane Heat Pump System for Field Testing	**Project ID:**	R001
Supervisor:	Professor Davide Ziviani	**Support Faculty/Staff:**	Riley Barta, Tyler Shelly

Project Description:

According to E.I.A. buildings consume approximately 40% of the primary energy used in the U.S. The energy-independence challenge is particularly acute for buildings in colder U.S. climates that have a longer heating season. Heating is by far the biggest consumer of energy, accounting for at least 30%, and in some cases as much as 60%, of total energy use. In addition, the gradually phase down of current refrigerants requires further research to identify suitable low-GWP replacements. Hydrocarbons represent a possible solution, but their flammability yields to a number of challenges towards the actual commercialization in the residential sector. To this end, a packaged heat pump with external flow reversibility is proposed as viable solution to safely utilizing flammable refrigerants such as propane (R-290), as shown in Figure 1. The proposed systems can also be adapted to serve as a cold-climate heat pump that provides heating, cooling, and domestic hot water. During Spring 2020, a prototype packaged heat pump system for laboratory testing has been designed. The prototype unit served the purpose of proving the concept, obtaining experimental data for validating the detailed cycle model.

As a next step, a field-testing unit needs to be developed that includes an optimized cycle architecture, minimized charge inventory, and essential control logic and sensor equipment. In addition, a techno-economic analysis will be carried out to assess the economic viability of the unit in different U.S. locations with extended heating seasons as well as the integration of thermal storage.

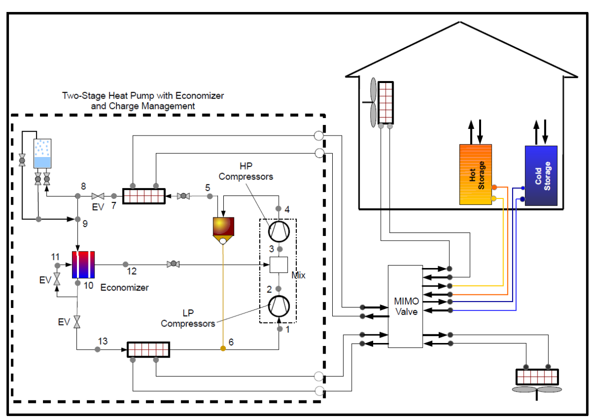

Figure 1. Concept schematic of the packaged R-290 CCHP with secondary loops, external flow reversal, and possible coupling with cold and hot storage tanks.

Final Deliverables:

- Updated sizing of the heat pump system
- Component selection and procurement
- Detailed 3D CAD assembly including external flow reversal valve assembly

	• Commissioning and testing of the prototype unit and assembly of the field-test unit (if allowed)
Desired Qualifications (optional)	• Basic knowledge of thermodynamics and heat transfer • Programming skills (at least one software): MATLAB and/or EES and/or Python • CAD software: SOLIDWORKS (preferred)

Project Name:	IBAC	**Project ID:**	R002
Supervisor:	Professor Euiwon Bae	**Support Faculty/Staff:**	Hyun Jung Min (Ph.D. student)
Project Description:	• Using Matlab image processing toolbox, develop a series of algorithm for bacterial colony count		
Final Deliverables:	• Matlab script and final report		
Desired Qualifications (optional)	• Fluency in Matlab (required) • Experience in image processing (recommended) • Eagerness to tackle a real life problem • Group of 4-6 is preferred		

Project Name:	Data-driven modeling of additively manufactured metal parts	Project ID:	R003
Supervisor:	Professor Yung C. Shin	Support Faculty/Staff:	
Project Description:	• This project is to build the data-driven models that link microstructures of additively manufactured parts to corresponding mechanical properties • Students will learn how to get the distributions of grains and phases from the EBSD images of additively manufactured parts • Students will learn basic tools of data-driven modeling using MATLAB. Instructions with tutorials will be given over Webex. • Students will tackle various metals parts individually or as a group to perform the tasks. • Students will carry out the modeling tasks, analyze the results and generated reports individually or as a group		
Final Deliverables:	• Compilation of images from the open literature and corresponding mechanical properties • Data driven models that correlate the microstructural details to the corresponding mechanical properties • Final reports describing the data, models and analysis		
Desired Qualifications (optional)	• Sophomore or higher standing with the minimum GPA of 3.3		

Project Name:	Development of a Low Speed Wind tunnel for Optical Diagnostics	Project ID:	R004
Supervisor:	Professor Guillermo Paniagua	Support Faculty/Staff:	Iman Rahbari
Project Description:	• Develop the installation plan for the implementation of a new subsonic wind tunnel in the ZL5, Zucrow Laboratories • Additionally the team will learn about measurement techniques, and how to implement into the wind tunnel • A senior design team has already developed a design of the wind tunnels • This project will review the design, and proceed to develop the implementation plans, and acquisition of the parts. • This project will also explore how to integrate a Robot to enable changing models remotely		
Final Deliverables:	• Presentation of the final design and plans for implementation • Final drawings for the installation of the wind tunnel in the Zucrow Laboratories ZL5		
Desired Qualifications (optional)	• ME309		

