PURDUE UNIVERSITY | Mechanical Engineering

Summer 2021 Undergraduate Research Projects

Project Name:	Nanoscale 3D printing	**Project ID:**	R001
Supervisor:	Xianfan Xu	**Number of Positions**	Up to 4
Project Description:	The ability to create 3D structures in the micro and nanoscale is important for many applications including electronics, microfluidics, and tissue engineering. This project deals with development mechanics models for 3D nanoscale printing. A method known as two photon polymerization is used to fabricate such structures in which a polymer is exposed to laser and at the point of the exposure the polymer changes its structure. Moving the laser in a predefined path results in the desired shape and the structures. The summer undergraduate project will involve using software such as Solidworks to simulate the printed structure and evaluate its mechanical properties and other properties. The students may also have opportunities to print nanostructures in the lab if the covid situation improves.		
Final Deliverables:	Weekly and final report		
Desired Qualifications	Mechanical Engineering Junior or Senior standing with GPA > 3.5, CAD models, Solidworks		

Project Name:	Fracture of LEGO Structures	**Project ID:**	R002
Supervisor:	Thomas Siegmund	**Number of Positions**	2-3
Project Description:	Study how structures made of LEGO bricks fracture.		
Final Deliverables:	Report and Poster		
Desired Qualifications	ME Student, ME 270 required, ME 323 desired		

Project Name:	Assembly of Interlocking Structures	**Project ID:**	R003
Supervisor:	Thomas Siegmund	**Number of Positions**	2-3
Project Description:	Create CAD models, STL files, 3D printed parts for the assembly of interlocking structures.		
Final Deliverables:	Report and Poster		
Desired Qualifications	ME Student, ME 270 required, ME 323 desired		

Project Name:	Mechanics of Puzzle Structures	**Project ID:**	R004
Supervisor:	Thomas Siegmund	**Number of Positions**	2-3
Project Description:	Study how 3D puzzles (spheres) deform and break		
Final Deliverables:	Report and Poster		
Desired Qualifications	ME Student, ME 270 required, ME 323 desired		

Project Name:	Li-ion Battery Analytics	**Project ID:**	R005
Supervisor:	Partha P. Mukherjee	**Number of Positions**	3
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 physics based modeling, machine learning based 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	Rising senior or Junior (with good analytical thinking and skills with Matlab or similar analysis tools)		

Project Name:	Efficient and sustainable water technology	**Project Name:**	R006
Supervisor:	David Warsinger	**Number of Positions:**	6
Project Description:	Widespread access to affordable, clean water is imperative for a successful future. However, today, water technologies suffer from low energy efficiencies, low yields, and the inability to remove very harmful contaminants. Further, advances in nanotechnology, material science and artificial intelligence allow for new avenues to improve the widespread implementation of desalination and water purification technology. This project aims to explore nanofabricated membranes, light-driven reactions, artificial intelligence control algorithms, and thermodynamic optimization of systems. The student will be responsible for fabricating membranes, building hydraulic systems, modeling thermal fluid phenomenon, analyzing data, or implementing control strategies in novel system configurations.		
Final Deliverables:	All students will be required to read relevant, peer-reviewed literature and keep a notebook or log of weekly research progress. At the end of the semester or term, each student will present a talk or poster on their results. Students must produce graphs, graphics, and writing towards journal publications.		
Desired Qualifications	Applicants should have an interest in thermodynamics, water treatment, and sustainability. Applicants with experience in some (not all) of the following are preferred: experimental design and prototyping, manufacturing, Python, LabView, EES, MATLAB, 3D CAD Software, & Adobe Illustrator. Rising Juniors and Seniors are preferred. Interest in continuing in the lab during the semester is ideal.		

Project Name:	Course grained modeling of proteins	**Project ID:**	R007
Supervisor:	Arezoo Ardekani	**Number of Positions**	3
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 is to model a 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 in different scenarios. We will quantify the aggregation propensity of the protein. 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		
Desired Qualifications	Junior		

Project Name:	Analysis of viral particles for continuous processing approach	**Project ID:**	R008
Supervisor:	Arezoo Ardekani	**Number of Positions**	3
Project Description:	The increasing worldwide demand for vaccines along with the intensifying economic pressure on health care systems underlines the need for further improvement of vaccine manufacturing. In addition, regulatory authorities are encouraging investment in the continuous manufacturing processes to ensure robust production, avoid shortages, and ultimately lower the cost of medications for patients. The limitations of in-line process analytical tools are a serious drawback of the efforts taken in place. In line analysis of viral particles are very limited, due to the large time required for the current techniques for detection, qualitative and quantitative analysis. Therefore, there is a need for new alternatives for viral detection.		
Final Deliverables:	Working model of the device or fabrication of the device		
Desired Qualifications	Junior		

Project Name:	Design and analysis of tidal current energy converter	**Project ID:**	R009
Supervisor:	Jun Chen/ Greg Jensen	**Number of Positions:**	6
Project Description:	• A team of six students will work on the design and analysis of a tidal current energy converter that harvests energy from the ocean tidal currents. The students will examine the design of individual parts in the system to explore ways to achieve the optimal system performance.		
Final Deliverables:	• Models • Analyses (parts and system/sub-systems) reports • Design drawings for manufacture		
Desired Qualifications (optional)	• ME junior or senior, interested in hand-on design work, CAD experience with Siemens teamcenter or NX preferred, good team spirit.		

Project Name:	Elasticity in Minecraft	Project ID:	R010
Supervisor:	Adrian Buganza Tepole	Number of Positions	4
Project Description:	In summer 2020, a group of 5 undergraduates worked in the Tepole Lab to create an elasticity solver in Minecraft. Here is the product of their work: https://www.youtube.com/watch?v=1tipALPvj04 We know have a Minecraft Mod to solve the elasticity equations! One of the undergraduates from that project has continued to work on this, and we have started a collaboration with Prof. William Watson who studies the use of games in education. The goal is to create modules for ME270 Statics, ME323 Mechanics of Materials, and modules for the general public that can be shared through the Tepole Lab website and Youtube channel to convey concepts of elasticity in a gaming environment. The students working in this project will learn about numerical solvers for elasticity equations, they will polish their programming skills in Java and Python, and get to play Minecraft. The goals are: i) to improve the code so it can be more efficient and handle larger structures, ii) create examples and challenges for ME270, ME323, and general audiences, iii) generate website content and Youtube videos to pair with the examples and challenges.		
Final Deliverables:	• Code for updated Minecraft Mod capable of handling large structures • Examples and challenges for ME270, ME323 and general audiences (trusses, beam bending examples, etc.) • Website content and videos explaining the core concepts at play in the different examples (concept of force balance, stress, moment of inertia, etc…)		
Desired Qualifications	• Programming experience, Java would be ideal since Minecraft is in Java, but experience with Python or C++ would be good as well. • Knowledge of mechanics of materials i.e. ME323		

Project Name:	Visualizing How Magnetic Fields Shape Ferrofluid Droplets Using Python and Jupyter Notebooks	Project ID:	R011
Supervisor:	Prof. Ivan C. Christov	Number of Positions:	3-5
Project Description:	Recently, there has been significant interest in the physics of active and responsive fluids at the micro- and nanoscale. One promising approach to creating active fluids with controllable properties and behaviors is by suspending many mechanical micro swimmers made from shape-programmable materials and actuating their motion via an external magnetic field. This actuation mechanism is particularly enticing for biomedical applications due to the safe operation of magnetic fields in the clinical setting. In this project, a Jupyter-notebook-based nanoHUB tool (http://nanohub.org) will be created to illustrate how magnetic field shape 2D interfaces of ferrofluids (such as droplets). The project will involve learning some background on ferrofluid dynamics and their fascinating dynamics, as well as Python and Jupyter fundamentals.		
Final Deliverables:	Expected outcomes: • Ability to change magnitude and direction of the applied magnetic field with respect to a flat (or circular) initial fluid interface. • Ability to change geometric properties of the ferrofluid drop confinement.		