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Project Name:	Development of a rotating detonation engines	**Project ID:**	R005
Supervisor:	Professor Guillermo Paniagua	**Support Faculty/Staff:**	James Braun
Project Description:	• The final objective is to assess the mechanical design towards the continuous operation of a turbine coupled with a Rotating Detonation combustor • A senior design team has already developed a cooling system and coupling to a turbocharger for our Turbine-integrated High-pressure Optical Rotating rig • This project will assess that the proposed solution provides sufficient operational range • Additionally the team will learn about measurement techniques, and how to implement into the wind tunnel		
Final Deliverables:	• Presentation of the final design, routing of the service lines, fuel and cooling • Final drawings for the installation of the test bench in ZL3 Zucrow Laboratories		
Desired Qualifications (optional)	• ME309		

Project Name:	Personal protective equipment for protection against virus transmission	**Project ID:**	R006
Supervisor:	Professor Arezoo Ardekani	**Support Faculty/Staff:**	PhD student Andres Barrion Zhang
Project Description:	The coronavirus disease 2019 (COVID-19) has put severe pressure on the healthcare systems all around the world. This is due to several factors that include the high spread rate of the virus, the high rate of infected people that need hospitalization, high rate of actively infected patients that need intensive care, and the long period of hospitalization. The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus spreads from person to person through droplets or aerosols, becoming airborne when infected people cough, sneeze, talk, or breath. These droplets carry viral particles that can be either inhaled or come in contact with a person after being deposited on surfaces. The shortage and inadequacy of personal protective equipment (PPE) is considered one of the main causes of high infection rate among healthcare workers. Innovative designs of masks and personal protective equipment will have social impact on reducing exposure of individuals and healthcare workers to viral transmission.		
Final Deliverables:	Design of personal protective equipment for protection against virus transmission		
Desired Qualifications (optional)			

Project Name:	Course grained modeling of proteins	**Project ID:**	R007
Supervisor:	Professor Arezoo Ardekani	**Support Faculty/Staff:**	PhD student Rajat Dandekar
Project Description:	Therapeutic proteins are commonly employed in the treatment of various human diseases such as cancer, autoimmune and infectious diseases. The goal of this project tis to model protein using a structurally consistent coarse-grained model taking into account the spatially varying hydrophobic nature of the protein molecule. For realizing time and length scales relevant to protein dynamics, we will employ the numerical scheme of dissipative particle dynamics to represent the system force field using an open source code. We capture the time evolution of the protein microstructure and elucidate the important processes governing the protein dynamics in different scenarios. We will quantify the aggregation propensity of the protein and the governing parameters. This study shows that numerical simulations can be an important tool for understanding the molecular mechanisms driving protein aggregation and efficiently designing molecular structures of proteins.		
Final Deliverables:	Working computational code modeling three different protein types and a post-processing code quantifying their aggregation		
Desired Qualifications (optional)			

Project Name:	Experiential Learning in Engineering Mechanics and Computation	**Project ID:**	R008
Supervisor:	Professor Thomas Siegmund	**Support Faculty/Staff:**	Tanner Balance, Kyle Mahoney, Dong Young Kim (all GRAs)
Project Description:	• Toys – Jenga, No-Break-the-Ice, Popsicle Stickbombs, Tessellation Puzzles – are great entertainment, but have a background in mechanics and mathematics. This summer we want to not just play these games but use our engineering skills to model and analyze these with engineering tools, and invent new ways to use the toys. Participants we use experiments at home, use computer tools to code and build models of the toy systems.		
Final Deliverables:	• Individual reports on projects. Can we invent new ways to use already known toys once we understand the mechanics principles behind these?		
Desired Qualifications (optional)	• Students should have completed engineering mechanics courses, ME 274, ME 323 (optional), ME 489 (optional)		

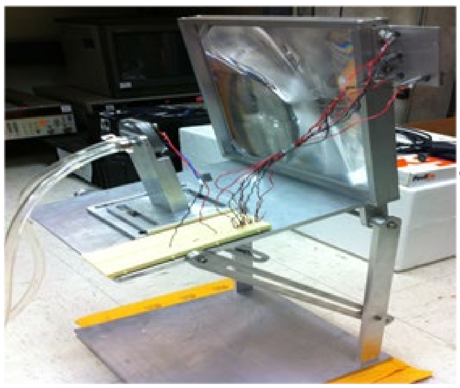
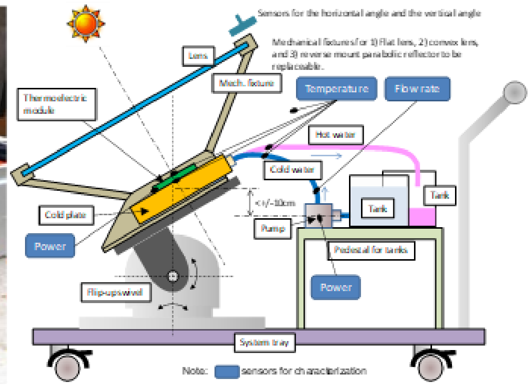
Project Name:	Computational Cardiovascular Fluid Mechanics	**Project ID:**	R009
Supervisor:	Professor Ivan C. Christov	**Support Faculty/Staff:**	Dr. Kimberly A. Stevens Boster