	• Ability to control numerical schemes used and validate the observed dynamics. • Ability to add interactive features and animations in Jupyter, including with simtool.
Desired Qualifications	• Basic Python programming (or equivalent) • Familiarity with differential equations • Familiarity with terminology and concepts from undergraduate fluid mechanics and electromagnetism • Motivation and enthusiasm for learning new topics and collaborating with others • Curious, creative, and self-motivated

Project Name:	Research in laser-based manufacturing and materials processing	**Project ID:**	R012
Supervisor:	Prof. Benxin Wu	**Number of Positions**	~2
Project Description:	Students are expected to perform work in the field of laser-based manufacturing and materials processing. A student may be involved in one or multiple topics in laser-based additive and/or substractive manufacturing.		
Final Deliverables:	Students will be evaluated based on the quantity, quality and difficulty of the work performed. The exact form of deliverables depends on the actual topic(s) in which the student is involved.		
Desired Qualifications	Good hands-on, material characterization and/or machine shop capabilities, etc.		

Project Name:	Manufacturing agricultural fertilizer using twin screw granulation	**Project ID:**	R013
Supervisor:	Carl Wassgren	**Number of Positions**	1
Project Description:	The objective of this project is to determine the feasibility of manufacturing agricultural fertilizer granules using twin screw (TS) wet granulation. Feasibility will be determined by measuring critical quality attributes of the granules and the sensitivity of these attributes to the TS operating parameters. The student working on this project will need to complete the following tasks: (1) Complete laboratory safety training. (2) Complete twin screw granulation training. (3) Complete training on laboratory characterization equipment. (4) Review prior work to become familiar with the TS granulation unit operation. (5) Perform TS manufacturing runs at different operating conditions to produce granules. (6) Measure granule characteristics, including the size distribution, shape, density, friability, and dissolution time. (7) Participate in fortnightly teleconferences with industrial partners. (8) Help prepare a written report describing the project effort. The student will work closely with the Lab Manager, Dr. Clairmont Clementson, and Prof. Carl Wassgren.		
Final Deliverables:	The project deliverables include: (1) fortnightly Zoom-based project updates with the industrial partners and (2) a written report describing the project effort. The student will also be expected to participate in weekly research group meetings where they'll provide short updates (~5 – 10 minutes) on their work.		

Desired Qualifications	The student working on this project should be comfortable working in a laboratory setting and have good communication skills. There is no requirement on having familiarity with TS granulation or laboratory characterization equipment as this training will be provided.

Project Name:	Production network modeling: A case study of an electro-mechanical system	**Project ID:**	R014
Supervisor:	Jitesh Panchal (ME) Philip E. Paré (ECE)	**Number of Positions**	2
Project Description:	**Background:** Globalization has significantly increased the rate at which opinions spread through social media, enabling rapid shifts in demand that is challenging for manufacturers to handle. One such example is the spike in demand for PPE and ventilators at the beginning of the COVID-19 pandemic. A drastic shift in demand requires a timely response from manufacturing supply networks. However, to avoid overcommitting to shifts in demand, optimal resource allocation from manufacturers is necessary. Professors Panchal and Paré, along with their graduate student, are developing a computational approach based on hybrid production network/social network model that effectively captures opinion dynamics on social networks, and their impact on production networks. In this project, the undergraduate students will have an opportunity to develop a case study of the supply/opinion network for an electro-mechanical system. **Activities:** The students participating in this project will formulate a case study by targeting a class of electro-mechanical products, decompose them into their materials and manufacturing processes, collect data from real supply chains to map out the production network. The students will then develop a computational model of the flow of materials on the production network, and study the impact of different shocks (e.g., spikes in demand) on the network. This model will be critical for developing and validating the hybrid network model in the future. **Learning:** Students participating in this project will gain fundamental knowledge of product design and manufacturing, and production network modeling and analysis.		
Final Deliverables:	1. A report with a well-documented case study. 2. Weekly updates to group members. 3. End-of-summer presentation.		
Desired Qualifications	Interest in design and manufacturing. Basic programming skills in Matlab or Python. Coursework in Linear Algebra and Differential Equations.		

Project Name:	Layered Safety Strategies for Grid-Scale Battery Energy Storage	**Project ID:**	R015
Supervisor:	Rebecca Ciez	**Number of Positions**	2
Project Description:	Battery energy storage systems can help to incorporate more renewable energy into our electricity grids. Widespread adoption of battery energy storage systems depends on reducing their cost and maintaining their safety. To do this, safety measures are implemented at the battery cell level and at a system level for grid storage. The aim of this project is to estimate how safety technologies at different levels of a grid storage system interact to influence the overall probability of failure, and how these safety system designs vary based on the role and services battery energy storage systems provide to electricity grids. Working with a graduate student, students would help to gather data about the types and performance of different safety technologies, and contribute to Python models of how these technology combinations influence system performance, the cost of storing electricity, and the probability of system failure.		
Final Deliverables:	Database of relevant safety technologies, shareable code, written explanations and figures that could contribute to academic publications.		
Desired Qualifications	Prerequisites: ME200, ECE 20001, working familiarity with Python and/or MATLAB. Experience with GitHub is also a plus.		

Project Name:	Data-driven Vulnerability Model for Space Habitats	**Project ID:**	R016
Supervisor:	Prof. Shirley J. Dyke	**Number of Positions**	Up to 3
Project Description:	In this project, we will develop a data-driven vulnerability model for a structure under the meteorite impact. The finite element model of the structure and the stochastic model of the meteorite impact are available. Students need to get familiar with the finite element model of the structure and the stochastic model of the meteorite impact and integrate the two models in the first step. The second step is determining the definitions of structure damage levels according to the available literature. The third step would be designing and running the simulations (using the integrated model) to generate a dataset including the meteorite impact characteristics (e.g., velocity, mass, etc.), structure characteristics (e.g., material, geometry, size, etc.), and the damage level of the structure. Ultimately, we need to use this dataset to train a model that can input the meteorite impact and structure characteristics and output the damage level of the structure.		
Final Deliverables:	1. Dataset 2. Predictive data-driven model 3. A brief and concise report describing the dataset and the model		
Desired Qualifications	1. Familiar with Matlab and Python 2. Interested in data science and developing predictive models		