Project Description:	• **Week 1 & 2:** Introduction to cardiovascular flows and computational fluid dynamics (CFD). (via WebEx + PDF lecture notes)
	• **Week 3 & 4:** Tutorials on using the open-source SimVascular computational cardiovascular fluid mechanics software.
	(via WebEx live sessions + individual/group work by students on their computers)
	• **Weeks 5 & 6:** Exercise and practice with SimVascular; perform validation/verification exercises on model problems (Poiseuille flow, Womerseley profile, etc.) to make sure the simulations are setup correctly, and to reinforce the core concepts of Weeks 1 – 4. (via WebEx live sessions + group work by students on their computers and/or the Brown cluster at Purdue)
	• **Weeks 7, 8 & 9:** Students break up into teams of 2 to 4 (depending on how many enroll). Course staff provide students with interesting cardiovascular geometries, and students run flow simulations through them; students will vary the inflow and outflow conditions on the model.
	    o There will be some basic homework exercises on using the open-source visualization software ParaView (a standard in the field) to visualize flows via, say streamlines, pressure fields, and so on.
	    o Student groups will collect and curate a database of flow data from their SimVascular simulations.
	    o Student groups will use already developed algorithms (by the course staff), to generate synthetic 4D (3D+time) flow data from their SimVascular simulations.
	    o Enrichment lectures and exercises about the connections between CFD, in vivo flow measurements, and patient care will be provided by the staff.
	(via WebEx, PDF lecture notes, prepared scripts and codes on GitHub)
	• **Week 10:** Advanced topics, as time permits. Students will be taught about "lumped parameter network" (LPN) representations of cardiovascular systems as hydraulic systems, how to estimate the latter's parameters from the CFD simulations, and will calculate LPN parameters based off of their geometries, using pre-developed code.
	(via WebEx, PDF lecture notes, prepared python and MATLAB scripts and codes)		

Final Deliverables:	• SimVascular simulation case files for models provided • Flow and pressure data produced from latter, including post-processing scripts and plots • A brief group-based final report discussing results obtained and what the students learned from this project.		
Desired Qualifications (optional)	• ME309 or equivalent required • Some intermediate programming experience (e.g., have used linux, knowledge of basic python) desirable		

Project Name:	Modeling of additive manufacturing	**Project ID:**	R010
Supervisor:	Professor Xianfan Xu	**Support Faculty/Staff:**	Paul Somers
Project Description:	This project will use Finite Element Analysis (FEA) software to analyze the additive manufacturing / 3D printing processes and mechanical properties of 3D structures		
Final Deliverables:	Weekly Webex meeting, bi-weekly reports, and a final report.		
Desired Qualifications (optional)	Up to 5 students		

Project Name:	3D image processing	**Project ID:**	R011
Supervisor:	Professor Song Zhang	**Support Faculty/Staff:**	Yi-Hong Liao
Project Description:	This project will develop software algorithms to process 3D images captured by commercial sensors or the high-end sensor developed in XYZTLab. The target application is autonomous vehicle, 3D video conferencing, and additive manufacturing.		
Final Deliverables:	Weekly WebEx meeting, bi-weekly written reports, and a final report.		
Desired Qualifications (optional)	Prior programming experience with Matlab or others. Up to 6 student		

<table>
<tr><td>Project Name:</td><td>See the Heat</td><td>Project ID:</td><td>R012</td></tr>
<tr><td>Supervisor:</td><td>Professor Amy Marconnet</td><td>Support Faculty/Staff:</td><td></td></tr>
<tr><td>Project Description:</td><td colspan="3">Design experiments or demonstration systems to demonstrate heat transfer principles to broad audiences including undergraduate students and/or K-12 students and teachers at outreach events. The exact direction will be determined by the supervisor in consultation with the interested students. One initial idea would be to create a solar thermal energy generation testbed similar to that developed by a team of undergraduates at UC-Santa Cruz shown in the photo and schematic below:


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<tr><td>Final Deliverables:</td><td colspan="3">• Project report document design and design process
• Bill of materials
• CAD files
• Simulation results</td></tr>
<tr><td>Desired Qualifications (optional)</td><td colspan="3">Required:
• Familiarity with CAD and MATLAB
• Thermodynamics (A- or better, preferred)
Preferred:
• Fluid Mechanics (A- or better, preferred)
• Heat Transfer (A- or better, preferred)
• Familiarity with finite element simulation tools</td></tr>
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The Multi-Scale Robotics and Automation Lab (MSRAL) has four different research project opportunities that can accommodate up to 2 students each. They are related to microrobotics and surgical robotics design, control, and automation.

Project Name:	MSRAL_1: Microgripper Design	**Project ID:**	R013
Supervisor:	Prof. Cappelleri	**Support Faculty/Staff:**	Georges Adam (PhD student)
Project Description:	• Explore different actuation methods for microgrippers (DC Micromotor, pneumatic, piezoelectric/resistive, etc.) • Design microgripper based on actuation method. • Design optimization of a microgripper device • Simulation of inputs and actuation • FEA analysis of the structure as well as possible force sensing mechanism based on beam stiffness		
Final Deliverables:	• Microgripper design specifications and capabilities • Full simulation of the actuation method and microgripper in action		
Desired Qualifications (optional)	• Upperclassman (Junior/Senior) • Programming experience (optimization mainly) • Matlab, Simulink, CAD, FEA experience		

Project Name:	MSRAL_2: Using Reinforcement learning for Control of Microrobots through Local Potential Fields	**Project ID:**	R014
Supervisor:	Prof. Cappelleri	**Support Faculty/Staff:**	Benjamin Johnson (Post-doc)
Project Description:	• Explore the possibility of applying machine learning algorithms for controlling and path planning of magnetic microrobots • Design test bed in MATLAB to simulate motion of the magnetic microrobot based on a physics model • Develop and test algorithms to determine optimized paths for multiple magnetic microrobots in MATLAB • Test the new paths on the microrobot actuation platform in lab (if/when on-campus work is possible)		
Final Deliverables:	• MATLAB based test-bed that simulates motion of multiple magnetic microrobots • Test algorithms to evaluate feasibility for planning/control		
Desired Qualifications (optional)	• Upperclassman (Junior/Senior) • Familiarity with MATLAB, Object Oriented Programming, Machine Learning		

Project Name:	MSRAL_3: Surgical Manipulator Actuation Mechanism Design	**Project ID:**	R015
Supervisor:	Prof. Cappelleri	**Support Faculty/Staff:**	Benjamin Johnson (Post-doc)
Project Description:	• Mechanical design of a mechanism to actuate surgical tool end-effectors • Mechanism should work under design constraints that enable use of the tool along with existing robotic instruments inside a robotic cannula system • Existing surgical tools are designed for robotic actuation. A mechanical user interface will allow for lower-cost option and an intuitive interaction mode for surgeons to operate the tools.		
Final Deliverables:	• Study of existing methods/patents that pertains to this problem • Design optimization, FEA, and fatigue analysis of mechanical design • Generate CAD assemblies and bill of materials of possible designs • Build prototype and iterate design (if/when on-campus work is possible)		
Desired Qualifications (optional)	• Upperclassman (Junior/Senior) • Mechanism design (ME352) • Experience with prototyping (Machine shop/3D printing etc.) optional		

Project Name:	MSRAL_4: Design of an automated assembly system for 3D printed robotic surgical instruments	**Project ID:**	R016
Supervisor:	Prof. Cappelleri	**Support Faculty/Staff:**	Benjamin Johnson (Post-doc)
Project Description:	• The assembly of robotic instruments designed for lumbar discectomy requires a re-design for high-throughput manufacturing • The interface between the end-effectors and the actuators (shape memory alloys) is designed to be modular. Re-design would allow for easy engaging-disengaging procedure that can help automate the assembly process		
Final Deliverables:	• Propose and evaluate design ideas for automating the assembly of the surgical instrument using design methodologies. • CAD design and analysis of fixtures and procedures for automating the assembly of existing robotic surgical tools designed in the lab • Prototype and testing of the assembly system (if/when on-campus work is possible)		
Desired Qualifications (optional)	• Upperclassman (Junior/Senior) • ME263 (Design methodologies) • ME 352 (Machine Design) • Prototyping experience (3D printing, machine tools)		

Project Name:	Control Software Design for 3D Printers	Project ID:	R017
Supervisor:	Prof. Liang Pan	Support Faculty/Staff:	
Project Description:	We will use LabView based programming environment to design a control software for 3D printer that can take G-code models and control the printing processes		
Final Deliverables:	LabView codes that are ready to be tested on hardware		
Desired Qualifications (optional)			

Project Name:	Multi-physics modeling for mechanical engineering problems	Project ID:	R018
Supervisor:	Prof. Liang Pan	Support Faculty/Staff:	
Project Description:	We will learn the basics of multiphysics simulations based on finite element method (FEM). Students will learn COMSOL as a universal FEM tool and know the basics of multiphysic modeling for engineering problems.		
Final Deliverables:	Students will learn Comsol as a universal FEM tool and know the basics of multiphysic modeling for engineering problems.		
Desired Qualifications (optional)			

Project Name:	Plant surveying robot	Project ID:	R019
Supervisor:	Professor Sadegh Dabiri	Support Faculty/Staff:	Sadegh Dabiri
Project Description:	The team will design a robot that can autonomously perform corn stand counting, determine plant spacing and identify abnormal germination for space optimization. As farms are becoming more automatic, the need to automatic surveying, treating and harvesting robots has increased. The team is challenged to develop a robot that can detect germination status, perform necessary actions according to the given germination status, and report a germination map. The team will explore existing solutions, summarize advantages and disadvantages and design a new robotic mechanism.		
Final Deliverables:	Design a robot capable of surveying plants		
Desired Qualifications (optional)	Machine Design, Basic Mechanics, Mechanics of Material, Measurement and Control Systems		