Project Name:	Design and Implementation of a hybrid microscale optical 3D printer	**Project ID:**	R017
Supervisor:	Liang Pan	**Number of Positions**	3-5
Project Description:	Three-dimensional (3D) printing is routinely performed to create macro- and micro-scale structures using different methods, such Stereolithography (SLA), Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), and Digital Light Process (DLP). Here we will assemble a team to experimentally create a new kind of microscale 3D printer with software infrastructure that can support a hybrid operation mode that can seamlessly work with both Stereolithography (SLA) and Digital Light Process (DLP). This will incorporation the advantages of both methods.		
Final Deliverables:	A working microscale 3D printer, including the hardware and control software		
Desired Qualifications	Applicants expect to have one of the following capabilities. 1. Operation of 3D printers 2. Use of CAD to create 3D geometries 3. Labview programing 4. Basic digital circuits and the use of oscilloscope and other electronics. 5. Mechatronics		

Project Name:	Design and build demonstration systems for heat transfer courses	**Project ID:**	R018
Supervisor:	Liang Pan	**Number of Positions**	3-5
Project Description:	ME315 and its lab components have been well established for a few decades. With the recent technology development, we are putting together efforts to modernize the lab related components as well as classroom demonstrations. Through this project, we aim to design and implement a number of turn-key systems to study and illustrate the heat transfer processes, particularly in modern applications and using new detection methods. The results from this project will help future ME students for many years.		
Final Deliverables:	One or more demonstration systems that can study and illustrate the key fundamentals in modern heat transfer applications		
Desired Qualifications	Applicants expect to have one or more of the following capabilities. 1. Have taken ME315 2. Fabrication skills in machine shop 3. Use of CAD software 4. Labview programing 5. Mechatronics		

Project Name:	Machine Shop Student Project Prototype	**Project ID:**	R019
Supervisor:	Mike Logan	**Number of Positions**	3
Project Description:	Work with Mike Logan, Song Zhang, Eric Naumann, and John Wheeler to develop a few options for Machine Shop projects that are cost effective and time effective while still generating the desired experiences using specific tools and processes Students would spend first third doing conceptual designs for approximately 12 potential projects. At this time, the advisors/team would select three projects to physically prototype. The second third of the summer would be working in the Machine Shop and having the students actually build those three prototypes. This may result in 9 (or more) distinct prototype projects being completed. The final portion will be spent developing required revisions and integrating this into a full ready to use package. This includes materials lists, cost estimates per student, technical drawings, and instructions for the student.		
Final Deliverables:	Prototype Samples of projects, Instructions for students to make Project, and Full Technical Drawings. Total of three unique projects suitable for use in the Milestones or Shop Experience plans		
Desired Qualifications	CAD/Solid Modeling		

Project Name:	Persistent Autonomous Surface Vehicle	**Project ID:**	R020
Supervisor:	Nina Mahmoudian	**Number of Positions**	Max of 4
Project Description:	The team will use the current state of the art autonomy package developed by Mahmoudian's lab and add it to a large inflatable carameran boat. Select motors, associate components, and size solar and battery system for expected load to create a cohesive system that can work consistently over long period of time. The work has to be conducted in Kepner Lab in Lafayette.		
Final Deliverables:	An Autonomous Surface Boat equipped with Solar Panels and long duration tests to show the battery state of charge over several hours		
Desired Qualifications	Programming, Electrical Engineering basics, Control and System Design, At least one student needs to have driving license to support field experiments.		

Project Name:	Simulation of refrigeration equipment	Project ID:	R021
Supervisor:	Patricia Davies	Number of Positions	2
Project Description:	Sound simulation of equipment noise to help in design of products. This will involve MATLAB programming, and development of some program user interfaces. It will also involve some sound measurement and analysis. It will build on work done by previous students, pulling different developed components together.		
Final Deliverables:	Software developed that can be further refined by future students, and be easily adapted to be used in different applications.		
Desired Qualifications	Preferably someone going into their senior year, or are half way through their junior year.		

Project Name:	Fabric based wearable devices	**Project ID:**	R022
Supervisor:	Tian Li	**Number of Positions**	3
Project Description:	Here in this work, we address the discrepancy between the requirements for wearability and electronic devices by redesigning traditional textile fibers towards a wearable human-machine interactive platform. This work also features cost-effectiveness of the raw materials with scale-up potential.		
Final Deliverables:	Understanding solid mechanics analysis and demonstration of stretchable devices.		
Desired Qualifications	Background (previous courses or research experience) on electronic devices and solid mechanics analysis are preferred.		

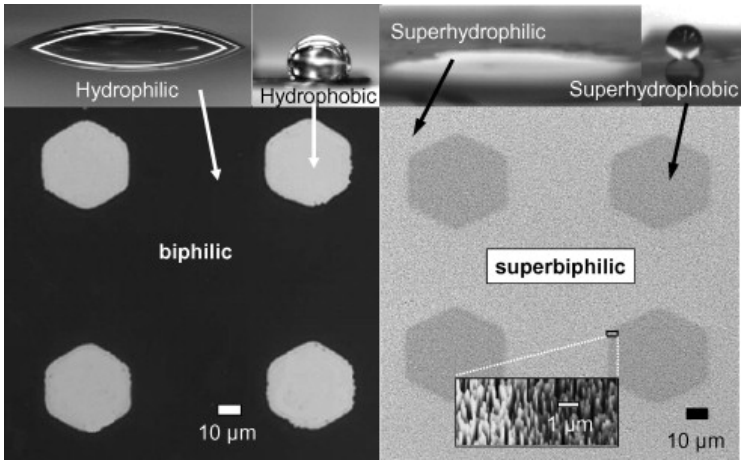
Project Name:	3D printer with 3D vision sensor for in-situ diagnosis and closed-loop control	**Project ID:**	R023
Supervisor:	Song Zhang	**Number of Positions**	2
Project Description:	This project aims at designing a 3D printer that can incorporate a high-end customized 3D vision system for in-situ diagnosis and quality control. Undergraduate students will be responsible for identifying suitable hardware components, designing, fabricating and integrating hardware system. Undergraduate students will also work with graduate student mentor to explore software algorithms for fault diagnosis and close-loop controls.		
Final Deliverables:	• Design of system with 3D software • Identify hardware components and prices • Fabricate and integrate the entire printing system (if time allows)		
Desired Qualifications	Prior experiences using Solidworks or CAD design software, strong communication and hands-on skills.		