Project Name:	Desal4Development	Project ID:	R020
Supervisor:	Prof. David Warsinger	Support Faculty/Staff:	
Project Description:	Motivation • As global water security worsens, better desalination technologies that remove salts and pathogens are increasingly needed. Prof. Warsinger has developed a new technology called Batch Reverse Osmosis, which is an improvement on the leading desalination technology. This technology uses a clever design to vary pressure over time, thus saving energy costs, reducing membrane fouling, and reducing costs. Expectation • Undergraduate researchers will work directly with the project mentor to pursue several BRO tasks: 1) complete design of a pilot, 2) work with graduate mentors (Sandra Cordoba & Akshay Rao) to model performance, and 3) analyze uses for Kenya to sustainably use the normally wasted brine. The project is compatible with remote work. One position will develop the control system of the prototype in LabVIEW, including for data acquisition and actuating components. Other positions will design the connections and structure of the physical BRO system. If COVID-19 quarantines are lifted, the students will work on constructing the pilot too, and testing it for varied recovery ratios and feedwater salinities. The researchers will study salt tolerances for agricultural uses and generate a model that relates system recovery ratios to agricultural usability. Researchers will then use experimental results and theories to draft a journal paper. Application • Our project may be applied to the decontamination of water in the arid region of Kenya. Many near-surface groundwater aquifers in Kenya and neighboring countries are not safe for human consumption, usually containing high levels of harmful chemicals. In response, the government of Kenya is forcibly closing boreholes, causing people to switch back to potentially contaminated surface waters. In many cases, people are relocating altogether. Destination • Our main objective is to create a framework for understanding how these systems can be deployed in different regions of Africa and Peru to maximize the recovery of safe, potable water, solving their issues of high salinity, heavy metals, and pathogens. We wish to investigate how various water different ratios could produce brine that may have other uses such as feeding livestock and irrigating crops.		
Final Deliverables:	• SolidWorks CAD model of the BRO prototype. Construction if possible. • Model that relates system recovery ratio to agricultural usability • Journal paper		
Desired Qualifications	• Experience with Fluid Mechanics and Labview		

Project Name:	Class Design for edX	Project ID:	R021
Supervisor:	Professor Marisol Koslowski	Support Faculty/Staff:	Marisol Koslowski / Catherine J Hixon
Project Description:	• Help with the design of a MS class to be delivered online with edX. The job includes: review class notes and lectures, develop a website with sample problems.		
Final Deliverables:	• Reviewed class notes, lectures, homework solutions		
Desired Qualifications (optional)	• Python programing		

Project Name:	Digital twin for bio-inspired structures	Project ID:	R022
Supervisor:	Professor Ajay P. Malshe	Support Faculty/Staff:	Salil Bapat
Project Description:	The subject(team) interest in this project is exploring digital twins. The project will explore the application of the digital twin concept to the bioinspired structures. This exercise will explore the architecture of snakeskin surface for multifunctional applications including mechanical traction and antimicrobial functions for mechanical fixtures. Mechanical fixtures will be geared for manufacturing processes including robots.		
Final Deliverables:	A knowledge framework developed using literature review, research, and development work for creating a digital twin for bio-inspired surface structures.		
Desired Qualifications (optional)	Fundamentals of science and engineering, critical thinking and curiosity driven learning aptitude		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Design of Collapsible Basket Array of 3D Organoids/Spheroids Compatible with High Throughput Robots	**Project ID:**	R023
Supervisor:	Professor Bumsoo Han	**Support Faculty/Staff:**	

Project Description:

In order to develop FDA-approved drugs, numerous chemical compounds need to be evaluated for their efficacy and toxicity using various model platforms and clinical trials. It is estimated that the development of one FDA-approved drug typically requires an evaluation of 10,000 - 50,000 chemical compounds, which takes 6-12 years and costs approximately $1-2 billion. Recently, three-dimensional (3D) cell culture is an emerging tool for cell biology, pharmacology, toxicology, and personalized medicines. However, method development for handling and assessing 3D tissue models is significantly lagging. The analysis of 3D cultures requires a laborious, low throughput, and mostly manual process. This includes harvesting spheroids/organoids from multiwell plates, manually converting them into "histology specimens," embedding them in freezing medium or processing to paraffin embedding for cryo- or routine sectioning respectively. Then, careful sectioning of frozen or paraffin specimens is further required to locate the multi-cellular aggregates in the specimen. This tedious, mostly manual process cannot possibly keep pace with robotic systems used in modern high-throughput screening in multiwell plate formats.

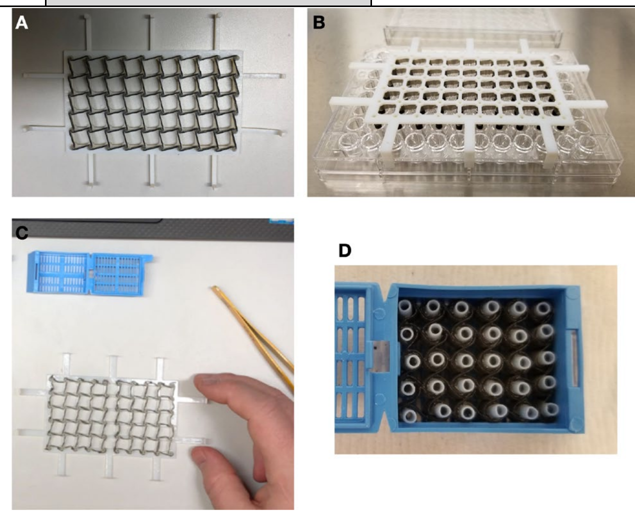

Figure 1. Assembly and function of the CBA. (A) Fully assembled CBA. (B) A CBA on a 96-well plate. (C) Retrieval of CBA for post histology analysis. (D) Collapsed basket array into a histology cassette.