Project Name:	Additive manufacturing of energetic materials	**Project ID:**	R024
Supervisor:	Yung C Shin	**Number of Positions**	2
Project Description:	This study is to continue to explore the additive manufacturing of energetic materials using a new 3D printer available in the supervisor's lab. The student is expected to optimize the process parameters to build successful samples using various provided materials and work with a graduate student to study its resultant properties. The participating undergraduate student(s) is expected to work on preparation of specimens by optimizing process parameters of additive manufacturing, conduct heat treatment, if necessary, and carry out necessary testings with a graduate student, and analyze the results to generate reports on findings.		
Final Deliverables:	It is expected to submit weekly or bi-weekly reports describing the findings and results of research project during the regularly scheduled meeting. A final written report is required for the final grade, which contains all the experimental results, collected testing results and analysis results.		
Desired Qualifications	Junior or higher standing with the minimum GPA of 3.4		

Project Name:	Laser micromachining of polymers and glasses	**Project ID:**	R025
Supervisor:	Yung C Shin	**Number of Positions**	2
Project Description:	The research is to investigate the effects of various process parameters on forming microchannels on polymers and glasses using a CO2 laser. These microchannels are useful for making micro heat exchangers or microfluidic devices. To this end the student will carry out the following tasks: 1. Literature review of related field 2. Design experiments and carry out systematic parametric study on the relationship between process parameters and microchannel quality using the available laser micromachining system. 3. Characterize the resultant microchannel quality using various optical measurement techniques such as optical microscope and optical surface profiler. 4. Optimize the process parameters to achieve the best quality and throughput. 5. Generate a technical report summarizing all the findings. • The student will learn how to schedule and prioritize his/her work according to the overall goals and tasks. He will have a weekly meeting with me to discuss the progress and future directions. • The student will be required to write a weekly report summarizing the results, ideas and future plans. • The student will be required to write a final report summarizing all the findings and achievements during the course of the program. • The student will gain the knowledge and skills about lasers, operation of the laser, and characterization method. • The student will gain the essential knowledge about how to do research or solving an open ended problem using creative thinking.		
Final Deliverables:	It is expected to submit weekly or bi-weekly reports describing the findings and results of research project during the regularly scheduled meeting. A final written report is required for the final grade, which contains all the experimental results, collected microstructure data and analysis results.		
Desired Qualifications	Junior or higher standing with the minimum GPA of 3.4		

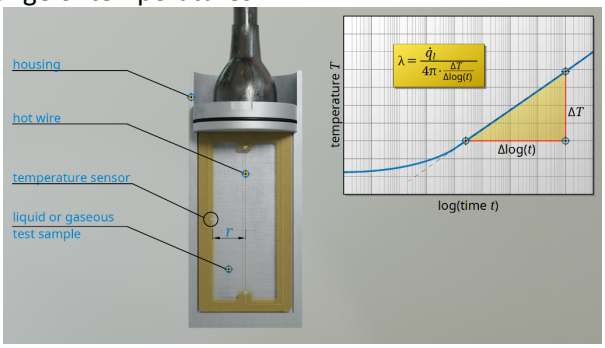
Project Name:	Data-driven model for microstructure- properties of additively manufactured metal parts	**Project ID:**	R026
Supervisor:	Yung C Shin	**Number of Positions:**	2
Project Description:	This study is to investigate the mechanical properties of metal alloy parts built by additive manufacturing in terms of the resultant microstructure and to establish a data-driven model between the microstructure and mechanical properties. Additive manufacturing is gaining global popularity due to its unprecedented capabilities that it can provide. One of the challenges remaining for wide spread industrial use of AM is to predict/control the resultant mechanical properties. Additive manufacturing due to its nature of localized heating and solidification layer by layer inherently produces non-homogeneous microstructure. This study is to establish property-structure relationships of AM built metal parts. The participating undergraduate student(s) is expected to work on preparation of		

	tensile and compression specimens by additive manufacturing alone or with a graduate student, prepare samples for microstructure measurement, conduct heat treatment, if necessary, and mechanical testing using a universal testing machine, and analyze the results to generate reports on findings. Finally, it is expected to establish microstructure-mechanical property relationships using a machine learning technique such as multilayer neural networks and deep learning methods.
Final Deliverables:	It is expected to submit weekly reports describing the progress, findings and results of the research project during the regularly scheduled meeting. A final written report is required for the final grade, which shall contain literature review, collected microstructure data, all the experimental results, and analysis results.
Desired Qualifications:	Junior or higher standing with the minimum GPA of 3.5

Project Name:	Heterogenous Surfaces for Confined Boiling	**Project ID:**	R027
Supervisor:	Albraa Alsaati Prof. Amy Marconnet	**Number of Positions**	2-4
Project Description:	Several industrial applications rely on boiling for exchanging energy. Experimental observations indicate that surface wettability significantly affects the thermal performances of boiling surfaces. Hydrophobic (water-repelling) surfaces typically result in lower surface temperature; while hydrophilic (water-loving) surface increases the maximum heat flux limit before the surface dries out. Therefore, heterogenous surfaces with spatially distinct domains of wettability, known as biphilic surfaces, recently emerged as a solution to achieve advantages of both hydrophilic and hyrdrophobic surfaces.  https://doi.org/10.1016/j.ijheatmasstransfer.2012.10.080 This project aims to establish a process to produce heterogenous coatings that are optically transparent on glass surfaces. The coating process needs to be able to produce wettability patterns with a 10 micron spatial resolution and the patterns need to thermally stable at temperatures up to 120C. The coated samples produced in this project will later be evaluated for boiling applications in confined configurations.		
Final Deliverables:	• A coating process for glass surfaces that is: ○ Optically transparent.		

	○ Thermally stable up to 120C. ○ Capable of producing patterns with ~10 micron resolution. • Data on surface wettability as a function of the coating parameters • Final report summarizing all projects outcomes
Desired Qualifications	Experience with the following processes is a plus, but we don't expect candidates to be familiar with them: • Surface functionalization processes. • Dynamic contact angle measurement. • Spin coating. • Photolithography. • Laser etching.

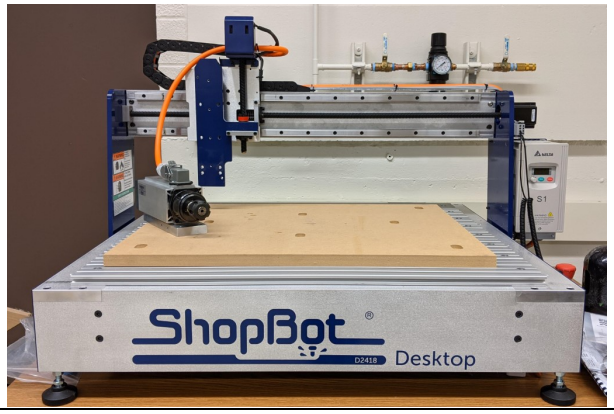
Project Name:	High Temperature Thermal Characterization of Metal Hydrides	**Project ID:**	R028
Supervisor:	Amy Marconnet Timothee Pourpoint	**Number of Positions**	2-4
Project Description:	The high energy density of metal hydrides makes them attractive for thermal energy storage and high heat flux thermal management applications. For instance, to mitigate the temperature rise at the leading edge of hypersonic vehicles. In practice, metal hydrides are used in a particulate form and the effective thermophysical properties of the powdered metal hydrides are not well known. In this project, students will design, build, and test a fixture for characterizing the thermal conductivity and heat capacity of metal hydride powders based on either the hot wire or transient plane source techniques. This will involve using FEA models to predict performance and design the optimal configuration of the test rig. After fabrication, inert well known materials (like silica) will be used to calibrate and validate the measurement technique. Finally, the metal hydride powders will be tested at a range of temperatures.		
Final Deliverables:	• Experimental text fixture for characterizing thermal conductivity • Calibration data for inert powders		



Example hot wire fixture. The setup consists of a thin wire running through the packed powder bed. The wire acts as a heat source and temperature sensors. For the metal hydrides, conventional designs will need to be improved considering the corrosive nature and the electrical conductivity of the material, as well as the temperatures of interest.

https://www.tec-science.com/thermodynamics/heat/transient-hot-wire-method-method-for-determining-thermal-conductivity-thw/

	• Data on thermophysical properties of a metal hydride powder • Final report documenting design and data
Desired Qualifications	The following skills are desirable for the team, but not every candidate need have all skills: • CAD for drafting part designs • Hands on fabrication experience: machining to build the system • Exposure to finite element analysis (FEA) • Labview for programming data acquisition system • Experience with soldering, circuits, etc.