Thus, a 96-well Collapsible Basket Arrays (CBAs) for high throughput culture and histology analysis of spheroids/organoids has been developed as shown in Figure 1. This CBA is designed to transfer spheroids/organoids from each well of a 96-well plate into a standard histology cassette with a single stroke and maintain the 8x12 array registry throughout the histology processing. The resulting histology section contains all spheroids/organoids in the same array format for high-throughput evaluation. For more details, see a recent news release https://www.purdue.edu/newsroom/releases/2020/Q1/collapsible-basket-technology-aims-to-improve-drug-discovery,-personalized-medicine.html. To move this prototype to next level, the CBA is desired to be compatible with high throughput robotic systems. This project is to brainstorm and propose design solutions to expand the CBA design compatible to the robotic systems.

Final Deliverables:

- Literature and market review on current high throughput robotic systems
- A list of new modified designs of current CBA prototype compatible with the robotic systems in CAD files for 3D printing (STL format)

Desired Qualifications

Project Name:	Design lab and field test apparatus for radiative cooling	**Project ID:**	R024
Supervisor:	Xiulin Ruan	**Support Faculty/Staff:**	PhD student: Joseph Peoples
Project Description:	Raditive cooling is a passive cooling technology by reflecting the sunlight and emitting heat to the deep sky. It has the potential to provide free air conditioning to buildings and other infrastructures (To learn more, watch this TED talk). In this project the student team will design the apparatus for lab test and field tests. The main components will include a chamber, sample compartment, feedback heaters, temperature sensor, solar power sensor, thermal insulations, control programs, etc.		
Final Deliverables:	Literature and information search, conceptual design, detailed design including CAD drawings, manufacturing plan, assembly drawings, computer program.		
Desired Qualifications (optional)	Students who have taken thermodynamics are preferred.		

Project Name:	3D cell culturing	**Project ID:**	R025
Supervisor:	Cagri Savran	**Support Faculty/Staff:**	Cagri Savran
Project Description:	Creating model 3D tumors in a lab environment is highly valuable because these models can then be used to test drugs, before the drug is applied on the actual patient. Our lab developed a technique to create a tumor from single cells. We are now in the process of expanding the method to various cell lines to prove its wide-ranging applicability. We have a paper in revision in a high impact journal, and are now gearing up to write a review paper in collaboration with Purdue's to cancer biologists. We need an undergrad to work with our grad student in conducting a thorough literature review. This is a hot field with significant potential impact, and a review article would help attain and ensure Purdue leadership in the field. This will be a great opportunity for an undergrad who has plans to apply to grad school, since it will teach them how to conduct literature reviews which is at the heart of a grad level study. In addition to this, should the COVID situation change towards the better, i.e. allowing undergrads in the labs, the student will also have the opportunity to immediately start working with a grad student to also obtain hands on experience in cell culturing.		
Final Deliverables:	A thorough literature review on single cell 3D cell culturing techniques.		
Desired Qualifications (optional)			

Project Name:	Minecraft SPH elasticity solver	**Project ID:**	R026
Supervisor:	Adrian Buganza Tepole	**Support Faculty/Staff:**	
Project Description:	PI Buganza Tepole is interested in developing biomechanics learning tools in video game settings. Minecrat® is a popular videogame available in many platforms (Windows, Mac, gaming consoles) in which the player can build anything buy assembling individual cubes (https://www.minecraft.net/en-us/). Minecraft allows for users to code their own behaviors in the game, and this is used already for teaching basic programing in high-school settings. The goal of this project would be for Purdue undergraduates to implement a basic stress calculation subroutine using the SPH method in Minecraft. The students would learn the basic stress analysis tools and applied them to create some basic examples on structures they build on Minecraft. The longer term goal is to create examples and challenges for the public.		
Final Deliverables:	For this summer, the students would develop the SPH stress analysis code guided by PI Tepole and use it to solve the stress distribution of a structure created in Miinecraft. The deliverable would be the code, a demo showing the stress analysis on the structure, and a report.		
Desired Qualifications (optional)	• Python or java programming • ME323 Mechanics of materials • ME489 would be ideal but not required		

Project Name:	Analysis of COVID-19 global impact using Artificial Intelligence	**Project ID:**	R027
Supervisor:	Veeraraghava Raju Hasti	**Support Faculty/Staff:**	Veeraraghava Raju Hasti
Project Description:	The novel COVID-19 pandemic has infected several millions across the globe and caused 169,773 fatalities as of 04/20/2020. This caused isolation of several billion people globally and adversely affected our day to day lives, education, economy, and operations. We will look at the publicly available data to understand the spread rate, specific patterns, reasons, its impact on the health, energy, environment and economy through exploratory data analysis using the artificial intelligence techniques. This analysis will help to identify the root causes for its rapid spread and also helps to draw best practices to control such pandemic and its impact on our society in the near future.		
Final Deliverables:	Student learning outcomes • Principles of data science • Basic statistical methods • Basics of neural networks • Python • Tensorflow • Keras Technical outcomes • Identify the specific patterns in the COVID-19 data on health, energy, environment and economy and their relationships • Root causes of the rapid spread • Control measures		
Desired Qualifications (optional)	• Interest to learn, self-motivation, passion and commitment		