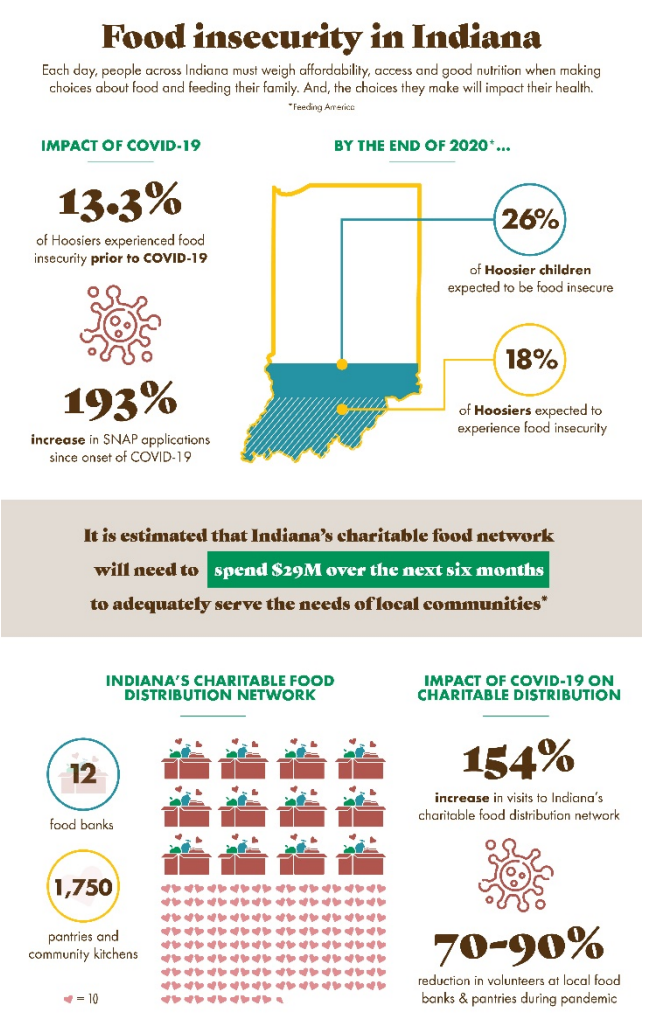
Project Name:	Multimaterial printer development for soft electronics	**Project ID:**	R029
Supervisor:	Alex Chortos	**Number of Positions**	2
Project Description:	**High level goal**: Soft and stretchable electronics offer the potential to interface with the human body to repair or augment biological systems. This requires developing highly specialized materials that can be patterned and distributed in precise 3D arrangements. As part of this process, we are setting up a multimaterial 3D printing system to deposit multiple soft materials that include sensors and actuators.  **Completed progress**: replacement of the control board to use open-source firmware and control hardware. Fabrication of material dispensers.		
Final Deliverables:	• Implement controls for Z axis actuators • Implement control for printhead dispensers • Demonstration prints: simple soft electrostatic actuators and strain sensors		
Desired Qualifications	• Experience with 3D printing, CNC machines, control languages (Gcode, Labview, etc.), or materials		

Project Name:	IoT4Ag: AgBot	**Project ID:**	R030
Supervisor:	David J. Cappelleri	**Number of Positions**	2-3
Project Description:	This project is on the design and implementation of a small-scale mobile robot for precision agriculture applications. Specifically, this robot will be used to autonomously sample corn leaves from plants at different times during the growing cycle. The project will consist of both design and field work testing the prototype robot system.		
Final Deliverables:	Functional prototype, field demonstration, final report		
Desired Qualifications	Mechanical design, mechatronics, electronics, and programming experience		

Project Name:	Inhomogeneities in Granular Gases to Prevent Instability Onset	**Project ID:**	R031
Supervisor:	Prof. Aaron Morris	**Number of Positions**	1
Project Description:	Granular flows describe a variety of natural phenomena (shockwaves through sand, planetary rings), and industrial processes. The inelasticity of granular particles give rise to unique molecular dynamics of granular flows such as the aggregation of particles, or clustering. It is well known that the onset and characteristics of clustering and other instabilities are intrinsically tied to the particle-system scale and particle's material properties. One such trend is the increased likelihood of instability onset with increased dissipation between particle-particle collisions. The project would seek to understand if a normally unstable granular gas can become stable and more predictable if elastic particles are introduced. Insight may suggest possible avenues in industrial processes to retaining homogeneous flows. The student will work on simulating granular mixtures using discrete element techniques. The student may also learn Direct Simulation Monte Carlo methods as well.		
Final Deliverables:	Presentation/Document summarizing their findings		
Desired Qualifications	- Experience coding (FORTRAN preferred but not necessary) - Organized and self-motivated - Ability to do independent research		

Project Name:	Data-science for Fluid Dynamics	**Project ID:**	R032
Supervisor:	Carlos M Corvalan (Associate Professor, by courtesy)	**Number of Positions**	2-3
Project Description:	Data-science for fluid dynamics: This project is about the intersection of new data-science methods and the classical field of fluid dynamics. Data-driven discovery and machine learning provide a new powerful framework that can enhance and even transform current lines of fluid mechanics research and industrial applications. This project will bring together machine learning, and engineering mathematics to integrate modeling and simulation of dynamical systems with modern methods in data science. We will discuss and apply recent advances in scientific computing and machine learning that enable data-driven discovery to be applied to a diverse range of fluid systems.		
Final Deliverables:	Working computer codes leveraging machine-learning to solve engineering problems		
Desired Qualifications	Background in differential equations and scientific computing are desirable.		