PURDUE UNIVERSITY | Mechanical Engineering

Project Name:	Smart Combustion Concepts for Low Emissions	**Project ID:**	R028
Supervisor:	Veeraraghava Raju Hasti	**Support Faculty/Staff:**	Veeraraghava Raju Hasti
Project Description:	As emissions standards worldwide are becoming more and more stringent, there is an intense pressure on the industry to deliver low emission combustor technology to meet emissions regulations and improve fuel economy. This project focuses on studying the novel combustor concepts for lowering the nitrogen oxides (NOx) emissions. The lean premixed combustion with exhaust gas-recirculation (EGR) will be explored in detail to achieve ultra-low NOx emissions. The detailed flame structure will be analyzed using the Cantera and CFD software to understand the pollutant formation mechanism. Deep learning techniques will be explored for data-driven modeling and combustion process control to lower the pollutant formation.		
Final Deliverables:	Student learning outcomes • Fundamentals of fluid mechanics, thermodynamics, heat transfer, and combustion, and chemical kinetics • Basic numerical methods • Principles of data science • Basic neural networks • Python • Cantera • ANSYS Fluent (CFD) • Tensorflow • Keras Technical outcomes • Identify novel low emission combustor concepts • Understand the mechanism of pollutant formation in engines • Data-driven reduced-order models for flames		
Desired Qualifications (optional)	• Interest to learn, self-motivation, passion, and commitment		

Project Name:	Li-ion Battery Thermal Analytics	**Project ID:**	R029
Supervisor:	Partha P. Mukherjee	**Support Faculty/Staff:**	
Project Description:	Lithium ion (Li-ion) batteries are ubiquitous. Thermal characteristics of these systems are critical toward safer and high-performance batteries for electric vehicles. As part of this research, thermal analysis of heat generation rates under normal and anomalous operating conditions of Li-ion cells will be performed.		
Final Deliverables:	The student will work closely with a senior graduate student researcher on the modeling and data analysis in the form of weekly reports. The final deliverable will be one end-of-summer research report (based on the weekly progress) and a presentation at the research group meeting.		
Desired Qualifications (optional)	Mechanical engineering rising junior with experience in Matlab and data analysis.		

Project Name:	Image processing techniques for high speed flows	**Project ID:**	R030
Supervisor:	Terrence R. Meyer	**Support Faculty/Staff:**	

Project Description:	• The project will provide an opportunity for the students to learn the fundamentals of image processing algorithms used in high speed flows captured at Zucrow Laboratories. The project aims to understand the propagation behavior of detonation waves in rotating detonation engines and post detonation fireballs used for bio-agent neutralization.
	• The students will team up into two groups of two students:
	    ○ Team1: Will work on optical flow to determine velocity information from PLIF images obtained from Rotating Detonation Combustor flow path. This task provides the necessary information to characterize the axial flow properties present in RDC injection system. The second task is to perform exit plume image characterization. The team will analyze exit plume images from RDCs to obtain the spatial location of the detonation waves in the images.
	    ○ Team 2: Will perform analysis to PLIF images to obtain a volumetric reconstruction of the detonation wave images. In addition, the team will work on images obtained from post detonation fire-balls to		

Final Deliverables:	• A comprehensive code for detonation location tracking • Code to implement MATLAB based optical flow measurements on PLIF images obtained from RDCs • 3D volumetric reconstruction of detonation wave from PLIF images		
Desired Qualifications (optional)	• Elementary coding knowledge in MATLAB.		

Project Name:	Design of Calibration burner system	**Project ID:**	R031
Supervisor:	Terrence R. Meyer	**Support Faculty/Staff:**	
Project Description:	• The project aims to design a fully automated system for operating a Hencken Calibration burner, used for laser diagnostics calibration. The students will design and engineer the flow system and instrumentation to operate a Hencken burner using different fuel / oxidizer combinations. The tasks will include the development of a plumbing and instrumentation diagram, the selection of fluid components, CAD model of the test bed architecture, instrumentation and wiring design, LabVIEW design and control as well as final systems integration. The LabVIEW visual interface is designed to allow selection of fuel/oxidizer as well as implement logic controls to determine appropriate flow rates necessary for operating the burner at the required test conditions. This work allows to transition the current architecture of manual setup of flame to a turn-key system.		
Final Deliverables:	• Flow rate calculations for operating fleams • Plumbing and instrumentation diagram • Selection of fluid components for operating the burner • Wiring diagram for the system • CAD model for the integrated burner • LabVIEW Visual Interface		
Desired Qualifications (optional)	• Elementary coding knowledge in MATLAB. • Use of MS Excel • If possible, elementary knowledge on National Instruments LabVIEW VI.		

Project Name:	Model analysis of modular river current energy converter	Project ID:	R032
Supervisor:	Jun Chen	Support Faculty/Staff:	Greg Jensen and Yijie Wang (PhD student)
Project Description:	• A team of four students will work on the design optimization and analysis of a modular river current energy converter that harvests energy from running rivers. Under the supervisions of the graduate mentor and faculty advisors, the students will examine the design of individual parts in the system to explore ways to achieve the optimal system performance.		
Final Deliverables:	• Design drawings for manufacture • Analysis report		
Desired Qualifications (optional)	• ME junior or senior, interested in hand-on design work, CAD experience with Siemens teamcenter or NX preferred, good team spirit.		