Project Name:	3DP FIRE Project 1: **Printability Characterization of Food Inks with Solid Particles**	**Project ID:**	R033
Supervisor:	Prof. Ajay Malshe (faculty), Dr. Salil Bapat (Post-doctoral Fellow) and Vishvesh Koranne (Ph.D. students)	**Number of Positions**	2
Project Description:	**Project 3DP FIRE: 3D Printing Food Inks REsearch Background**		

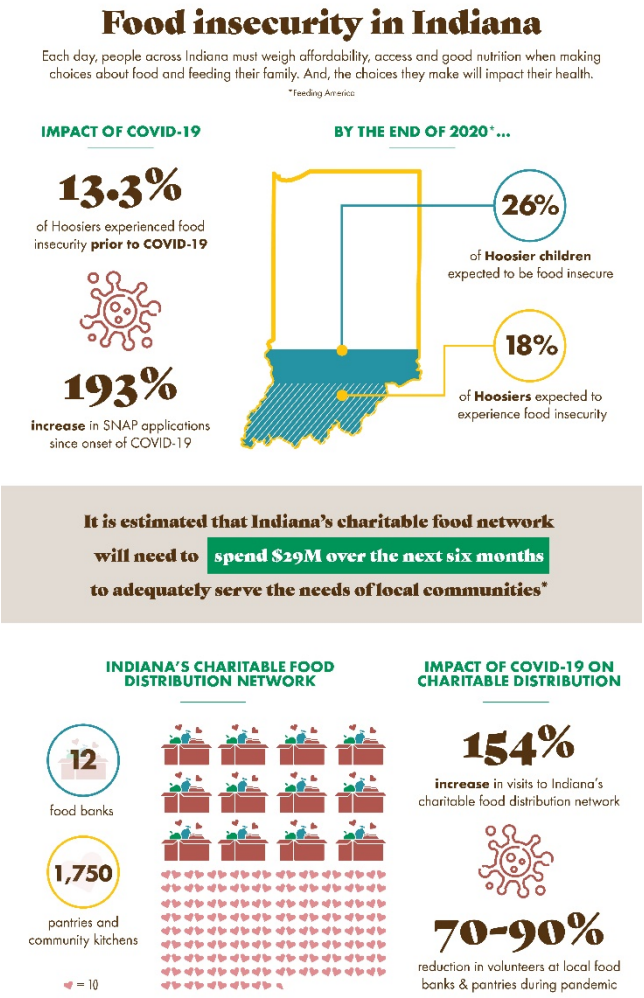


The U.S. Department of Agriculture (USDA) defines **Food Insecurity** as a lack of consistent access to enough food for an active, healthy life. It is a social challenge that plagues both developed and developing countries. In United States, as of 2017, the average fraction of households at a risk of hunger was 12.7%. The Hoosier state of Indiana, before the pandemic, had 13.3% of its population who were food insecure. As the pandemic has crippled many of our social institutions, this figure is expected to be rise with nearly 1 out of 5 Hoosiers and 1 out of 4 Hoosier children projected to be food insecure. Amid Industry 4.0 and the Second Agricultural Revolution, **nobody should be forced to make a choice between tasty, healthy food and a healthy life**.

Three-dimensional printing of food is one of the manufacturing solutions to this problem. Not only does food printing allow logistical flexibility with getting food, it has the potential to customize food for taste, texture and nutrition for every individual then be it an infant, an expecting mother, an athlete, an astronaut, an elder person or high-school or university students. The State-of-the-Art research in this field currently involves discovery and characterization of food inks for their printability. Malshe Labs has three projects for interested undergraduate students to get a flavor of research in this emerging field.

	Aim To study the rheological properties of food inks with solid particles and model their flowability **Description** In this project, students will study the rheological properties of heterogeneous food inks with solid particles (like granola, protein flours) dispersed in readily printable inks (like chocolate, mashed potato with starch), model and print structures with 3D Food Printers, and, study the printability assessing print quality parameters for the structures. **Relevance** This research has relevant applications in novel, affordable and sustainable food ink discovery which will help in proliferation of food printing technology to people of all social strata. **Additional Details** Students will work with a PhD student (Vishvesh Koranne) supervised by Prof. Ajay Malshe and Dr. Salil Bapat.
Final Deliverables:	Students will come up optimal food ink composition and printing process parameters for the most desirable print and a framework to characterize food inks dispersed with solid particles. Towards the end of the project term, students will be expected to consolidate their findings in a report and present them to the group.
Desired Qualifications	Curiosity and Enthusiasm are the only essential qualities! 3D Modeling/Printing Experience preferred but not necessary.

Project Name:	3DP FIRE Project 2: Printability **Characterization of Food Inks with Fibrous Materials**	**Project ID:**	R034
Supervisor:	Prof. Ajay Malshe (faculty), Dr. Salil Bapat (Post-doctoral Fellow) and Vishvesh Koranne (Ph.D. students)	**Number of Positions**	2
Project Description:	**Project 3DP FIRE: 3D Printing Food Inks REsearch**		



Background

The U.S. Department of Agriculture (USDA) defines **Food Insecurity** as a lack of consistent access to enough food for an active, healthy life. It is a social challenge that plagues both developed and developing countries. In United States, as of 2017, the average fraction of households at a risk of hunger was 12.7%. The Hoosier state of Indiana, before the pandemic, had 13.3% of its population who were food insecure. As the pandemic has crippled many of our social institutions, this figure is expected to be rise with nearly 1 out of 5 Hoosiers and 1 out of 4 Hoosier children projected to be food insecure. Amid Industry 4.0 and the Second Agricultural Revolution, **nobody should be forced to make a choice between tasty, healthy food and a healthy life**.

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Aim

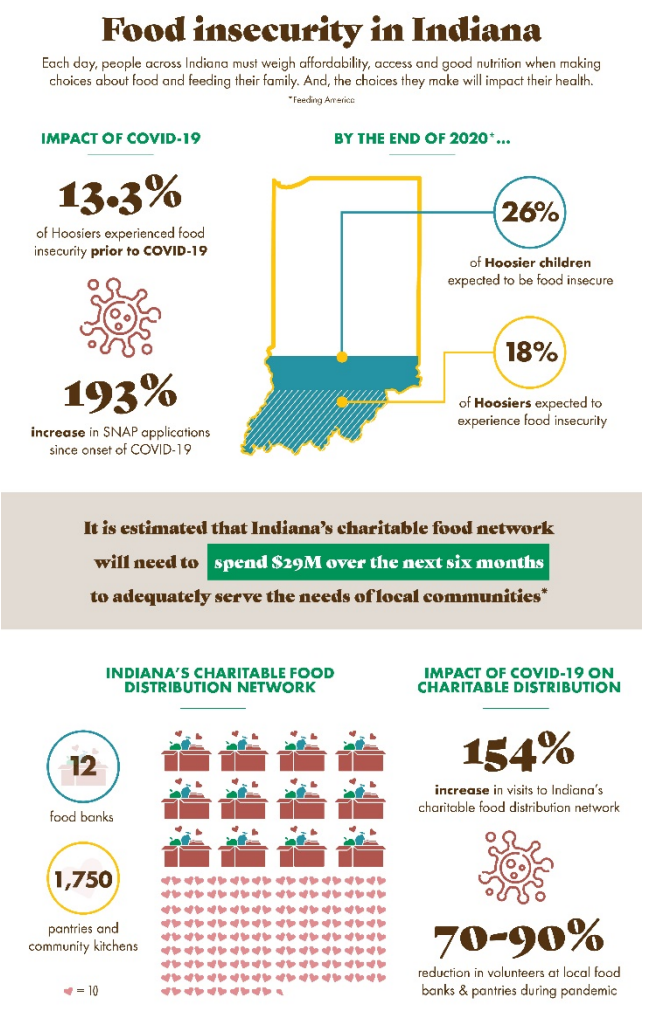
To study the rheological properties of food inks with different base fiber characteristics for scaffold printing

Description

In this project, students will study the rheological properties of fibrous food inks composed of cellulose, soy proteins, or other plant proteins, (produced with base

	materials consisting of different fiber lengths), model and print scaffolds with them using 3D Food Printers, and, assess the print quality of scaffolds. **Relevance** This research has relevant applications in discovery of sustainable alternatives to traditional meat with similar meat quality attributes. **Additional Details** Students will work with a PhD student (Vishvesh Koranne) supervised by Prof. Ajay Malshe and Dr. Salil Bapat.
Final Deliverables:	Students will study the effect of base fiber length on print quality of scaffolds for different materials and characterize food inks with fibrous materials for printing different scaffolds. Towards the end of the project term, students will be expected to consolidate their findings in a report and present them to the group.
Desired Qualifications	Curiosity and Enthusiasm are the only essential qualities! 3D Modeling/Printing Experience preferred but not necessary.