PURDUE UNIVERSITY | Mechanical Engineering

Summer 2020
Technical Service Projects

Project Name:	ME Clock automated winding device design	**Project ID:**	TS001
Supervisor:	Mike Sherwood (mechanics), Bert Gramelspacher (control system)	**Support Faculty/Staff:**	Mike Logan, Galen King
Project Description:	• Design a new perpetual mechanism (2-3 students working together) • Design a control system including feedback sensing (2 students working together)		
Final Deliverables:	• Full 3-D CAD model of final assembly and drawings of all components • Appropriate mechanical and electrical analysis to justify the final design • Full Bill of materials • Purchased materials (including raw stock) specifications and quotes • Detailed manufacturing drawings (tolerances, material type, etc.) • Electronic schematics and circuit diagrams • Assembly instructions • User's manual (normal operation, maintenance, troubleshooting, etc.)		
Unique Job Requirements	• Mechanical – Solidworks or AutoDesk • Controls System – completion of EE201		
Number of students needed	• 4 or 5 (2 or 3 focused on mechanical, 2 focused on control system)		

Project Name:	ME maker machines' student tutorials	**Project ID:**	TS002
Supervisor:	Steve Florence	**Support Faculty/Staff:**	Steve Kessler, Mike Sherwood
Project Description:	• Develop a tutorial for each machine in ME that is available for student use (PCB fabrication machine, 3D printers, machine shop equipment, Malott Innovation & Design Studio equipment, etc.)		
Final Deliverables:	• Complete web-based tutorials that enables all ME students to use each machine safely (for the student, machine, and facility), effectively, and efficiently to complete course and project work. • Tutorial too include, but not limited to demo video and written documentation how video was created.		
Unique Job Requirements	• None		
Number of students needed	• 2		

Project Name:	ME wind tunnels pitot tube adjuster	**Project ID:**	TS003
Supervisor:	Bert Gramelspacher	**Support Faculty/Staff:**	Mike Logan, Mike Sherwood, Tami Armstrong
Project Description:	• Design a control structure for pitot tubes to mount to the ME wind tunnels that would allow for the precise adjustment & positioning of the pitot tubes.		
Final Deliverables:	• Precise multi-axis adjustment capability • Positional feedback and display • CAD design for complete assembly • Electrical schematics • Bill of Materials • Specifications for accuracy and precision of the device • 2 complete designs – one high-cost version and one low-cost version		
Unique Job Requirements	• Prefer completion of ME 309 • Solidworks or Autodesk experience		
Number of students needed	• 2		

Project Name:	Herrick Labs portable rolling gantry	**Project ID:**	TS004
Supervisor:	Charlie Baxter	**Support Faculty/Staff:**	Jeff Rhoads
Project Description:	• Provide a proposed solution for researchers and technical staff to access fixturing and test articles on the expander head or body of the Cube Shaker in the Perception Based Engineering Lab at Herrick. • Work with supervisor to identify comprehensive design requirements for rolling gantry • Develop 3D model of proposed design • Contact external vendors to get quotes for the production and delivery of the rolling gantry • If possible work with Purdue Research Machine Shop to get an internal quote for production of rolling gantry		
Final Deliverables:	• Complete specification document for rolling gantry including production drawings and a model package • At least 2 competitive quotes for the production and delivery of the gantry		
Unique Job Requirements	• 3D CAD Proficiency (Solidworks or AutoDesk Inventor preferred) • Strong grasp of statics (ME270) to evaluate loading requirements		
Number of students needed	• 2-3		

Project Name:	Herrick Labs portable loading ramp	**Project ID:**	TS005
Supervisor:	Charlie Baxter	**Support Faculty/Staff:**	Jeff Rhoads
Project Description:	• Provide a proposed solution for technical staff to load test articles on the Cube Shaker in the Perception Based Engineering Lab at Herrick • Should be manifested as a portable ramp that allows equipment up to 1000lbs. to be delivered from the floor of PBE to the expander head of the cube with a pallet jack • Work with supervisor to identify comprehensive design requirements for loading ramp • Develop 3D model of proposed design • Contact external vendors to get quotes for the production and delivery of the portable loading ramp for the cube shaker • If possible work with Purdue Research Machine Shop to get an internal quote for the production of the loading ramp for the cube shaker		
Final Deliverables:	• Complete specification document for loading ramp including production drawings and a model package • At least 2 competitive external quotes for production and delivery of the portable loading ramp		
Unique Job Requirements	• 3D CAD Proficiency (Solidworks or AutoDesk Inventor preferred) • Strong grasp of statics (ME270) to evaluate loading requirements		
Number of students needed	• 3-4		

Mechanical Engineering

Project Name:	ME 35401(L) lab manual development	**Project ID:**	TS006
Supervisor:	Beth Hess	**Support Faculty/Staff:**	
Project Description:	• Develop a lab manual for ME 35401(L) to be used during the Fall 2020 semester (and beyond). ○ Generate pre-lab assignments and lab activities based on skeletons/ideas provided by faculty. ○ Set-up necessary infrastructure (e.g., test rigs) and procure test specimens.		
Final Deliverables:	• ME 35401(L) lab manual to be used by students this fall.		
Desired Qualifications (optional)	• Have taken ME 352 (would prefer to have taken ME 452 also), earning a B or better.		
Number of students needed	• 3-4		