Project Name:	3DP FIRE Project 3: **Formulation of Food Inks with difficult-to-print ingredients**	**Project ID:**	R035
Supervisor:	Prof. Ajay Malshe (faculty), Dr. Salil Bapat (Post-doctoral Fellow) and Vishvesh Koranne (Ph.D. students)	**Number of Positions**	2
Project Description:	**Project 3DP FIRE: 3D Printing Food Inks REsearch**		



Background

The U.S. Department of Agriculture (USDA) defines **Food Insecurity** as a lack of consistent access to enough food for an active, healthy life. It is a social challenge that plagues both developed and developing countries. In United States, as of 2017, the average fraction of households at a risk of hunger was 12.7%. The Hoosier state of Indiana, before the pandemic, had 13.3% of its population who were food insecure. As the pandemic has crippled many of our social institutions, this figure is expected to be rise with nearly 1 out of 5 Hoosiers and 1 out of 4 Hoosier children projected to be food insecure. Amid Industry 4.0 and the Second Agricultural Revolution, **nobody should be forced to make a choice between tasty, healthy food and a healthy life**.

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Final Deliverables:	Students will study the printability from macronutrient and micronutrient viewpoints and develop a method or guidelines to discover novel food inks with desired nutrients. Towards the end of the project term, students will be expected to consolidate their findings in a report and present them to the group.
Desired Qualifications	Curiosity and Enthusiasm are the only essential qualities! 3D Modeling/Printing Experience preferred but not necessary.

Project Name:	Design Considerations for Habitat for In-Space Manufacturing	**Project ID:**	R036
Supervisor:	Ajay P. Malshe (faculty) and Albert Patrick (Ph.D. students)	**Number of Positions**	1
Project Description:	Project 1: Simulation of Aeroponic Growth System in Microgravity Project would revolve around students designing an aeroponic growth system with reliable delivery system of nutrients and maintain growing parameters of plant. Aeroponic growth is different from hydroponic growth in the lack of a liquid phase of nutrient delivery in favor of an aerated delivery through usually water vapor. The challenge would be to deliver nutrients and maintain all other growing parameters in the harsh and persistent microgravity environment. Students would design, test, and simulate a working habitat from top to bottom ie power source, chosen plant, materials used, etc. If possible this could be converted to a physical project though would require changing parameters to include a 2D or 3D clinostat to properly simulate a microgravity environment.		
Final Deliverables:	Final deliverables would be a presentation dictating the difficulties and a simulation of the system with proper power distribution and plant being growth within a month's time under constant microgravity interaction.		
Desired Qualifications	Desired qualifications would be skill in simulation software (ANSYS or other), strong math and geometric ability, and willing to understand agricultural aspects in a different environment.		

Project Name:	Design Considerations for Habitat for In-Space Manufacturing	**Project ID:**	R037
Supervisor:	Ajay P. Malshe (faculty) and Albert Patrick (Ph.D. students)	**Number of Positions**	1
Project Description:	Project 2: Simulation of FDM Food Printing in Microgravity Project would include dealing with the difficulties of 3D printing in microgravity along with the difficulty of printing food in general. 3D food printing has difficulty in post-processing and slow printing time, but offers high customizability. Microgravity presenting the difficulty with layer by layer adhesion and lack of gravity for guiding deposited material. Students would be tasked with designing a way to counteract the lack of gravity and determine a material composition for proper printing. Simulation can be done using ANSYS and the material composition can be shown using the ByFlow printer.		
Final Deliverables:	Final deliverables would be a presentation dictating the difficulties and a simulation of the system with proper printing techniques and material composition under constant microgravity interaction.		
Desired Qualifications	Desired qualifications would be skill in simulation software (ANSYS or other), strong math and geometric ability, and willing to understand additive manufacturing aspects in a different environment.		

Project Name:	Design Considerations for Habitat for In-Space Manufacturing	**Project ID:**	R038
Supervisor:	Ajay P. Malshe (faculty) and Albert Patrick (Ph.D. students)	**Number of Positions**	1
Project Description:	Project 3: Design of microgravity exterior habitat on surface factories Project would revolve around students designing an exterior growth system that the crew of a surface factory would be able to interact without a containment system for the plants. Exterior growth is more difficult than interior due to lack of environment stability. The challenge would be to deliver nutrients and maintain all other growing parameters in the harsh and persistent microgravity environment. Students would design, test, and simulate a working habitat from top to bottom ie power source, chosen plant, materials used, etc.		
Final Deliverables:	Final deliverables would be a presentation dictating the difficulties and a simulation of the system with material acquisition, agricultural growth system, and power system considerations under constant microgravity interaction.		
Desired Qualifications	Desired qualifications would be skill in simulation software (ANSYS or other), strong math and geometric ability, and willing to understand additive manufacturing aspects in a different environment.		

Project Name:	Design Considerations for Habitat for In-Space Manufacturing	**Project ID:**	R039
Supervisor:	Ajay P. Malshe (faculty) and Albert Patrick (Ph.D. students)	**Number of Positions**	1
Project Description:	Project 4: Simulated design of in-situ agriculture habitat for usage on surface factories Project would revolve around students determining the usage of in-situ material ie lunar regolith for design and creation of a lunar habitat capable of growing plants until harvest. In-situ materials on the moon are scarce and the materials and environment given is unforgiving. Although complete building from the moon is impossible it will be assumed that the minimum amount of materials brought will be determined through research. The challenge would be to deliver nutrients and maintain all other growing parameters in the harsh and persistent microgravity environment along with lunar day and night cycles and weather. Students would design, test, and simulate a working habitat from top to bottom ie power source, chosen plant, materials used, etc.		
Final Deliverables:	Final deliverables would be a presentation dictating the difficulties and a simulation of the system with material acquisition, agricultural growth system, and power system considerations under constant microgravity interaction.		
Desired Qualifications	Desired qualifications would be skill in simulation software (ANSYS or other), strong math and geometric ability, and willing to understand additive manufacturing aspects in a different environment.		

Project Name:	TaskXR	Project ID:	R040
Supervisor:	Prof. Karthik Ramani	Number of Positions	6
Project Description:	Computer vision based analytics of Activities - Interns will get to work with data management, annotation frameworks and the building blocks of an Artificial Intelligence System		
Final Deliverables:	1. Curated and annotated data 2. Baseline performances of Algorithms, if 1 is sufficiently completed		
Desired Qualifications	• Programming experience in Python - with exposure to NumPy and OpenCV frameworks • Basic familiarity with Machine Learning • Experience with UI development using Python/C++ or other programming languages is a plus		

Project Name:	WeAR	Project ID:	R041
Supervisor:	Professor Karthik Ramani	Number of Positions	1
Project Description:	The project intends to develop a wearable device that allow users to interact with Augmented Reality. The goal is to develop a wearable device that can create interaction modalities to manipulate virtual objects in any moment or location. Hardware and software development are part of the project. If interested please contact Luis Paredes at: lparede@purdue.edu		
Final Deliverables:	Wearable implementation – communication with Head mounted displays (Bluetooth/Wifi) – data processing – microcontroller programming.		
Desired Qualifications	• Microcontrollers Programming experience • 3D Graphics software is useful (C#/Unity) • Some data collection experience will be useful		

Project Name:	FabWear	Project ID:	R042
Supervisor:	Professor Karthik Ramani	Number of Positions	1
Project Description:	The project intends to provide designers with a system that allows them to design wearable devices using a digital interface. The users should be able to personalize functionalities and forms of their wearables by rendering wires over complex geometric shapes, visualizing electrical components, and manipulating locations. The user of the software should be able to use the interface to select the components, place the components over a 3D geometry, create circuit traces, generate a geometric contour around the components. Current requirements are for integrating multiple separate software modules developed into one general interface. If interested please contact Luis Paredes at: lparede@purdue.edu		
Final Deliverables:	**Interface** for wearable devices design – **integration of the different software modules** like rendering, circuit traces, shape configuration, and printable file generation.		
Desired Qualifications	• Programming experience • 3D Graphics software is required: - **JavaScript/Tree.js** (desired) - C++/OpenGL or C#/Unity (alternative)		

Project Name:	Distance learning module for hydraulic trainer	**Project ID:**	R043
Supervisor:	Sadegh Dabiri	**Number of Positions**	4
Project Description:	The goal of this project is to develop an attachment for hydraulic trainer systems so that students can remotely control and observe the trainer and gain hands-on experience in fluid power. This laboratory experience will be utilized in online and distance learning classes. Students need to learn about components of fluid power systems and hydraulic trainers.		
Final Deliverables:	Design and prototype of the frame. Selection of sensors and actuators for the control system.		
Desired Qualifications	Hands-on experience with CAD design and prototyping; experience with sensors, actuators, raspberry-pi.		

Project Name:	Modeling Human Trust in Self-Driving Vehicles	**Project ID:**	R044
Supervisor:	Neera Jain and Tahira Reid Smith	**Number of Positions**	2
Project Description:	This project will involve the design of human subject experiments aimed at stimulating and measuring human trust during interactions with autonomous systems. The students will work closely with graduate students to design and develop the experiments. The experiments will involve a medium fidelity driving simulator as well as data collection via psychophysiological sensors.		
Final Deliverables:	The final deliverables will be a written report and presentation to our research groups.		
Desired Qualifications	Students with strong coding skills are required, ideally with experience in multiple languages including Python. Experience with Unreal Engine or Unity is desirable but not necessary.		

Project Name:	Design and Fabrication of Flexible Structures using 3D Printing, and Vibration Measurements	**Project ID:**	R045
Supervisor:	Anil K Bajaj	**Number of Positions**	2
Project Description:	Flexible elements/structures are prevalent in nature though their modeling and then analysis is complicated. They are starting to see applications in flexible robotics, medical devices etc. Such structures undergo easily, large deformations and possibility of buckling. Due to the availability now of low-cost 3D printing with polymers, we can design simple models of such structures and conduct experiments to understand their behavior under various loadings. In this project, we propose to design and fabricate simple structures like cantilever and fixed-fixed beams, arch structures, and plates with different boundary conditions. We propose to then analyse the structures for their deformations under static loading to find limits of linear response and ensuing nonlinear characteristics using FEM software with various deformation models. Comparing to simple experiments with displacement measurement techniques can allow for extraction of material properties essential for more deeper design and modeling efforts.		
Final Deliverables:	Literature review, Project report including – Elements Designs and 3D Printed Beams/Arches of various types/Software Codes for Statics/Dynamics of structures from Ansys		
Desired Qualifications	Matlab/ME 365/ME 323/Ansys or Abacus/		

Project Name:	Dynamic Simulations in NEMS and MEMS	**Project ID:**	R046
Supervisor:	Anil K Bajaj	**Number of Positions**	2
Project Description:	MEMS and NEMS have become very well studied structural systems with multiple physics including electrostatic actuation (with fringing field effects), stretching nonlinearities due to large displacements, squeeze-film and other damping effects, van der Waal forces fields, etc. Classic examples of these structures are clamped-clamped and cantilever beams with electrodes located on one or both sides (below and above). The beams can be modeled as Euler-Bernoulli beams for thin beams. With increase in steady actuation levels (static voltages), the structure deforms transversely in a continuous manner, till a sudden jump to large displacement takes place. The phenomenon, called pull-in instability brings down the beam in contact with the electode(s) causing shorting or disruption of the device function. This behavior can be analytically modeled for thin beams but for thicker structures, and with multiple physical effects, simulations are much more useful for prediction of performance as well for design iteration studies. In this project, after a quick review of the essential literature, the nonlinear governing equations/model of the structure, are to be simulated by two approaches: the simulation will be using software tools in Ansys as well as the classical analytical models. The influences of basic nondimensional parameters on the pull-in instability as well as the natural frequency are to be investigated.		
Final Deliverables:	Literature review, Project report including - Coupled Codes/Software and some Animations of Dynamics from Ansys		
Desired Qualifications	Matlab/ME 365/ME 323/Ansys or Abacus/		

Project Name:	Understanding Users, Stakeholders, and Beneficiaries in Complex Engineering Problems	**Project ID:**	R047
Supervisor:	Tahira Reid Smith	**Number of Positions**	2-6
Project Description:	Traditional design methods of product design often require significant investments of time and resources often months to years with millions of dollars invested. They often work best on consumer products or services. With systems becoming more complex with potential impacts on various stakeholders, the need to quickly think through and identify problems and potential solutions is becoming an imperative. In this project, students will be introduced to and use interdisciplinary design process methods to address a set of pre-selected topics of interest to NASA and/or that has implications on social justice. Students will work individually and/or in the context of a virtual team.		
Final Deliverables:	1. Written report and/or draft of a conference paper 2. A Power Point Presentation with Results		
Desired Qualifications	ME students of all levels are eligible to apply. Critical thinkers, students with great interest in human-centered design and/or that has interests in intersecting engineering and social issues are welcome.		

Project Name:	Rotating bending test development	**Project ID:**	R048
Supervisor:	Beth Hess	**Number of Positions**	4
Project Description:	This project would develop a lab to be incorporated into ME 35401: Machine Design Lab. The group would learn how to operate an existing rotary fatigue tester (see https://www.youtube.com/watch?v=wvE9ld2BjZ4), work with the machine shop to have specimens made for the rotating beam tests, run the tester to obtain a typical Wohler curve for a couple of different materials and/or different surface finishes, and develop a lab manual for ME 35401 students to utilize this fall.		
Final Deliverables:	Lab manual for ME 35401.		
Desired Qualifications	Have taken ME 354 and ME 35401.		